FOURTH EDITION Da,e:

BD Chaurasia's

HUMAN ANATOMY

Regional and Applied
Dissection and Clinical

VOLUME 1
Upper Limb and Thorax

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Medical knowledge is constantly changing, As new information becomes available, changes in treatment, procedures, equipment and the use of drugs become necessary. The author and the publisher have, as far as it is possible, taken care to ensure that the information given in this text is accurate and up to date. However, readers are strongly advised to confirm that the information, especially with regard to drug usage, complies with the latest legislation and standards of practice.

BDChaurasia's
HUMAN ANATOMY
Regional and Applied
Dissection and Clinical
Volume 1   *4/e*

dedicated to
my teacher

FOURTH EDITION

BD Chaurasia's

Regional and Applied
Dissection and Clinical

VOLUME 1
Upper Limb and Thorax

VOLUME 2
Lower Limb, Abdomen
and Pelvis

VOLUME 3
Head, Neck and Brain

flBOUT TH€ 6D1TOR

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This human anatomy is not systemic but regional
Oh yes, it is theoretical as well as practical
Besides the gross features, it is chiefly clinical
Included in anatomy, it is also histological

Rnatomy is not only of adult but also embryological
It is concise, comprehensive and clinical

Surface marking is provided in the beginning To light the instinct of surgeon-in-the-making

Lots of tables for the muscles are provided
€ven methods for testing are incorporated
Numerous coloured illustrations are added
So that right half of brain gets stimulated

Hope these volumes turn highly useful
The editor's patience and perseverance prove fruitful

Preface to the Fourth Edition

In July 1996, I had gone to the office of CBS Publishers and Distributors to hand over the manuscript of the third edition of our *Textbook of Histology,* when Mr SK Jain, Managing Director of CBS, requested me to shoulder the responsibility of editing the three volumes of their extremely popular book *BD Chaurasia's* **Human Anatomy,** the third edition of which was earlier edited by respected Prof. Inderbir Singh. This was a 'God given gift' which I accepted with great gratitude. This had also been the wishful thinking of my son, now a nephrologist in the US.

The three volumes of the fourth edition of this book are extremely student-friendly. All out efforts have been made to bring them closer to their hearts through serious and subtle efforts. Various ways were thought of, which I discussed with my colleagues and students, and have been incorporated in these volumes.

One significant method suggested was to add 'practical skills' so that these volumes encompass theoretical, practical and clinical aspects of various parts of human body in a functional manner. The paragraphs describing human dissection, printed with blue background, provide necessary instructions for dissection. These entail identifying structures deeper to skin which need to be cut and separated to visualise the anatomic details of various structures.

Dissection means patiently clearing off the fat and fasciae around nerves, blood vessels, muscles, viscera, etc. so that their course, branches and relations are appreciated. This provides the photogenic memory for the 'doctor-in-making'. First year of MBBS course is the only time in life when one can dissect at ease, although it is too early a period to appreciate its value. Good surgeons always refresh their anatomical knowledge before they go to the operation theatre.

Essential part of the text and some diagrams from the first edition have been incorporated glorifying the real author and artist in BD Chaurasia. A number of diagrams on ossification, surface marking, muscle testing, in addition to radiographs, have been added.

The beauty of most of the four-colour figures lies in easy reproducibility in numerous tests and examinations which the reader can master after a few practice sessions only. This makes them user-friendly volumes. Figures are appreciated by the underutilised right half of the cerebral cortex, leaving the dominant left half for other jobs in about 98% of right-handed individuals. At the beginning of each chapter, a few introductory sentences have been added to highlight the importance of the topic covered. A brief account of the related histology and development is put forth so that the given topic is covered in all respects. The entire clinical anatomy has been put with the respective topic, highlighting its importance. The volumes thus are concise, comprehensive and clinically-oriented .

Various components of upper and lower limbs have been described in a tabular form to revise and appreciate their "diversity in similarity". At the end of each section, an appendix has been added wherein the segregated course of the nerves has been aggregated, providing an overview of their entire course. These appendices also contain some clinicoanatomical problems and multiple choice questions to test the knowledge and skills acquired. Prayers, patience and perseverance for almost 8 years have brought out this new edition aimed at providing a holistic view of the amazing structures which constitute the human anatomy.

There are bound to be some errors in these volumes. Suggestions and comments for correction and improvement shall be most welcome: These may please be sent to me through e-mail at cbspubs@del3.vsnl.net.in.

KRISHNA GARG

'TMie necessity of having a simple, systematized J. and complete book on anatomy has long been felt. The urgency for such a book has become all the more acute due to the shorter time now available for teaching anatomy, and also to the falling standards of English language in the majority of our students in India. The national symposium on "Anatomy in Medical Education" held at Delhi in 1978 was a call to change the existing system of teaching the unnecessary minute details to the undergraduate students.

This attempt has been made with an object to meet the requirements of a common medical student. The text has been arranged in small classified parts to make it easier for the students to remember and recall it at will. It is adequately illustrated with simple line diagrams which can be reproduced without any difficulty, and which also help in understanding and memorizing the anatomical facts that appear to defy memory of a common student. The monotony of describing the individual muscles separately, one after the other, has been minimised by writing them out in tabular form, which makes the subject interesting for a lasting memory. The relevant radiological and surface anatomy have been treated in separate chapters. A sincere attempt has been made to deal, wherever required, the clinical applications of the subject. The entire approach is such as to attract and inspire the students for a deeper dive in the subject of anatomy.

The book has been intentionally split in three parts for convenience of handling. This also makes a provision for those who cannot afford to have the whole book at a time.

It is quite possible that there are errors of omission and commission in this mostly single handed attempt. I would be grateful to the readers for their suggestions to improve the book from all angles.

Gwalior
February, 1981

BD CHAURASIA

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Section 1

UPPER LIMB

Introduction to the Upper Limb

TMie fore and hind limbs were evolved basically for bearing the weight of the body and for locomotion as is seen in quadrupeds, for example cows or dogs. The two pairs of limbs are, therefore, built on the same basic principle.

Each limb is made up of a basal segment or girdle, and a free part divided into proximal, middle and distal segments. The girdle attaches the limb to the axial skeleton. The distal segment carries the five digits (Table 1.1).

Table 1.1: Homologous parts of the limbs

Upper limb	Lower limb
1. Shoulder girdle	1. Hip girdle
2. Shoulder joint	2. Hip joint
3. Arm with humerus	3. Thigh with femur
4. Elbow joint	4. Knee joint
5. Forearm with radius and ulna	5. Leg with tibia and fibula
6. Wrist joint	6. Ankle joint
7. Hand with	7. Foot with
(a) Carpus	(a) Tarsus
(b) Metacarpus	(b) Metatarsus and
(c) 5 digits	(c) 5 digits

However, with the evolution of the erect posture in man, the function of weight-bearing was taken over by the lower limbs. Thus the upper limbs, especially the hands became free and gradually evolved into organs having great manipulative skills.

This has become possible because of a wide range of mobility at the shoulder. The whole upper limb works as a jointed lever. The human hand is a grasping tool. It is exquisitely adaptable to perform various complex functions under the control of the brain. The unique position of man as a master mechanic of the animal world is because of the skilled movements of his hands.

Parts of the Upper Limb

We have seen that the upper limb is made up of four parts: (1) shoulder; (2) arm or brachium; (3) forearm or antebrachium; and (4) hand or manus. Further subdivisions of these parts are given below. Also see Table 1.2 and Fig. 1.1.

1.The *shoulder* region includes: (a) the *pectoral* or *breast region* on the front of the chest; (b) the *axilla* or *armpit;* and (c) the *scapular region* on the back comprising parts around the scapula. The bones of the shoulder girdle are the clavicle and the scapula. Of these only the clavicle articulates with the axial skeleton at the sternoclavicular joint. The scapula is mobile and is held in position by muscles. The clavicle and scapula articulate with each other at the acromioclavicular joint.

2.The arm (upper arm or brachium) extends from the shoulder to the elbow (or cubitus). The bone of the arm is the humerus. Its upper end meets the scapula and forms the shoulder joint. The shoulder joint permits movements of the arm.

3.The *forearm* (antebrachium) extends from the elbow to the wrist. The bones of the forearm are the radius and the ulna. At their upper ends they meet the lower end of the humerus to form the elbow joint. Their lower ends meet the carpal bones to form the wrist joint. The radius and ulna meet each other at the radioulnar joints.

The elbow joint permits movements of the forearm, namely flexion and extension. The radioulnar joints permit rotatory movements of the forearm called pronation and supination. In a midflexed elbow, the palm faces upwards in supination and downwards in pronation. During the last movement the radius rotates around the ulna.

4. The .hand (manus) includes: (a) the *wrist* or carpus, supported by eight carpal bones arranged in two rows; (b) the *hand proper* or metacarpus, sup ported by five metacarpal bones; and (c) five *digits*

Table 1.2: Parts of the upper limb

Parts	Subdivision	Bones	Joints
A. Shoulder region	1. Pectoral region, on the front of the chest 1.Axilla or armpit 2.Scapular region, on the back	Bones of the shoulder gridle (a) Clavicle (b) Scapula	(i) Sternoclavicular joint (ii) Acromioclavicular joint
B. Upper arm (arm or brachium) from shoulder to the elbow	—	Humerus (Scapulohumeral joint)	Shoulder joint
C. Forearm (antebrachium) from elbow to the wrist	—	(a) Radius (b) Ulna	(i) Elbow joint (ii) Radioulnar joints
D. Hand	1. Wrist 2. Hand proper 3. Five digits, numbered from lateral to medial side First=Thumb or pollex Second=Index or fore-finger Third = Middle finger Fourth=Ring finger Fifth=Little finger	(a) Carpus, made up of 8 carpal bones (b) Metacarpus, made up of 5 metacarpal bones (c) 14 phalanges—two for the thumb, and three for each of the four fingers	(i) Wrist joint (radiocarpal joint) (ii) Intercarpal joints (iii) Carpometacarpal joints (iv) Intermetacarpal joints (v) Metacarpophalangeal joints (vi) Proximal and distal interphalangeal joints

(thumb and four fingers). Each finger is supported by three phalanges, but the thumb has only two phalanges (there being 14 phalanges in all). The carpal bones form the wrist joint with the radius, intercarpal joints with one another, and carpometacarpal joints with the metacarpals. The phalanges form metacarpophalangeal joints with the metacarpals and interphalangeal joints with one another. Movements of the hand are permitted chiefly at the wrist joint: the thumb moves at the first carpometacarpal joint; and each finger at its metacarpophalangeal joint. Figure 1.2 shows the lines of force transmission.

Evolution of Upper Limbs

The forelimbs have evolved from the pectoral fins of fishes. In tetrapods (terrestrial vertebrates), all the four limbs are used for supporting body weight, and for locomotion. In arboreal (tree dwelling) human ancestors, the forelimbs have been set free from their weight-bearing function. The forelimbs, thus 'emancipated', acquired a wide range of mobility and were used for prehension or grasping, feeling, picking, holding, sorting, breaking, fighting, etc. These functions became possible only after necessary structural modifications such as : (a) appearance of joints permitting rotatory movements of the forearms (de-

scribed as supination and pronation), as a result of which food could be picked up and taken to the mouth; (b) addition of the clavicle, which has evolved with the function of prehension; (c) rotation of the thumb through 90 degrees, so that it can be opposed to other digits for grasping; and (d) appropriate changes for free mobility of the fingers and hand. The primitive pentadactyl limb of amphibians, terminating in five digits, has persisted through evolution and is seen in man. In some other species, however, the limbs are altogether lost, as in snakes; while in others the digits are reduced in number as in ungulates. The habit of brachiation, i.e. suspending the body by the arms, in anthropoid apes resulted in disproportionate lengthening of the forearms, and also in elongation of the palm of fingers. Some further details of the evolution of the upper limb will be taken up in appropriate sections.

Study of Anatomy

In studying the anatomy of any region (by dissection), it is usual to begin by studying any peculiarities of the skin, the superficial fascia and its contents, and the deep fascia. This is followed by the study of the muscles of the region, and finally, the blood vessels and nerves. This pattern is followed in the descriptions of various regions. These descriptions
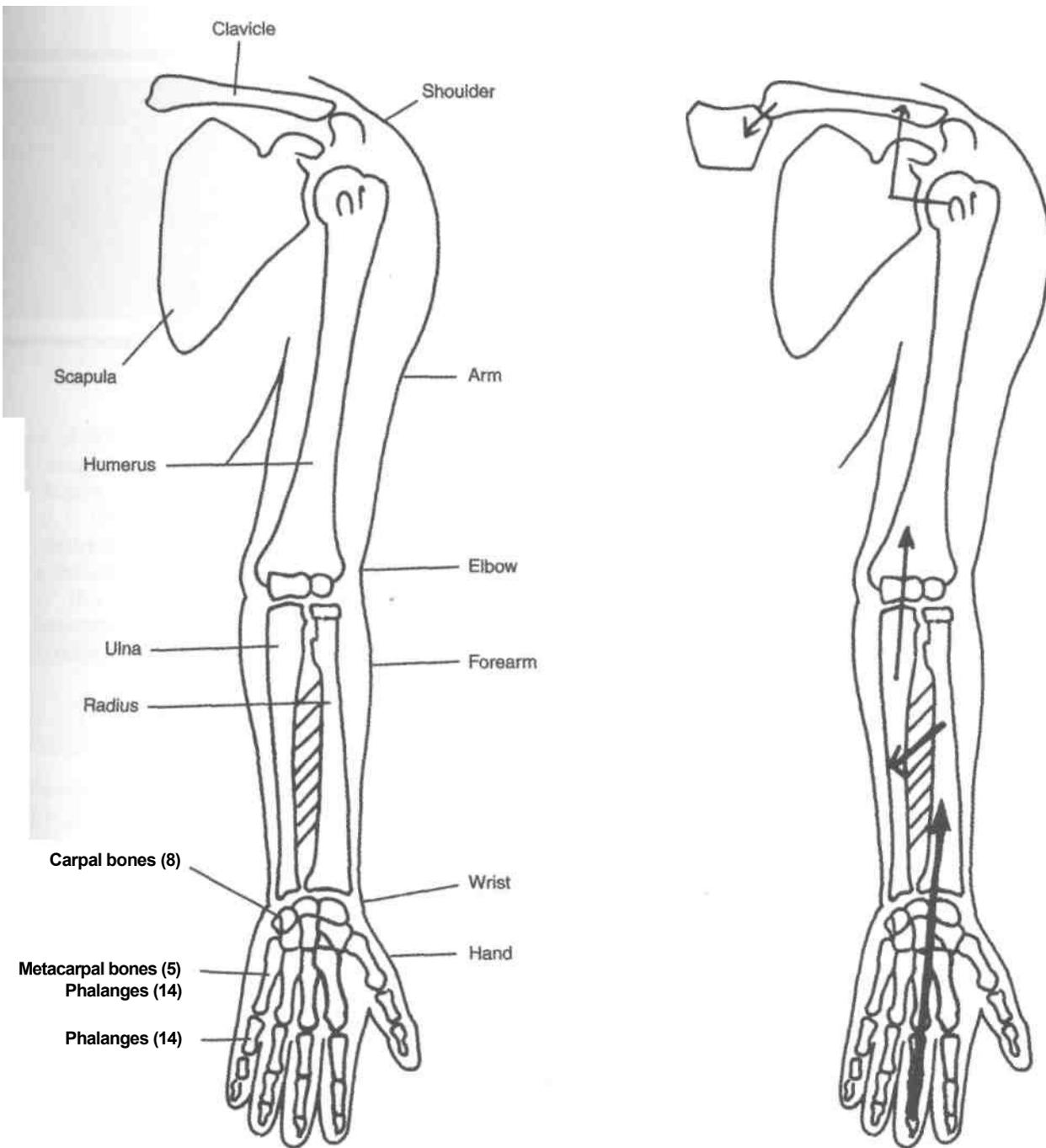
Fig. 1.1: Parts of the upper limb.

Fig. 1.2: Scheme of skeleton of upper limb showing lines of force transmission.

should be read only after the part has been dissected with the help of the steps of dissection provided in the book.

Before undertaking the study of any part of the body, it is essential for the student to acquire some knowledge of the bones of the region. It is for this reason that a chapter on bones (osteology) is given at the beginning of each section. While reading this chapter, the students should palpate the various parts of bones on themselves. They must possess set of loose bones for study, and for marking the attachments of muscles and ligaments.

Bones of the Upper Limb

Out of 206 total bones in man, the upper limbs contain as many as 64 bones. Each side consists of 32 bones, the distribution of which is shown in Table 2.1. The individual bones of the upper limb will be described one by one. Their features and attachments should be read before undertaking the dissection of the part concerned. The paragraphs on attachments should be revised when the dissection of a particular region has been completed.

THE CLAVICLE

The clavicle is a long bone (Figs 2.1-2.3). It supports the shoulder so that the arm can swing clearly away from the trunk. The clavicle transmits the weight of the limb to the sternum. The bone has a cylindrical part called the shaft, and two ends, lateral and medial.

The Shan

The shaft (Figs 2.1, 2.2) is divisible into the lateral one-third and the medial two-thirds.

The *lateral one-third of the shaft* is flattened from above downwards. It has two borders, anterior and posterior. The anterior border is concave forwards. The posterior border is convex backwards. This part of the bone has two surfaces, superior and inferior. The *superior surface* is subcutaneous and the inferior surface presents an elevation called the *conoid tubercle* and a ridge called the *trapezoid ridge.*

The *medial two-thirds of the shaft* is rounded and is said to have four surfaces. The anterior surface is convex forwards. The posterior surface is smooth. The superior surface is rough in its medial part. The inferior surface has a rough oval impression at the medial end. The lateral half of this surface has a longitudinal subclavian groove. The nutrient foramen lies at the lateral end of the groove.

Lateral and Medial Ends

1.The lateral or acromial end is flattened from above downwards. It bears a facet that articulates with the acromion process of the scapula to form the acromioclavicular joint.

2.The medial or sternal end is quadrangular and articulates with the clavicular notch of the manu-brium sterni to form the sternoclavicular joint. The articular surface extends to the inferior aspect, for articulation with the first costal cartilage.

Side Determination

The side to which a clavicle belongs can be determined from the following characters:

1.The lateral end is flat, and the medial end is large and quadrilateral.

2.The shaft is slightly curved, so that it is convex forwards in its medial two-thirds, and concave forwards in its lateral one-third.

3.The inferior surface is grooved longitudinally in its middle one-third.

Peculiarities of the Clavicle

1.It is the only long bone that lies horizontally.

2.It is subcutaneous throughout.

3.It is the first bone to start ossifying.

4.It is the only long bone which ossifies in membrane.

5.It is the only long bone which has two primary centres of ossification.

6.It is generally said to have no medullary cavity, but this is not always true.

7.It is occasionally pierced by the middle supra-clavicular nerve.
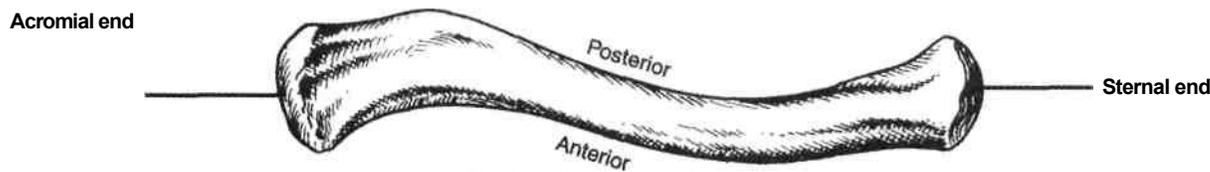
Fig. 2.1: Right clavicle: Superior aspect

Acromial end

Posterior

Anterior

Sternal end

Trapezoid ridge

Conoid tubercle

Costoclavicular ligament

Groove for subclavius Fig. 2.2:

Right clavicle: Inferior aspect.

Sex Determination

1.In females, the clavicle is shorter, lighter, thinner, smoother, and less curved than in males.

2.The midshaft circumference and the weight of the clavicle are reliable criteria for sexing the clavicle.

3.In females, the lateral end of the clavicle is a little below the medial end; in males, the lateral end is either at the same level or slightly higher than the medial end.

Morphology of the Clavicle

See morphology of shoulder girdle following description of scapula (Page-14).

ATTACHMENTS ON THE CLAVICLE

1.*At the lateral end* the margin of the articular surface for the acromioclavicular joint gives attachment to the joint capsule.

2.*At the medial end* the margin of the articular surface for the sternum gives attachment to: (a) the fibrous capsule all round; (b) the articular disc posterosuperiorly; and (c) the interclavicular ligament superiorly (Fig. 2.4).

3.*Lateral one-third of shaft*

(a)The anterior border gives origin to the *deltoid* (Figs 2.3A and 2.3B).

(b)The posterior border provides insertion to the *trapezius* (Fig. 5.4).

(c) The conoid tubercle and trapezoid ridge give attachment to the conoid and trapezoid parts of the *coracoclavicular ligament* (Fig. 2.4).

4. *Medial two-thirds of the shaft*

(a)The anterior surface gives origin to the *pectoralis major* (Fig. 4.2).

(b)The rough superior surface gives origin to the clavicular head of the *stemocleidomastoid.*

(c)The oval impression on the inferior surface at the medial end gives attachment to the *costoclavicular ligam en t.*

(d)The subclavian groove gives insertion to the *subclavius muscle.* The margins of the groove give attachment to the clavipectoral fascia (Fig. 4.2).

The nutrient foramen transmits a branch of the suprascapular artery.
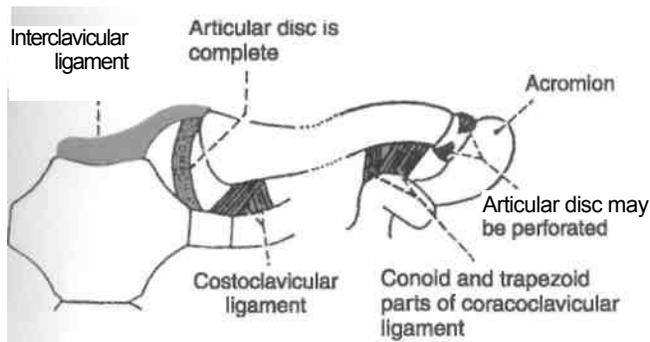
Fig. 2.4: *The sternoclavicular and acromioclavicular joints.*

Ossification: The clavicle is the first bone in the body to ossify (Fig. 2.5). Except for its medial end, it ossifies in membrane. It ossifies from two primary centres and one secondary centre.

The two primary centres appear in the shaft between the fifth and sixth weeks of intrauterine life, and fuse about the 45th day. The secondary centre for the medial end appears during 15-17 years, and fuses with the shaft during 21-22 years. Occasionally there may be a secondary centre for the acromial end.
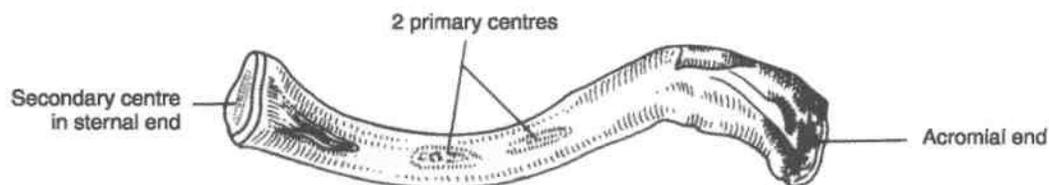
The clavicle is commonly fractured by falling on the outstretched hand (indirect violence). The most common site of fracture is the junction between the two curvatures of the bone, which is the weakest point. The lateral fragment is displaced downwards by the weight of the limb.

The clavicles may be congenitally absent, or imperfectly developed in a disease called *cleidocranial dysostosis.* In this condition, the shoulders droop, and can be approximated anteriorly in front of the chest.

The scapula is a thin bone placed on the posterolateral aspect of the thoracic cage. The scapula has two surfaces, three borders, three angles, and three processes (Fig. 2.6).

The Surfaces

1.The *costal surface* or subscapular fossa is concave and is directed medially and forwards. It is marked by three longitudinal ridges. Another thick ridge adjoins the lateral border. This part of the bone is almost rod-like: It acts as a lever for the action of the *serratus anterior* in overhead abduction of the arm.

2.The *dorsal surface* gives attachment to the spine of the scapula which divides the surface into a smaller *supraspinous fossa* and a larger *infraspinous fossa.* The two fossae are connected by the spinoglenoid notch, situated lateral to the root of the spine.

The Borders

1.The *superior border* is thin and shorter. Near the root of the coracoid process it presents the *suprascapular notch.*

2.The *lateral border is* thick. At the upper end it presents the *infraglenoid tubercle.*

Fig. 2.5: *Ossification.*
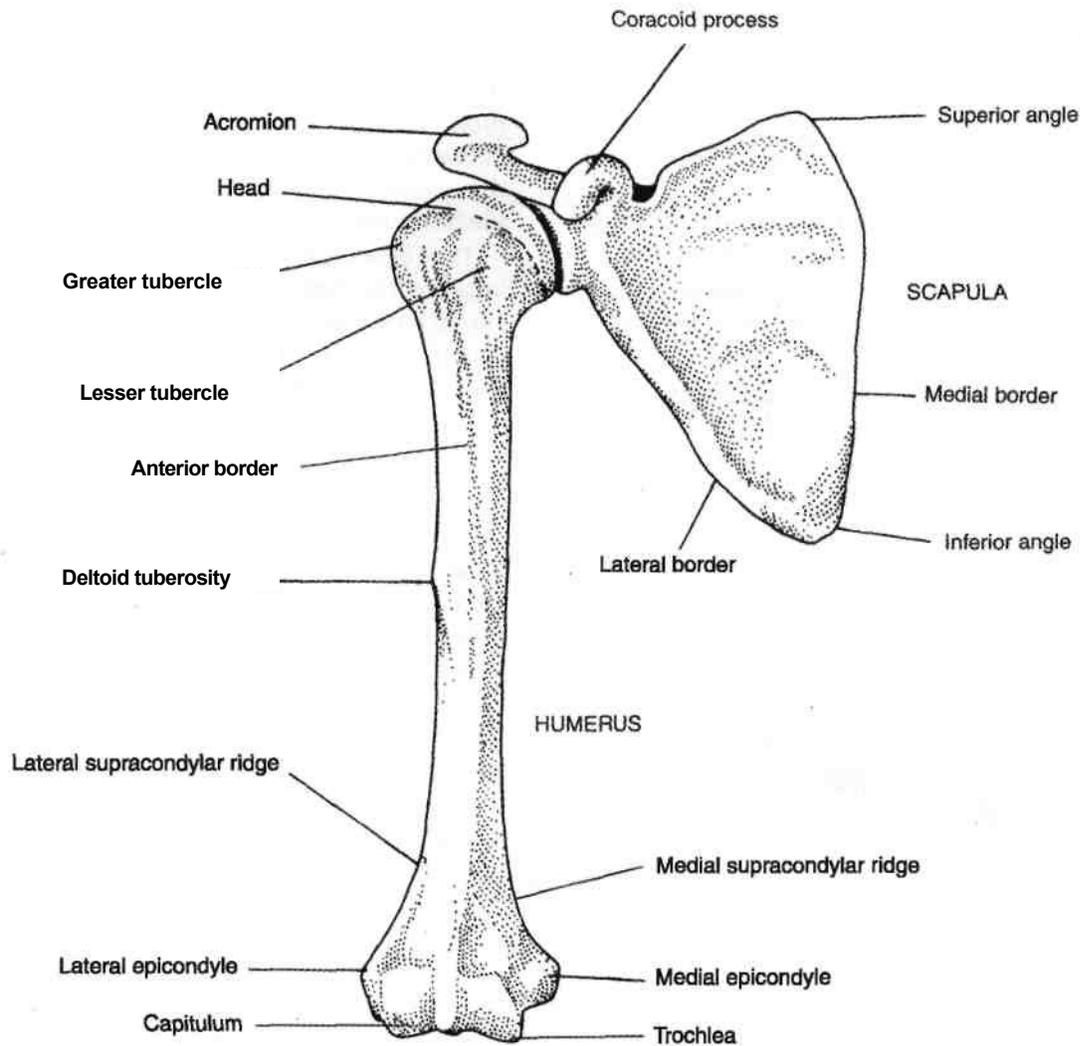
Fig. 2.6: *General features of right scapula and humerus (anterior view).*

Labels in figure:
Coracoid process
Acromion
Head
Greater tubercle
Lesser tubercle
Anterior border
Deltoid tuberosity
Lateral supracondylar ridge
Lateral epicondyle
Capitulum
Superior angle
SCAPULA
Medial border
Inferior angle
Lateral border
HUMERUS
Medial supracondylar ridge
Medial epicondyle
Trochlea

3. The *medial border* is thin. It extends from the superior angle to the inferior angle.

The Angles

1. The *superior angle* is covered by the trapezius.
2. The *inferior angle* is covered by the *latissimus dorsi.* It moves forwards round the chest when the arm is abducted.
3. The *lateral or glenoid angle* is broad and bears the glenoid cavity or fossa, which is directed forwards, laterally and slightly upwards.

The Processes

1. The *spine or spinous process* is a triangular plate of bone with three borders and two surfaces. It divides the dorsal surface of the scapula into the

supraspinous and infraspinous fossae. Its posterior border is called the *crest of the spine.* The crest has upper and lower lips.

1. The *acromion* has two borders, medial and lateral; two surfaces, superior and inferior; and a facet for the clavicle (Fig. 2.7).
2. The *coracoid* process is directed forwards and slightly laterally.

Side Determination

1. The lateral or glenoid angle is large and bears the glenoid cavity.
2. The dorsal surface is convex and is divided by the triangular spine into the supraspinous and infraspinous fossae. The costal surface is concave to fit on the convex chest wall.
3. The lateral thickest border runs from the glenoid cavity above to the inferior angle below.

Suprascapular notch

Acromion

Spine

Greater tubercle

Groove for radial nerve

Infraglenoid tubercle

Deltoid tuberosity

Olecranon fossa
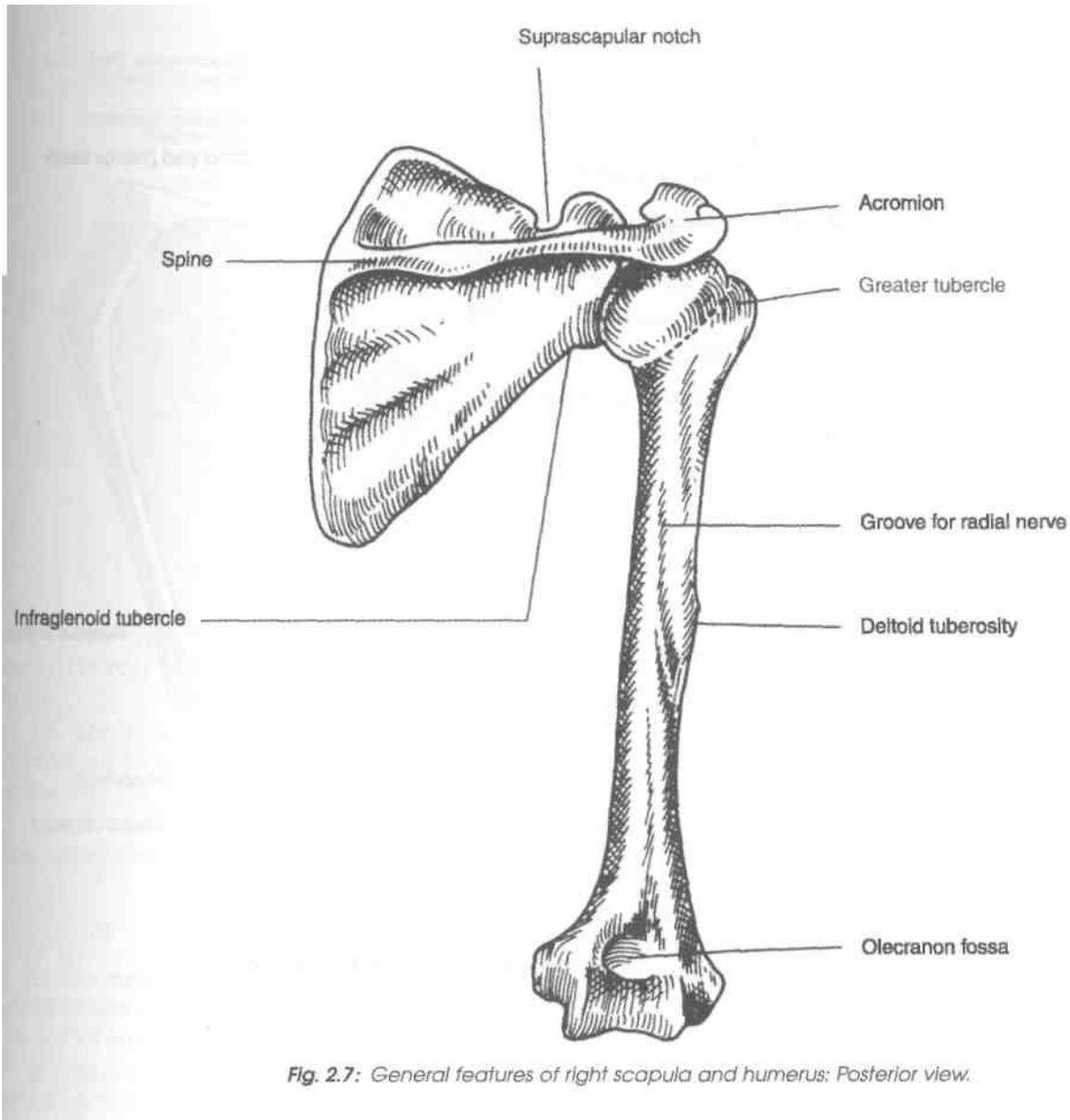
Fig. 2.7: *General features of right scapula and humerus: Posterior view.*

Muscles

1. The multipennate *subscapularis* arises from the medial two-thirds of the subscapular fossa (Figs 2.8, 7.4).

2. The *supraspinatus* arises from the medial two-thirds of the supraspinous fossa including the upper surface of the spine (Fig. 7.3).

3. The *infraspinatus* arises from the medial two-thirds of the infraspinous fossa, including the lower surface of the spine (Fig. 2.9).

4. The *deltoid* arises from the lower border of the crest of the spine and from the lateral border of the acromion (Fig. 2.10). The acromial fibres are multipennate.

1. The *trapezius* is inserted into the upper border of the crest of the spine and into the medial border of the acromion (Figs 2.9, 2.10).

2. The *serratus anterior* is inserted along the medial border of the costal surface: one digitation from the superior angle to the root of spine, two digitations to the medial border, and five digitations to the inferior angle (Figs 2.12-2.14).

3. The *longhead of the biceps brachii* arises from the supraglenoid tubercle; and the short *head* from the lateral part of the tip of the coracoid process (Fig. 8.3).

4. The *coracobrachialis* arises from the medial part of the tip of the coracoid process.

5. The *pectoralis minor is* inserted into the medial border and superior surface of the coracoid process.

Clavicular facet

Capsule of acromioclavicular joint

Deltoid

Acromion

Suprascapular ligament

Coracoid process

Omohyoid (inferior belly)

Coracobrachialis and short head of biceps

Pectoralis minor

Coracoclavicular ligament

Long head of triceps

Lateral border of scapula

Serratus anterior

Trapezius

Deltoid

Acromion

Supraspinatus

Levator scapulae

bscapularis

Costal aspect.

Coracobrachialis and short head of biceps

Long head of biceps

Triceps, long head

Teres minor

Circumflex scapular artery

Infraspinatus

Rhomboideus minor

Teres major

Rhomboideus major

Latissimus dorsi

Fig. 2.9: *Right scapula: Dorsal aspect.*

1.The *long head of the triceps* arises from the infraglenoid tubercle.

2.The teres *minor* arises from the upper two-thirds of the rough strip on the dorsal surface along the lateral border.

1.The teres *major* arises from the lower one-third of the rough strip on the dorsal aspect of the lateral border.
2.The *levator scapulae* is inserted along the dorsal aspect of the medial border, from the superior angle up to the root of the spine.
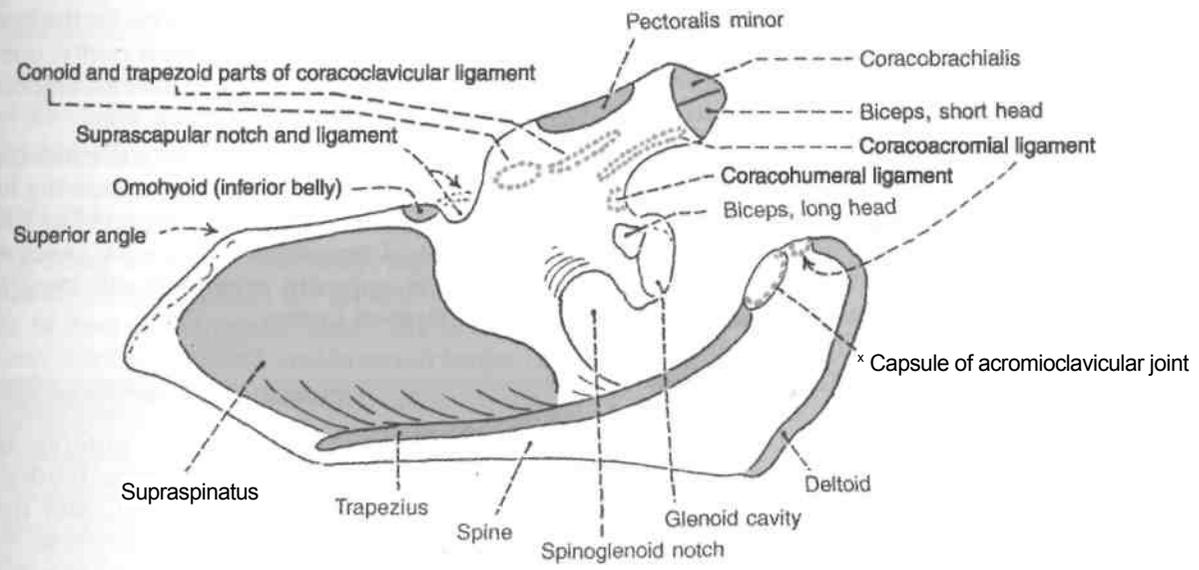
Fig. 2.10: Right scapula: Superior aspect.

ar

14. The *rhomboideus minor* is inserted into the medial border (dorsal aspect) opposite the root of the spine.

1. The *rhomboideus major* is inserted into the medial border (dorsal aspect) between the root of the spine and the inferior angle.
2. The *inferior belly of the omohyoid* arises from the upper border near the suprascapular notch.

Ligaments

1. The margin of the glenoid cavity gives attachment to the capsule of the shoulder joint and to the *glenoidal labrum* (Fig. 10.4).
2. The margin of the facet on the medial aspect of the acromion gives attachment to the capsule of the acromioclavicular joint.

1. The *coracoacromial ligament is* attached: (a) to the lateral border of the coracoid process, and (b) to the medial side of the tip of the acromion process (Figs 2.10, 7.8, 10.4).

2. The *coracohumeral ligament* is attached to the root of the coracoid process.

3. The coracoclavicular ligament is attached to the coracoid process: the trapezoid part on the superior aspect, and the conoid part near the root.

4. The suprascapular ligament bridges across the suprascapular notch and converts it into a foramen which transmits the suprascapular nerve. The suprascapular vessels lie above the ligament (Fig. 10.3).

5. The spinoglenoid ligament bridges the spinoglenoid notch. The suprascapular vessels and nerve pass deep to it (Fig. 10.3).

First digitation

Second and third digitation

Fourth to eighth digitation

capula

of scapula

uscles.
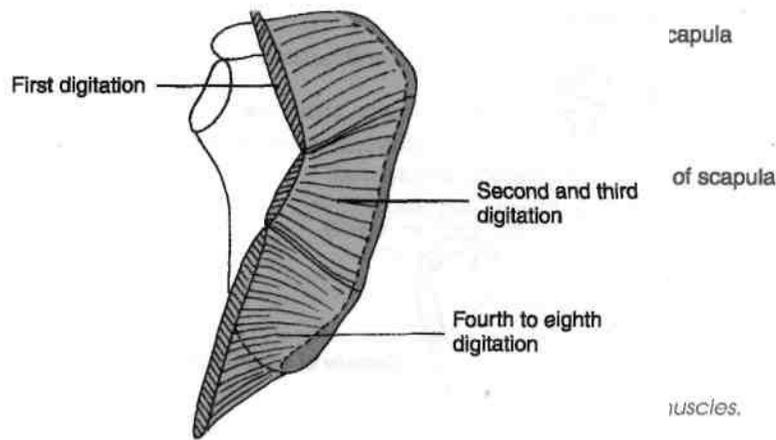
Fig. 2.13: Manner of insertion of serratus anterior into scapula.

First rib

Eighth rib

Fig. 2.12: The serratus anterior.

Chest wall
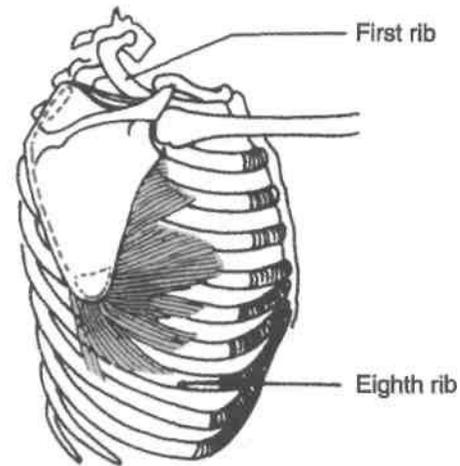
Serratus anterior

Subscapularis

Scapula

Fig. 2.14: Diagram showing relation of serratus anterior to chest wall and subscapularis.

Ossification: The scapula ossifies from one primary centre and seven secondary centres. The primary centre appears near the glenoid cavity during the eighth week of development. The first secondary centre appears in the middle of the coracoid process during the first year and fuses by the 15th year. The subcoracoid centre appears in the root of the coracoid process during the 10th year and fuses by the 16th to 18th years (Fig. 2.15). The other centres,

Appearance—10th year
Fusion—16th–18th year

Appearance—1st year
Fusion—15th year

Appearance—Puberty
Fusion—25th year

Eighth week of intrauterine life
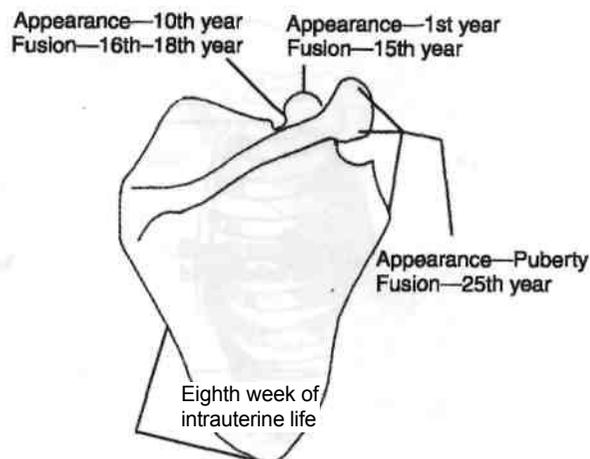
Fig. 2.15: Ossification of scapula.

Appearance—Puberty
Fusion—25th year

including two for the acromion, one for the lower two-thirds of the margin of the glenoid cavity, one for the medial border and one for the inferior angle, appear at puberty and fuse by the 25th year.

The fact of practical importance is concerned with the acromion. If the two centres appearing for acromion fail to unite, it may be interpreted as a fracture on radiological examination. In such cases a radiograph of the opposite acromion will mostly reveal similar failure of union.

<div align="center">**CLINICAL ANATOMY**</div>

1.Paralysis of the serratus anterior causes 'winging' of the scapula. The medial border of the bone becomes unduly prominent, and the arm cannot be abducted beyond 90 degrees.

2.In a developmental anomaly called *scaphoid scapula,* the medial border is concave.

Morphology of the Shoulder Girdle

The shoulder girdle of man has evolved from that of primitive animals. The girdle of the duckbill (a primitive egg-laying mammal) and that of primitive reptiles are alike. This basic form appears to be the precursor of the various types of mammalian shoulder girdles. The primary reptilian girdle is divisible into a dorsal and a ventral element. The dorsal element of the girdle arch consists of the *scapula.* The ventral element of the girdle arch is more complex and is made up of a posterior part, the *coracoid,* and an anterior part, the *precoracoid.* Both components of the ventral element articulate ventrally with the sternum. The dorsal end of the coracoid helps the scapula in forming the glenoid cavity. In the duckbill, the coracoid is represented by two bones, the coracoid and the *epicoracoid.*

In man, and all higher mammals, where the upper limbs are freely mobile, the coracoid element is much reduced in size to form the coracoid process which fuses with the scapula. The costocoracoid ligament may be a derivative of the ventral part of the coracoid element. The precoracoid has been partly or entirely replaced in all mammals by the clavicle, which is the sole mammalian survivor of a considerable variety of dermal elements (like cleithrum and interclavicle) present in the pectoral girdles of lower vertebrates. The interclavicle is represented in man by the inter-clavicular ligament. The epicoracoid of the duckbill corresponds to the occasional suprasternal ossicles of man. Recalling the homologous parts, the shoulder and hip girdles, it may be noted that (a) the scapula corresponds to the ilium; (b) the coracoid to the ischium; and (c) the precoracoid to the pubis.

THE HUMERUS

The humerus is the bone of the arm. It is the longest bone of the upper limb. It has an upper end, a lower end and a shaft (Figs 2.6, 2.7).

The Upper End

1. The head is directed medially, backwards and upwards. It articulates with the glenoid cavity of the scapula to form the shoulder joint. The head forms about one-third of a sphere and is much larger than the glenoid cavity.

2. The line separating the head from the rest of the upper end is called the *anatomical neck.*

3. The *lesser tubercle* is an elevation on the anterior aspect of the upper end.

4. The *greater tubercle* is an elevation that forms the lateral part of the upper end. Its posterior aspect is marked by three impressions-upper, middle and lower.

5. The *intertubercular sulcus* or bicipital groove separates the lesser tubercle medially from the anterior part of the greater tubercle. The sulcus has medial and lateral lips that represent downward prolongations of the lesser and greater tubercles.

6. The narrow line separating the upper end of the humerus from the shaft is called the *surgical neck.*

The Shaft

The shaft is rounded in the upper half and triangular in the lower half. It has three borders and three surfaces.

Borders

1. The upper one-third of the *anterior* borderforms the lateral lip of the intertubercular sulcus. In its middle part, it forms the anterior margin of the *deltoid tuberosity.* The lower half of the anterior border is smooth and rounded.

2. The *lateral border* is prominent only at the lower end where it forms the *lateral supracondylar ridge.* In the upper part, it is barely traceable up to the posterior surface of the greater tubercle. In the middle part, it is interrupted by the *radial or spiral groove.*

3. The upper part of the *medial border* forms the medial lip of the intertubercular sulcus. About its middle it presents a rough strip. It is continuous below with the *medial supracondylar ridge.*

Surfaces

1. The *anterolateral surface* lies between the anterior and lateral borders. The upper half of this surface is covered by the deltoid. A little above the middle it is marked by a V-shaped deltoid tuberosity. Behind the deltoid tuberosity the radial_groove runs downwards and forwards across the surface.

1. The *anteromedial surface* lies between the anterior and medial borders. Its upper one-third is narrow and forms the floor of the intertubercular sulcus. A nutrient foramen is seen on this surface near its middle, near the medial border.

2. The *posterior surface* lies between the medial and lateral borders. Its upper part is marked by an oblique ridge. The middle one-third is crossed by the radial groove.

The Lower End

The lower end of the humerus forms the condyle which is expanded from side to side, and has articular and non-articular parts. The *articular part* includes the following.

1. The *capitulum* is a rounded projection which articulates with the head of the radius (Fig. 2.6).

2. The *trochlea* is a pulley-shaped surface. It articulates with the trochlear notch of the ulna. The medial edge of the trochlea projects down 6 mm more than the lateral edge: this results in the formation of the *carrying angle.*

The *non-articular part* includes the following.

1. The *medial epicondyle* is a prominent bony projection on the medial side of the lower end. It is subcutaneous and is easily felt on the medial side of the elbow.

2. The *lateral epicondyle* is smaller than the medial epicondyle. Its anterolateral part has a muscular impression.

3. The sharp lateral margin just above the lower end is called the *lateral supracondylar ridge.*

4. The *medial supracondylar ridge* is a similar ridge on the medial side.

5. The *coronoid fossa* is a depression just above the anterior aspect of the trochlea. It accommodates the coronoid process of the ulna when the elbow is flexed.

6. The *radial fossa* is a depression present just above the anterior aspect of the capitulum. It accommodates the head of the radius when the elbow is flexed.

7. The *olecranon fossa* lies just above the posterior aspect of the trochlea. It accommodates the olecranon process of the ulna when the elbow is extended.

Side Determination

1. The upper end is rounded to form the head. The lower end is expanded from side to side and flattened from before backwards.

1. The head is directed medially and backwards.

2. The lesser tubercle projects from the front of the upper end and is limited laterally by the intertubercular sulcus or bicipital groove.

ATTACHMENTS ON THE HUMERUS"

1. The multipennate *subscapularis* is inserted into the lesser tubercle (Fig. 2.16).

2. The *supraspinatus* is inserted into the uppermost impression on the greater tubercle.

3. The *infraspinatus* is inserted into the middle impression on the greater tubercle.

4. The teres *minor* is inserted into the lower impassion on the greater tubercle (Fig. 2.17).

5. The *pectoralis major* is inserted into the lateral lip of the intertubercular sulcus. The insertion is bilaminar.
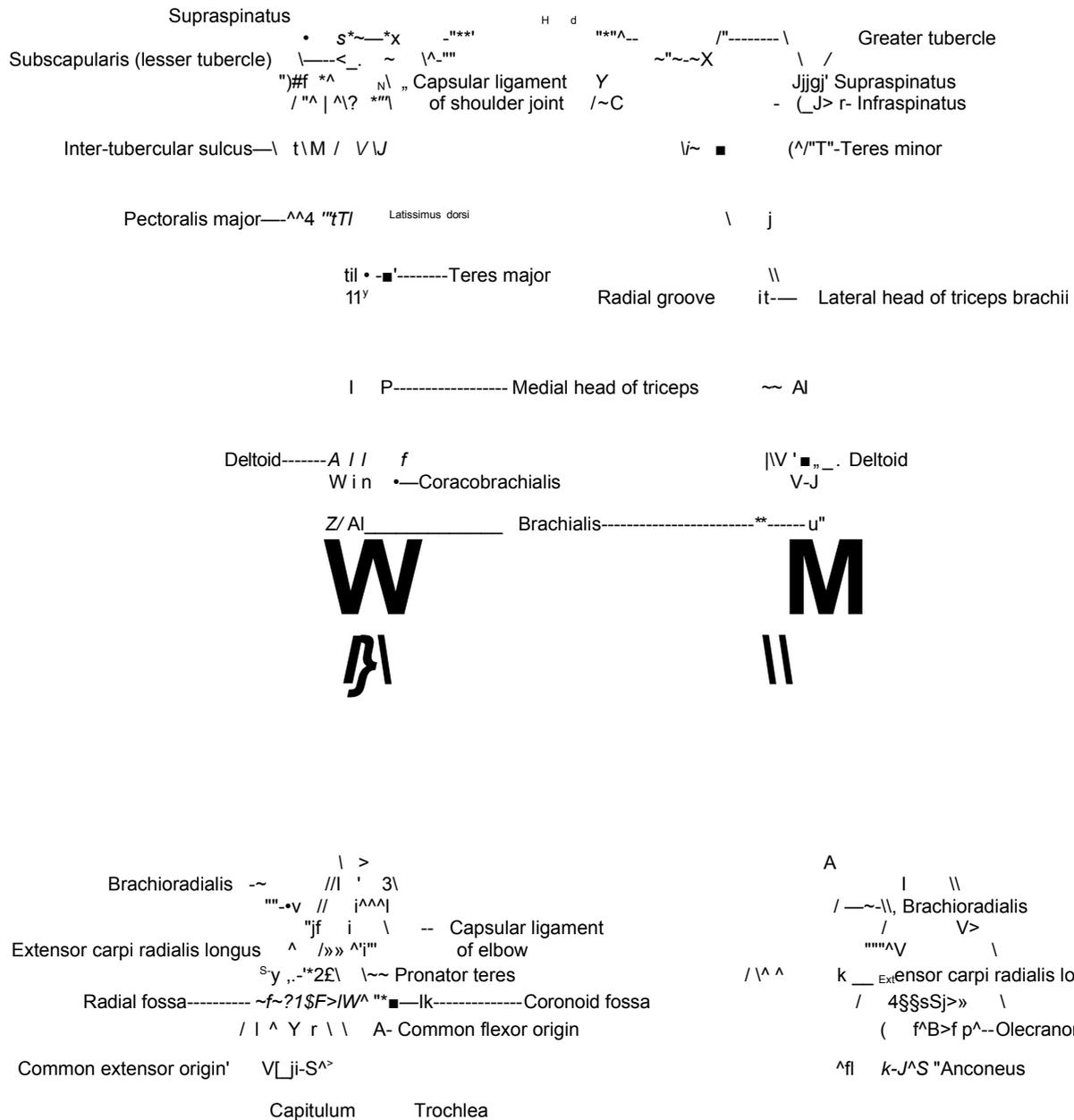
Fig. 2.16: Right humerus seen from front.

Fig. 2.17: Right humerus seen from behind.

1.The *latissimus dorsi* is inserted into the floor of the intertubercular sulcus.

2.The *teres major*is inserted into the medial lip of the intertubercular sulcus.

3.The contents of the intertubercular sulcus are: (a) the *tendon of the longhead of the biceps,* and its synovial sheath; and (ii) the ascending branch of the anterior circumflex humeral artery.

4.The *deltoidis* inserted into the deltoid tuberosity.

1.The *coracobrachialis* is inserted into the rough area on the middle of the medial border.

2.The *brachialis* arises from the lower halves of the anteromedial and anterolateral surfaces of the shaft. Part of the area extends on to the posterior aspect (Fig. 8.5).

3.The *brachioradialis* arises from the upper two-thirds of the lateral supracondylar ridge.

4.The *extensor carpi radialis longus* arises from the lower one-third of the lateral supracondylar ridge (Figs 2.18, 9.44).

5.The *pronator teres* (humeral head) arises from the lower one-third of the medial supracondylar ridge.

6.The *superficial flexor muscles* of the forearm arise by a common origin from the anterior aspect of the medial epicondyle. This is called the common flexor origin.

7.The *superficial extensor muscles* of the forearm have a common origin from the lateral epi-condyle. This is called the common extensor origin (Fig. 2.18).

1.The *anconeus* arises from the posterior surface of the lateral epicondyle.

2.Lateral head of *triceps brachii* arises from oblique ridge on the upper part of posterior surface above the radial groove, while its *medial head* arises from posterior surface below the radial groove (Fig. 2.17).

3.The capsular ligament of the shoulder joint is attached to the anatomical neck except on the medial side where the line of attachment dips down by about two centimetres to include a small area of the shaft within the joint cavity. The line is interrupted at the intertubercular sulcus to provide an aperture through which the tendon of the long head of the biceps leaves the joint cavity.

4.The capsular ligament of the elbow joint is attached to the lower end along a line that reaches the upper limits of the radial and coronoid fossae, anteriorly; and of the olecranon fossa posteriorly; so that these fossae lie within the joint cavity. Medially the line of attachment passes between the medial epicondyle and the trochlea. On the lateral side it passes between the lateral epicondyle and the capitulum.

Ossification: The humerus ossifies from one primary centre and 7 secondary centres. The primary centre appears in the middle of the diaphysis during the 8th week of development (Table 2.1).

Common extensor origin

The upper end ossifies from 3 secondary centres: one for the head (first year), one for the greater tubercle (second year), and one for the lesser tubercle (fifth year). The 3 centres fuse together during the sixth year to form one epiphysis, which fuses with the shaft during the 20th year. The epiphyseal line encircles the bone at the level of the lowest margin of the head. This is the growing end of the bone (remember that the nutrient foramen is always directed away from the growing end).

The lower end ossifies from 4 centres which form 2 epiphyses. The centres include: one for the capitulum and the lateral flange of the trochlea (first year), *one* for the medial flange of the trochlea (9th year), and one for the lateral epicondyle (12th year): all three fuse during the 14th year to form one epiphysis, which fuses with the shaft at about 16 years. The centre for the medial epicondyle appears during 4-6 years, forms a separate epiphysis, and fuses with the shaft during the 20th years.

Axillary

CLINICAL ANATOMY

1. Three nerves are directly related to the humerus and are, therefore, liable to injury: the axillary at the surgical neck, the radial at the radial groove, and the ulnar behind the medial epicondyle (Fig. 2.19).

2. The common sites of fracture are the surgical neck, the shaft, and the supracondylar region.

Supracondylar fracture is common in young age. It is produced by a fall on the outstretched hand. The lower fragment is mostly displaced backwards, so that the elbow is unduly prominent, as in dislocation of the elbow joint. However, in fracture, the three bony points of the elbow form the usual equilateral triangle. This fracture may cause injury to the median nerve. It may also lead to Volkmarm's isehaemic contracture, and myositis ossiflcans.

1. The humerus has a poor blood supply at the junction of its upper and middle thirds. Fractures at this site show delayed union or non-union.

2. The head of the humerus commonly dislocates inferiorly.

The radius is the lateral bone of the forearm, and is homologous with the tibia of the lower limb. It has an upper end, a lower end and a shaft.

The Upper End

1. The *head* is disc-shaped and is covered with hyaline cartilage (Figs 2.20, 2.21). It has a superior concave surface which articulates with the capitulum of the humerus at the elbowjoint. The circumference of the head is also articular. It fits into a socket formed by the radial notch of the ulna and the annular ligament, thus forming the superior radioulnar joint.

2. The *neck* is enclosed by the narrow lower margin of the annular ligament. The head and neck are free from capsular attachment and can rotate freely within the socket.

3. The *tuberosity* lies just below the medial part of the neck. It has a rough posterior part and a smooth anterior part.

The Shaft

It has three borders and three surfaces.

Borders

1. The *anterior* border extends from the anterior margin of the radial tuberosity to the styloid process. It is oblique in the upper half of the shaft, and vertical in the lower half. The oblique part is called the *anterior oblique line.* The lower vertical part is crest-like (Fig. 2.22).

2. The *posterior border* is the mirror image of the anterior border, but is clearly defined only in its

Coronoid process

Radial notch

Head

<u>HUMERUS</u>

middle one-third. The upper oblique part is known as the posterior oblique line (Fig. 2.23).

3. The *medial or interosseous border* is the sharpest of the three borders. It extends from the radial tuberosity above to the posterior margin of the ulnar notch below. The interosseous membrane is attached to its lower three-fourths. In its lower

part, it forms the posterior margin of an elongated triangular area.

Surfaces

1. The *anterior surface* lies between the anterior and interosseous borders. A nutrient foramen opens in its upper part, and is directed upwards. The nutrient artery is a branch of the anterior interosseous artery.

1. The *posterior surface* lies between the posterior and interosseous borders.
2. The *lateral surface* lies between the anterior and posterior borders.

The Lower End

The lower end is the widest part of the bone. It has 5 surfaces (Fig. 2.24).

1. The *anterior surface* is in the form of a thick prominent ridge. The radial artery is palpated against this surface.
2. The *posterior surface* presents four grooves for the extensor tendons. The dorsal tubercle (of Lister) lies lateral to an oblique groove.
3. The *medial surface* is occupied by the *ulnar notch* for the head of the ulna.
4. The *lateral surface* is prolonged downwards to form the styloid process.
5. The *inferior surface* bears a triangular area for the scaphoid bone, and a medial quadrangular area for the lunate bone. This surface takes part in forming the wrist joint.

Side Determination

The smaller circular and upper end is concave followed by a constricted neck. Just below the medial aspect of neck is the radial tuberosity.

The wider lower end is thick with a pointed styloid process on its lateral aspect and a prominent dorsal tubercle on its posterior surface. Medial or interosseous border is thin and sharp.

For lunate

ATTACHMENTS ON THE RADIUS

1. The *biceps brachii* is inserted into the rough posterior part of the radial tuberosity. The anterior part of the tuberosity is covered by a bursa (Fig. 2.25).

2. The *supinatoris* inserted into the upper part of the lateral surface (Fig. 2.26).

Olecranon

Brachialis

ler

1. The *pronator teres* is inserted into the middle of the lateral surface.

2. The *brachioradialis* is inserted into the lowest part of the lateral surface just above the styloid process.

3. The radial head of the *flexor digitorum superficialis* takes origin from the anterior oblique line or the upper part of anterior border (Fig. 2.27).

1. The *flexor pollicis longus* takes origin from the upper two-thirds of the anterior surface (Fig. 2.27).

2. The *pronator quadratus* is inserted into the lower part of the anterior surface and into the triangular area on the medial side of the lower end. The radial artery is palpated as "radial pulse" as it lies on the lower part of anterior surface of radius, lateral to the tendon of flexor carpi radialis (Fig. 9.11).

3. The *abductor pollicis longus* and the *extensor pollicis brevis* arise from the posterior surface.

4. The *quadrateligamentis* attached to the medial part of the neck.

1. The *oblique* cord is attached on the medial side just below the radial tuberosity.

2. The *articular capsule of the wrist joint* is attached to the anterior and posterior margins of the inferior articular surface.

3. The *articular disc* of the inferior radioulnar joint is attached to the lower border of the ulnar notch.

4. The *extensor retinaculum* is attached to the lower part of the anterior border.

5. The *interosseous membrane* is attached to the lower three-fourths of the interosseous border.

Ossification: The shaft ossifies from a primary centre which appears during the 8th week of development. The lower end ossifies from a secondary centre which appears during the first year and fuses at 20 years; it is the growing end of the bone. The upper end (head) ossifies from a secondary centre which appears during the 4th year and fuses at 18 years (Table 2.1).

CLINICAL ANATOMY

1. The radius commonly gets fractured about 2 cm above its lower end (Colles's fracture). This fracture is caused by a fall on the outstretched hand. The distal fragment is displaced upwards and backwards, and the radial styloid process comes to lie proximal to the ulnar styloid process. (It normally lies distal to the ulnar styloid process.)

2. *Smith's fracture* is the reverse of the Colles' fracture, the distal segment being palmar flexed rather than dorsiflexed. It is uncommon, and is produced by a fall on the dorsum of a palmar flexed hand.

3. *Congenital absence of the radius* is a rare anomaly. This results in gross radial deviation of the hand, and the thumb is often absent.

4. *Radioulnar synostosis* is also a rare condition in which the radius and ulna are fused

together, usually in the proximal *2.5 cm of* the bone. Pronation and supination *is* impossible in these cases.

5. A sudden powerful jerk on the hand of a child may dislodge the head of the radius from the grip of the annular ligament. This is known as subluxation of the head of the radius. The head can normally be felt in a hollow behind the lateral epicondyle of the humerus.

THE ULNA

The ulna is the medial bone of the forearm, and is homologous with the fibula of the lower limb. It has upper end, lower end, and a shaft.

The Upper End

The upper end presents the olecranon and coronoid processes, and the trochlear and radial notches (Figs 2.20, 2.21).

Triceps brachii -.___

' Olecranon process

Anconeus-------XL-L.

I— Head of radius

Common aponeurosis for flexor carpi uinaris, extensor carpi ulnaris and flexor digitorum profundus

•----- Supinator

•----Biceps brachii and radial tuberosity

RADIUS

Flexor digitorum profundus

Abductor pollicis longus

Extensor pollicis longus .

ULNA

— Pronator teres

Extensor indicia

-I- — Extensor pollicis brevis

Posterior border---------,
Medial surface---------

— Interosseous borders

Posterior border

\ / t \.**~ . Dorsal tubercle

Head of ulna _^

Sty/oid process „„

---- Styloid process

Fig. 2.26: *Right radius and ulna: Posterior aspect*
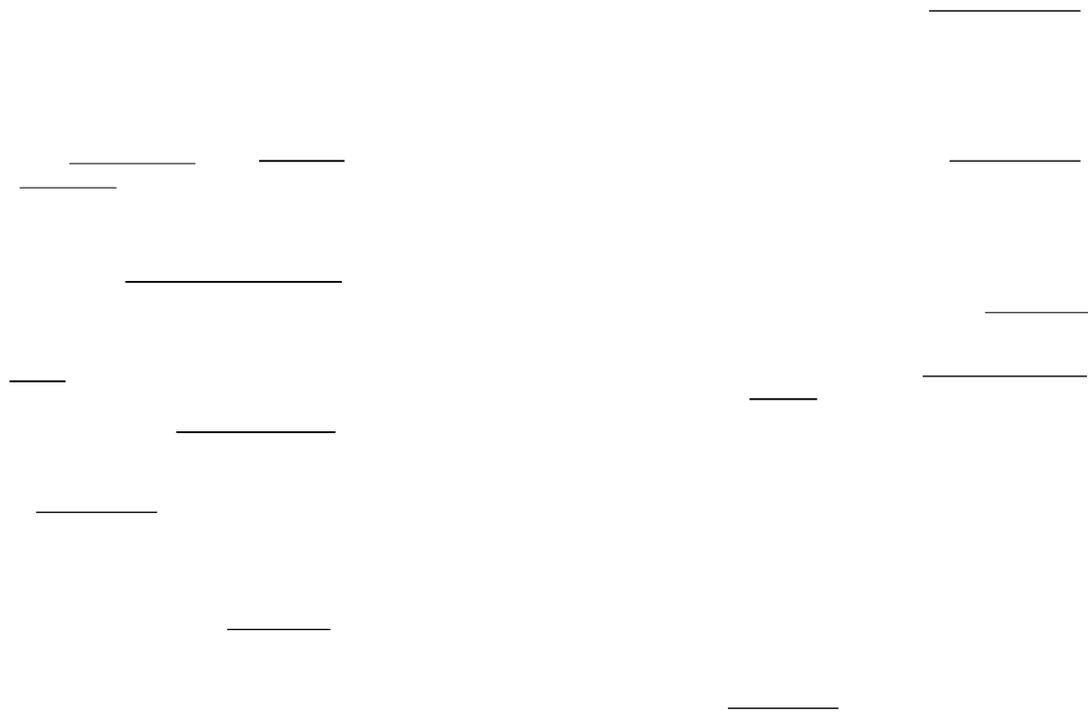
1.The *olecranon process* projects upwards from the shaft. It has superior, anterior, posterior, medial and lateral surfaces. The *anterior surface is* articular: it forms the upper part of the trochlear notch. The *posterior surface* forms a triangular subcutaneous area which is separated from the skin by a *bursa.* Inferiorly it is continuous with the posterior border of the shaft of the ulna. The upper part forms the point of the elbow. The *medial surface* is continuous inferiorly with the posterior surface of the shaft.

2.The *coronoid process* projects forwards from the shaft just below the olecranon and has four surfaces: superior, anterior, medial and lateral. The *superior surface* forms the lower part of the trochlear notch. The *anterior surface* is triangular and rough. Its lower corner forms the ulnar tuberosity. The upper part of its lateral surface is marked by the radial notch for the head of the radius. The annular ligament is attached to the anterior and posterior margins of the notch. The lower part of the lateral surface forms a depressed area to accommodate the radial tuberosity. It is limited behind by a ridge called the supinator crest.

1.The *trochlear notch* forms an articular surface that articulates with the trochlea of the humerus to form the elbow joint.

2.The *radial notch* articulates with the head of the radius to form the superior radioulnar joint.

The Shaft

The shaft has three borders and three surfaces (Fig. 2.22).

Borders

1.The *interosseous or lateral* border is sharpest in its middle two-fourths. Inferiorly, it can be traced to the lateral side of the head. Superiorly, it is continuous with the supinator crest.

2.The *anterior border* is thick and rounded. It begins above on the medial side of the ulnar tuberosity, passes backwards in its lower one-third, and terminates at the medial side of the styloid process.

3.The *posterior border* is subcutaneous. It be-gins, above, at the apex of the triangular subcutane-

ous area at the back of the olecranon, and terminates at the base of the styloid process.

Surfaces

1. The *anterior surface* lies between the anterior and interosseous borders. A nutrient foramen is seen on the upper part of this surface. It is directed upwards. The nutrient artery is derived from the anterior interosseous artery.

2. The *medial surface* lies between the anterior and posterior borders.

3. The *posterior surface* lies between the posterior and interosseous borders. It is subdivided into three areas by two lines. An oblique line divides it into upper and lower parts. The lower part is further divided by a vertical line into a medial and a lateral area.

The Lower End

The lower end is made up of the head and the styloid process. The head articulates with the ulnar notch of the radius to form the inferior radioulnar joint. It is separated from the wrist joint by the articular disc (Figs 2.23, 2.24). Ulnar artery and nerve lie on the anterior aspect of head of ulna (Fig. 2.28).

The styloid process projects downwards from the posteromedial side of the lower end of the ulna. Posteriorly, between the head and the styloid process there is groove for the tendon of the extensor carpi ulnaris.

Side Determination

1. The upper end is hook-like, with its concavity directed forwards.
2. The lateral border of the shaft is sharp and crest-like.
3. Pointed styloid process lies medial to the rounded head of ulna.

ATTACHMENTS ON THE ULNA

Muscles

1. The *triceps* is inserted into the posterior part of the superior surface of the olecranon. The anterior part of the surface is covered by a bursa (Fig. 2.26).
2. The *brachialis* is inserted into the anterior surface of the coronoid process including the tuber-osity of the ulna (Fig. 2.25).
3. The *supinator* arises from the supinator crest and from the triangular area in front of the crest.
4. The ulnar head of the *flexor digitorum superficialis* arises from a tubercle at the upper end of the medial margin of the coronoid process.

1. The ulnar head of the *pronator teres* arises from the medial margin of the coronoid process.

2. The *flexor digitorum profundus* arises from: (a) the upper three-fourths of the anterior and medial surfaces of the shaft; (b) the medial surfaces of the coronoid and olecranon processes; and (c) the posterior border of the shaft through an aponeurosis which also gives origin to the flexor carpi ulnaris and the extensor carpi ulnaris (Fig. 2.26).

3. The *pronator quadratus* takes origin from the oblique ridge on the lower part of the anterior surface.

4. The *flexor carpi ulnaris* (ulnar head) arises from the medial side of the olecranon process and from the posterior border (6 c).

5. The *extensor carpi ulnaris* arises from the posterior border.

1. The *anconeus* is inserted into the lateral aspect of the olecranon process and the upper one-fourth of the posterior surface (Fig. 2.26).

2. The lateral part of the posterior surface gives origin from above downwards to the *abductorpollicis longus,* the *extensor pollicis longus,* and the *extensor indicis.*

Other Attachments

1. The *interosseous membrane* is attached to the interosseous border.

2. The *oblique cord* is attached to the lateral side of the tuberosity.

3. The *capsular ligament of the elbow joint is* attached to the margins of the trochlear notch, i.e. to the coronoid and olecranon processes.

4. The *annular ligamentof* the superior radioulnar joint is attached to the two margins of radial notch of ulna.

5. The *ulnar collateral ligament* of the wrist is attached to the styloid process.

6. The *articular disc* of the inferior radioulnar joint is attached by its apex to a small rough area just lateral to the styloid process.

Ossification: The shaft and most of the upper end ossify from a primary centre which appears during the 8th week of development.

The superior part of the olecranon ossifies from a secondary centre which appears during the 10th year. It forms a scale-like epiphysis which joins the rest of the bone by 16 years. The lower end ossifies from a secondary centre which appears during the 5th year, and joins with the shaft by 18 years. This is the growing end of the bone (Table 2.1).

1.The ulna is the stabilising bone of the forearm, with its trochlear notch gripping the lower end of the humerus. On this foundation the radius can pronate and supinate for efficient working of the upper limb.

2.The shaft of the ulna may fracture either alone or along with that of the radius. Cross-union between the radius and ulna must be prevented to preserve pronation and supination of the hand.

3.*Dislocation of the elbow is* produced by a fall on the outstretched hand with the elbow slightly flexed. The olecranon shifts posteriorly and the elbow is fixed in slight flexion.

Normally in an extended elbow, the tip of the olecranon lies in a horizontal line with the two epicondyles of the humerus; and in the flexed elbow the three bony points from an equilateral triangle. These relations are disturbed in dislocation of the elbow.

1.*Fracture of the olecranon* is common and is caused by a fall on the point of the elbow. Fracture of the coronoid process is uncommon, and usually accompanies dislocation of the elbow.

2.*Madelung's deformity* is dorsal subluxation (displacement) of the lower end of the ulna, due to retarded growth of the lower end of the radius.

Ossification of Humerus, Radius, and Ulna

Law of Ossification

In long bones possessing epiphyses at both of their ends, the epiphysis of that end which appears first is last to join with the shaft. As a corollary, epiphysis which appeared last is first to join.

These ends of long bones which unite last with the shaft are designated as growing end of the bone. In case of long bones of the upper limb, growing ends are at shoulder and wrist joints. This implies that, the upper end of humerus and lower ends of both radius and ulna are growing ends; and each will, therefore, unite with their shaft at a later period than their corresponding ends.

The direction of the nutrient foramen in these bones, as a rule, is opposite to the growing end.

The time of appearance and fusion (either of various parts at one end, or with the shaft) are given in the Table 2.1.

Importance of Capsular Attachments and Epiphyseal Lines

Metaphysis is the epiphyseal end of the diaphysis. It is actively growing part of the bone with rich blood supply. Infections in this part of the bone are most common in the young age. The epiphyseal line is the line of union of metaphysis with the epiphysis. At the end of the bone, besides the epiphyseal line is the attachment of the capsule of the respective joints.

So infection in the joint may affect the metaphysis of the bone if it is partly or completely inside the joint capsule. As a corollary, the disease of the metaphysis if inside a joint may affect the joint. So it is worthwhile to know the intimate relation of the capsular attachment and the epiphyseal line at the ends of humeral, radial and ulnar bones as shown in Table 2.2.

The carpus is made up of 8 carpal bones, which are arranged in two rows (Fig. 2.29).

1.The proximal row contains   (from lateral to medial side): (i) the scaphoid, (ii) the lunate, (iii) the triquetral, and (iv) the pisiform bones.

2.The distal row contains in the same order: (i) the trapezium, (ii) the trapezoid, (iii) the capitate, and (iv) the hamate bones.

Identification

1.The *scaphoid,* is boat-shaped and has a tubercle on its lateral side.

2.The *lunate* is half-moon-shaped or crescentic.

3.The *triquetral* is pyramidal in shape and has an isolated oval facet on the distal part of the palmar surface.

4.The *pisiform* is pea-shaped and has only one oval facet on the proximal part of its dorsal surface.

5.The *trapezium* is quadrangular in shape, and has a crest and a groove anteriorly. It has a concavoconvex articular surface distally.

6.The *trapezoid* resembles the shoe of a baby.

7.The *capitate* is the largest carpal bone, with a rounded head.

8.The *hamate* is wedge-shaped with a hook near its base.

Side Determination

General Points

1.The proximal row is convex proximally, and concave distally.

2.The distal row is convex proximally and flat distally.

3.Each bone has 6 surfaces.

(i) The palmar and dorsal surfaces are non-articular, except for the triquetral and pisiform.

Table 2.1: Ossification of humerus, radius and ulna

Name vf bone and parts	Primary centre	Secondary centres	Times of fusion together	Times of fusion with shaft
Humerus			/r*^S:˙ :\	
Shaft	SwklUL	&•:'£& ˙J		
Radius	Upper end (intrauterine life)	V / Head	i yr	20th yr
Ulna	1styr -i \ ª j Greater tubercle	2nd yr 1		
	——' 6t Lesser tubercle	5th yr ᴶ		
	Lower end Capitulum + lateral part of trochlea			
	1styr Medial part of trochlea	9th yr		
	14 Lateral epicondyle	12yr Medial epicondyle		
	5th yr			
	Shaft 8 wk IUL	/ b I Lower		20th yr
	end 1 st yr	p.v?'-T'~^l		
				20th yr 18th yr
				/ 18thyr
	Upper end	4th year		
	Shaft 8 wk IUL	1 — -v		
	Lower end	5th yr L^ₘ\		
	Upper end	10th yr Vix"		

(il)
{iii} The lateral surfaces of the two lateral bones (scaphoid and trapezium) are non-articular. The medial surfaces of the three medial bones on

(triquetral, pisiform and hamate) are non-articular.

4. The dorsal non-articular surface is always larger than the palmar non-articular surface, except for the lunate, in which the palmar surface is larger than the dorsal.

The general points help in identifying the proximal, distal, palmar and dorsal surfaces in most of the bones. The side can be finally determined with the help of the specific points.

Specific Points

I. The *scaphoid.* The tubercle is directed laterally, forward and downwards.

2. The *lunate,* (i) A small semilunar articular surface for the scaphoid is on the lateral side, (ii) *A* quadrilateral articular surface for the triquetral is

the medial side.

1.The *triquetral.* (i) The oval facet for the pisiform lies on the distal part of the palmar surface, (ii) The medial and dorsal surfaces are continuous and non-articular.

2.The *pisiform,* (i) The oval facet for the triquetral lies on the proximal part of the dorsal surface, (ii) The lateral surface is grooved by the ulnar nerve.

3.The *trapezium,* (i) The palmar surface has a vertical groove for the tendon of the flexor carpi radialis. (ii) The groove is limited laterally by the crest of the trapezium, (iii) The distal surface bears a concavoconvex articular surface for the base of the first metacarpal bone.

Table 2.2: Relation of capsular attachment and epiphyseal lines

	Capsular attachment (C.A.)	Epiphyseal line (E.L)	Result
Humerus upper end	Laterally to the anatomical neck, medially 2 cm below the shaft	At the lowest part of articular surface of the head	Metaphysis is partly intracapsular
Humerus lower end	Follows the margins of radial and coronoid fossae and halfway through the olecranon fossa. Both epicondyles are extracapsular	A horizontal line at the level of lateral epicondyle. Medial epicondyle owns a separate epiphyseal line	Metaphysis is partly intracapsular
Radius upper end	Attached to the neck of the radius	The head forms the epiphysis	Metaphysis is partly intracapsular
Radius lower end	Close to the articular margin all around	Horizontal line at the level of the upper part of ulnar notch	Metaphysis is completely extracapsular
Ulna upper end	Near the articular surface of ulna	Scale-like epiphysis on the upper surface of olecranon	Metaphysis and part of diaphysis is related to capsular line. The epiphysis is extracapsular
Ulna lower end	Around the head of ulna	Horizontal line at the level of articulating surface of radius	Metaphysis is partly intracapsular

CA —

HUMERUS   **ULNA**

1. The *trapezoid.* (i) The distal articular surface is bigger than the proximal, (ii) The palmar non-articular surface is prolonged laterally.

2. The *capitate.* The dorsomedial angle is the distal-most projection from the body of the capitate. It bears a small facet for the 4th metacarpal bone.

3. The *hamate.* The hook projects from the distal part of the palmar surface, and is directed laterally.

ATTACHMENTS

There are four bony pillars at the four corners of the carpus. All attachments are to these four pillars (Fig. 2.30).

1. The tubercle of the scaphoid gives attachment to: (i) the flexor retinaculum; and (ii) a few fibres of the abductor pollicis brevis.

P2. The pisiform gives attachment to: (i) flexor carpi ulnaris, (ii) flexor retinaculum, (iii) abductor digiti minimi, and (iv) extensor retinaculurrA

3. The trapezium has the following attachments: (i) The crest gives origin to the abductor pollicis brevis, flexor pollicis brevis, and opponens pollicis. These constitute muscles of thenar eminence. Figure 2.31 shows the distribution of median and superficial branch of ulnar nerves in the palm, (ii) The edges of the groove give attachment to the two layers of the flexor retinaculum. (iii) The lateral surface gives

attachment to the lateral ligament of the wrist joint, (iv) The groove lodges the tendon of the flexor carpi radialis.

4. Hamate, (i) The tip of the hook gives attachment to the flexor retinaculum, (ii) the medial side of the hook gives attachment to the flexor digiti minimi and the opponens digiti minimi (Fig. 2.32).

Articulations

1. The scaphoid articulates with the following bones: radius, lunate, capitate, trapezium and trap-ezoid.

2. The lunate articulates with the following bones: radius, scaphoid, capitate, hamate and triquetral.

3. The triquetral articulates with the following bones: pisiform, lunate, hamate and articular disc of the inferior radioulnar joint.

4. The pisiform articulates with the triquetral.

5. The trapezium articulates with the following bones: scaphoid, first and second metacarpal and capitate.

Hook of hamate

Pisiform

Digital nerves

**Branches to second
and first lumbricals**

Communicating branch

**Branch to muscles of
thenar eminence**

Median nerve
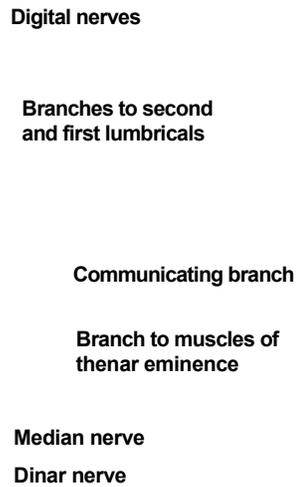
Dinar nerve

Fig. 2.31: *Median and superficial branch of ulnar nerves and
thenar muscles.*

1. The trapezoid articulates with the following
bones: scaphoid, trapezium, second metacarpal
and capitate.
2. The capitate articulates with the following bones:
scaphoid, lunate, hamate, 2nd, 3rd and 4th
metac-arpals and trapezoid.

Opponens pollicis

Arrangement	Tetrapod carpus	Human carpus
Proximal row	Os radiale Os intermedium Os ulnare	Scaphoid Lunate Triquetral
Central row	Os centrale	Absent*
Distal row	Os carpale 1 Os carpale 2 Os carpale 3 Os carpalia 4, 5	Trapezium Trapezoid Capitate Hamate

Some authorities believe that the tubercle of the scaphoid is derived from
the os centrale

Radius ~i_

	Metacarpal	Metatarsal
		1.The head and shaft are flattened from side to side.
		2.The shaft tapers distally.
	1.The head and shaft are	
Lunate		1.The dorsal surface of the shaft is uniformly convex.
		2.The base appears to be cut sharply and obliquely.
Triquetra!		
Pisiform	prismoid.	
Hamate	2.The shaft is of uniform thickness.	
	3.The dorsal surface of the shaft has an elongated, flat triangular area.	
	4. The base is irregular.	

Scaphoid

Trapezium

Characteristics of Individual Metacarpal Bones

A^XNXi

/•' W/tr? \ « *f*

/ | /' \ / \ |

Capitate   Metacarpals (1-5)

Fig. 2.34: *Arrangement of carpal bones in man. Compare with Fig. 2.33.*

Ossification: *The* year of appearance of centre of ossification in the carpal bones is shown in Figure 2.35A.

1. The metacarpal bones are 5 miniature long bones, which are numbered from lateral to the medial side [Fig. 2.29).
2. Each bone has a head placed distally, a shaft

and a base at the proximal end.

(i) The head is round. It has an articular surface which extends more anteroposteriorly than laterally. It extends more on the palmar surface than on the dorsal surface. The heads of the metacarpal bones form the knuckles.

The base has an elongated articular strip on its lateral side for the fourth metacarpal. The medial side of the base is non-articular and bears a tubercle.

Side Determination

The proximal, distal, palmar and dorsal aspects of each metacarpal bone can be made out from what has been stated above. The lateral and medial sides can be confirmed by the following criteria.

Metacarpal

I.   The anterolateral surface is larger than the anteromedial.

II.   (i)   The medial edge of the groove on the base is deeper than the lateral edge,
(ii)   The medial side of the base bears an articular strip which is constricted in the middle.

III. (i)   The styloid process is dorsolateral.
(ii) The lateral side of the base bears an articular strip which is constricted in the middle.
(iii) The medial side of the base has two small oval facets for the fourth metacarpal.

IV.   (i)   The lateral side of the base has two small oval facets for the third metacarpal.
(ii) The medial side of the base has an elongated articular strip for the fifth metacarpal.

V.   (i)   The lateral side of the base has an elongated articular strip for the fourth metacarpal.
(ii) The medial side of the base is non-articular and has a tubercle.

Main Attachments

The main attachment from shaft of metacarpals is of palmar and dorsal interossei muscles. Palmar interossei arise from one bone each except the third metacarpal (Fig. 2.36). Dorsal interossei arise from adjacent sides of two metacarpals (Fig. 2.37). The other attachments are listed below.

Metacarpal

I.   (i)
The *opponens pollicis* is inserted on the radial border and the anterolateral surface of the shaft (Fig. 2.38).
(ii) The *abductor pollicis* longus is inserted on the lateral side of the base. (iii) The first *palmar in terosseous* muscle arises
from the ulnar side of the base.

II.   (i)   The *flexor carpi radialis* is inserted on a tubercle on the palmar surface of the base.
(ii) The *extensor carpi radialis longus* is inserted on the dorsal surface of the base.
(iii) The *oblique head of the adductor* pollicis arises from the palmar surface of the base (Fig.2.39).

III. (i)   A slip from the *flexor carpi radialis* is inserted on the palmar surface of the base.

Fig. 2.36: Palmar interossei.

Fig. 2.37: Dorsal interossei.

(ii) The *extensor carpi radialis* brew's is inserted on the dorsal surface of the base, immediately beyond the styloid process.

(iii) The *oblique head of the adductor pollicis* arises from the palmar surface of the base.

(iv) The *transverse head of the adductor pollicis* arises from the distal two-thirds of the palmar surface of the shaft.

IV. Only the interossei arise from it.

V. (i) The *extensor carpi ulnaris* is inserted on the tubercle at the base.

(ii) The *opponens digit! minimi* is inserted on the medial surface of the shaft.

Articulations at the Bases

I. With the trapezium.

II. With the trapezium, the trapezoid, the capitate and the third metacarpal.

Oblique head

First palmar interosseous

Adductor pollicis

Medial

Sesamoid bones

First dorsal interosseous

IE. With the capitate and the 2nd and 4th metacarpals.

IV. With the capitate, the hamate and the 3rd and 5th metacarpals.

With the hamate and the 4th metacarpal. *Ossification:* The shafts ossify from one primary centre each, which appears during the 9th week of development. A secondary centre for the head appears in the 2nd to 5th metacarpals, and for the base in the first metacarpal. It appears during the 2nd-3rd year and fuses with the shaft at about 16-18 years (Fig. 2.35B).

CLINICAL ANATOMY

1. Fracture of the base of the first metacarpal is called Bennett's fracture. It involves the anterior part of the base, and is caused by a force along its long axis. The thumb is forced into a semiflexed position and cannot be opposed. The fist cannot be clenched.

2. The other metacarpals may also be fractured by direct or indirect violence. Direct violence usually displaces the fractured segment forwards. Indirect violence displaces them backwards.

3. Tubercular or syphilitic disease of the metacarpals or phalanges is located in the middle of the diaphysis rather than in the metaphysis because the nutrient artery breaks up into a plexus immediately upon reaching the medullary cavity. In adults, however, the chances of infection are minimized because the nutrient artery is replaced (as the major source of supply) by periosteal vessels.

4. When the thumb possesses three phalanges, the first metacarpal has two epiphyses one at each end. Occasionally, the first metacarpal bifurcates distally. Then the medial branch has no distal epiphysis, and has only two phalanges. The lateral branch has a distal epiphysis and three phalanges.

THE PHALANGES ^_

There are 14 phalanges in each hand, 3 for each finger and 2 for the thumb. Each phalanx has a base, a shaft and a head.

The Base

In the proximal phalanx, the base is marked by a concave oval facet for articulation with the head of the metacarpal bone. In the middle phalanx, or a distal phalanx, it is marked by two small concave facets separated by a smooth ridge.

The Shaft

The shaft tapers towards the head. The dorsal surface is convex from side to side. The palmar surface is flattened from side to side, but is gently concave in its long axis.

The Head

In the proximal and middle phalanges the head has a pulley-shaped articular surface. In the distal phalanges, the head is non-articular, and is marked anteriorly by a rough horseshoe-shaped tuberosity which supports the sensitive pulp of the fingertip.

ATTACHMENTS

7. *Base of the Distal Phalanx*

(i) The *flexor digitorum profundus* is inserted on the palmar surface (Fig. 2.40). (ii) Two side slips of digital expansion fuse to be inserted on the dorsal surface. These also extend the insertion of lumbrical and interossei muscles (Fig. 2.41).

2. *The Middle Phalanx*

(i) The *flexor digitorum superficialis* is inserted on each side of the shaft, (ii) The fibrous *flexor sheath* is also attached to the side of the shaft, (iii) A part of the *extensor digitorum* is inserted on the dorsal surface of the base (Fig. 2.41).

3. *The Proximal Phalanx*

(i) The fibrous *flexor sheath* is attached to the sides of the shaft, (ii) On each side of the base, parts of the *lumbricals and interossei* are inserted.

4. In the thumb, the base of the proximal phalanx provides attachments to the following structures (Fig 2.36).

(i) The *abductorpollicis brevis* and *flexor pollicis brew's* are inserted on the lateral side.

(ii) The *adductor pollicis* and the *first palmar interosseous* are inserted on the medial side.

(iii) The *extensor pollicis brevis* is inserted on the dorsal surface.

5. In the little finger, the medial side of the base of the proximal phalanx provides insertion to the *abductor digit! minimi* and the *flexor digiti minimi*.

A

Flexor digitorum profundus

Flexor digitorum superficialis

Fibrous flexor sheath

Capsules of interphalangeal joints

Capsules of metacarpophalangeal joints

B

Cruciate fibres of fibrous sheath

Transverse fibres of fibrous sheath

Deep transverse metacarpal ligament

C

Tendon of flexor digitorum profund·

Flexor digitorum superficialis
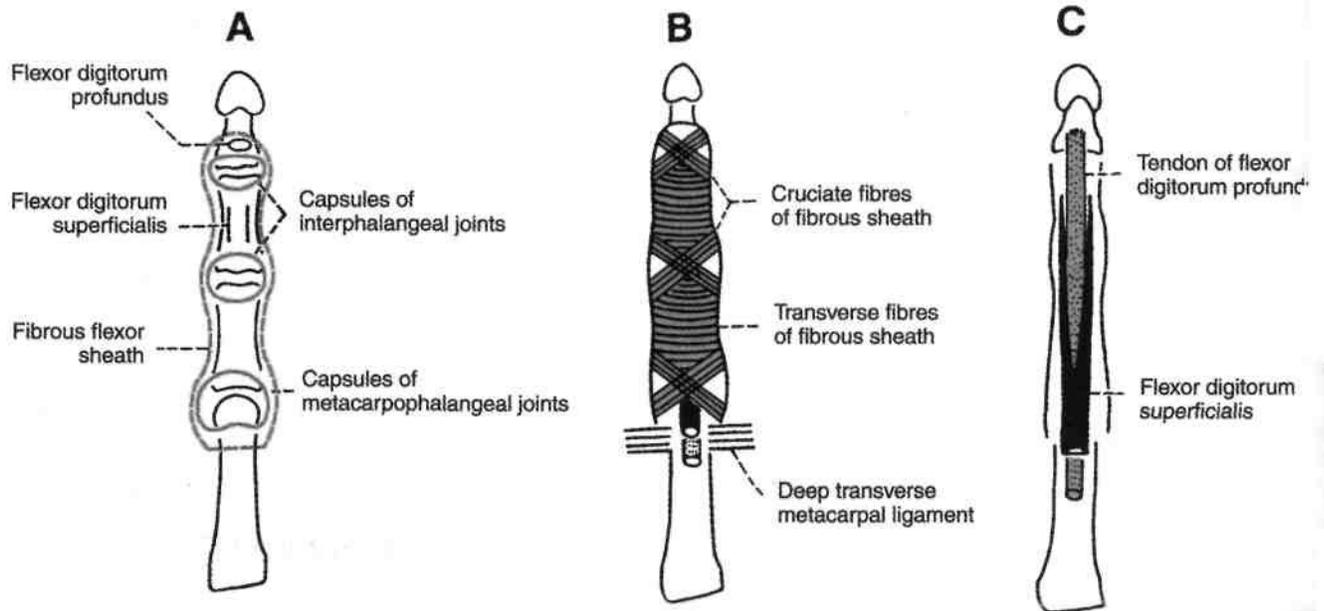
Fig. 2.40: The fibrous flexor sheath and its contents. (A) Bony attachments of the sheath and of the flexor tendons. (B) The fibrous sh showing transverse fibres in front of the bones and cruciate fibres in front of joints. (C) The flexor tendons after removal of the she

Dorsum of base of distal phalanx

The secondary centre appears for the base durir 2-4 years and fuses with the shaft during 15-11 years (Fig. 2.35).

Dorsum of base of middle phalanx

Second lumbrical

- Extensor expansion

Third dorsal interosseous

Second dorsal interosseous

Tendon of extensor digitorum
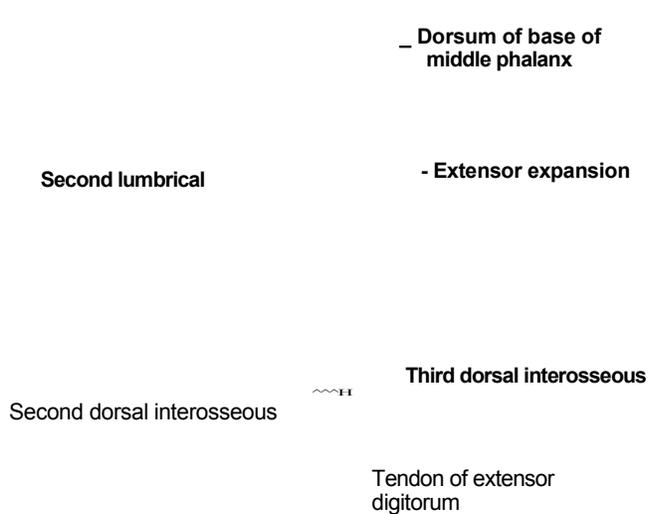
Fig. 2.41: *The dorsal digital expansion of the middle finger. Note the insertion of the lumbrical and interossei muscles into it.*

Ossification: The shaft of each phalanx ossifies from a primary centre which appears during the 8th week of development in the distal phalanx, 10th week in the proximal phalanx and 12th week in the middle phalanx.

THE SESAMOID BONES OF THE UPPER LIMB

Sesamoid bones are small rounded masses of bone I located in some tendons at points where they are I subjected to great pressure. They are variable in I their occurrence. These are as follows.

1.The pisiform is often regarded as a sesamoid bone lying within the tendon of the flexor carpi ulnaris.

2.Two sesamoid bones are always found on the palmar surface of the head of the first metacarpal bone.

3.One sesamoid bone is found in the capsule of the interphalangeal joint of the thumb, in 75% of subjects.

4.One sesamoid bone is found on the ulnar side of the capsule of the metacarpophalangeal joint of the little finger, in about 75% of subjects.

5.Less frequently, there is a sesamoid bone on the lateral side of the metacarpophalangeal joint of the index finger.

6.Sometimes sesamoid bone may be found at other metacarpophalangeal joints.

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The Pectoral Region

'TVie pectoral region lies on the front of the chest. .lit essentially consists of structures which connect the upper limb to the anterolateral chest wall.

SURFACE LANDMARKS

The following features of the pectoral region can be seen or felt on the surface of body.

1.The *clavicle* lies horizontally at the root of the neck, separating it from the front of the chest. The bone is subcutaneous, and therefore palpable, throughout its length. It is convex forwards in its medial two-thirds, and concave forwards in its lateral one-third. Medially, it articulates with the sternum at the *stemoclavicular joint,* and laterally with the acromion at the *acromioclavicular joint.* Both the joints are palpable because of the upward projecting ends of the clavicle (Fig. 3.1). The stemoclavicular joint may be masked by the sternocleidomastoid muscle.

2.*The jugular notch* (interclavicular or suprasternal notch) lies between the medial ends of the clavicles, at the superior border of the manubrium sterni.

3.The *sternal angle* (angle of Louis) is felt as a transverse ridge about 5 cm below the jugular notch (Fig. 3.1). It marks the manubriosternal joint. Laterally, on either side, the *second costal cartilage joins* the sternum at this level. The sternal angle thus serves as a landmark for identification of the second rib. Other ribs can be identified by counting downwards from the second rib.

4.The *epigastric fossa* (pit of the stomach) is the depression in the infrasternal angle. The fossa overlies the xiphoid process, and is bounded on each side by the seventh costal cartilage.

5.The *nipple* is markedly variable in position in females. In males, and in immature females, it usually lies in the fourth intercostal space just medial to the midclavicular line; or 10 cm from the midsternal line. In fact, the position of the nipple is variable even in males.

1.The *midclavicular line* passes vertically through the tip of the ninth costal cartilage and the midinguinal point.

2.The *infraclavicular fossa* (deltopectoral triangle) is a triangular depression below the junction of the lateral and middle thirds of the clavicle. It is bounded medially by the pectoralis major, laterally by the anterior fibres of the deltoid, and superiorly by the clavicle.
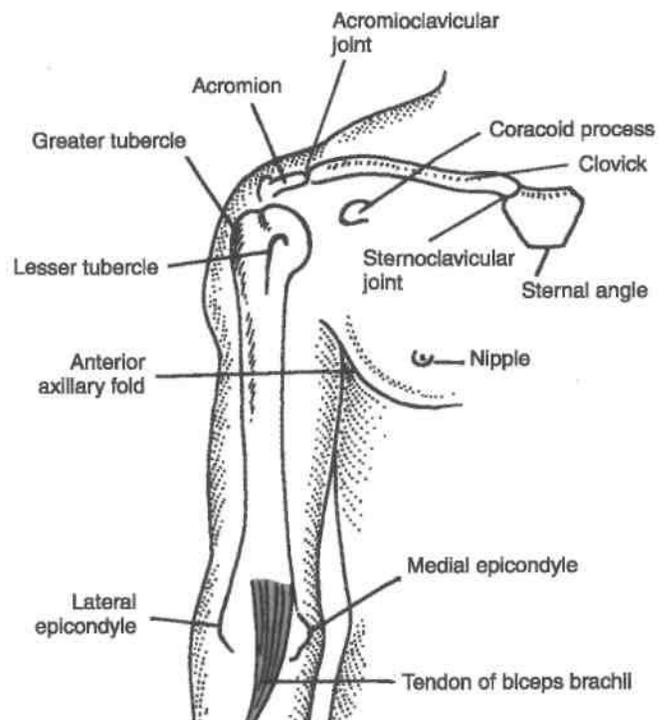
Fig. 3.1: *Surface landmarks: Shoulder, axilla, arm and elbow regions (anterior aspect).*

1.The tip of the *coracoid process* of the scapula lies 2-3 cm below the clavicle, overlapped by the anterior fibres of the deltoid. It can be felt on deep palpation just lateral to the infraclavicular fossa.

2.The *acromion* of the scapula *(acron* = summit; *omos* = shoulder) is a flattened piece of bone that lies, subcutaneously forming the top of the shoulder. The posterior end of its lateral border is called the acromial angle, where it is continuous with the lower lip of the crest of the spine of the scapula. The anterior end of its medial border articulates with the clavicle at the acromioclavicular joint. The joint can be felt because the clavicle projects slightly above the acromion.

1.The *deltoid* is triangular muscle with its apex directed downwards. It forms the rounded contour of the shoulder, extending vertically from the acromion to the deltoid tuberosity of the humerus.

2.The *axilla* (or armpit) is a pyramidal space between the arm and chest. When the arm is raised (abducted) the floor of the axilla rises, the anterior and posterior folds stand out, and the space becomes more prominent. The *anterior axillary fold* contains the lower border of the pectoralis major, and *posterior axillary fold* contains the tendon of the latissimus dorsi winding round the fleshy teres major.

The *medial wall of the axilla* is formed by the upper 4 ribs covered by the serratus anterior. The narrow *lateral wall* presents the upper part of the humerus covered by the short head of the biceps, and the coracobrachialis. Axillary arterial pulsations can be felt by pressing the artery against the humerus. The cords of the brachial plexus can also be rolled against the humerus. The head of the humerus can be felt by pressing the fingers upwards into the axilla.

12. The *midaxillary line* is a vertical line drawn midway between the anterior and posterior axillary folds.

SUPERFICIAL FASCIA

The superficial fascia of the pectoral region is visualised after the skin has been incised. It contains moderate amount of fat, and is continuous with that of surrounding regions. The *mammary gland,* which is well developed in females, is the most important of all contents of this fascia. The fibrous septa given off by the fascia support the lobes of the gland, and the skin covering the gland.

Contents

In addition to fat, the superficial fascia of the pectoral region contains: (i) cutaneous nerves derived from the cervical plexus and from the intercostal nerves; (ii) cutaneous branches from the internal thoracic and posterior intercostal arteries; (iii) the platysma; and (iv) the breast.

DISSECTION

Mark the following points: (i) centre of the suprasternal notch; (ii) xiphoid process, (iii) 7 o'clock position at the margin of areola, and (iv) lateral end of clavicle (Fig. 3.2).

Give an incision vertically down from the first point to the second which joins the centre of the suprasternal notch to the xiphoid process in the midsagittal plane. From the lower end of this line, extend the incision upward and laterally till you reach to the third point on the areolar margin. Encircle the areola and carry the incision upwards and laterally till the anterior axillary fold is i reached. Continue the line of incision downwards | along the medial border of the upper arm till its junction of upper one-third and lower two-thirds. Extend this incision transversely across the arm. Make another incision horizontally from the xiphoid process across the chest wall till the posterior axillary fold. Lastly give horizontal incision from the centre of suprasternal notch to the lateral (acromial) end of the clavicle.
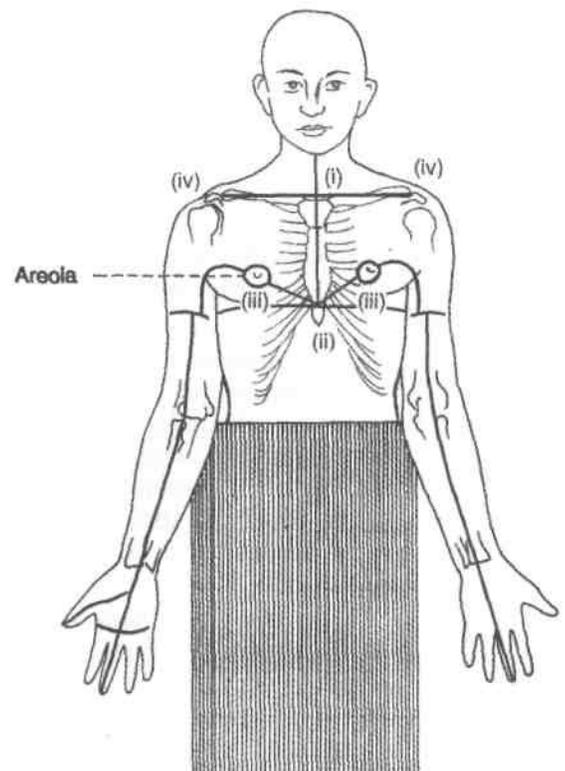
Fig. 3.2: *Points and lines of incision.*

Cutaneous Nerves of the Pectoral Region

The cutaneous nerves of the pectoral region are as follows (Figs 3.3, 3.4) :

1.The *medial, intermediate and lateral supraclavicular nerves are* branches of the cervical plexus (C3, C4). They supply the skin over the upper half of the deltoid and from the clavicle down to the second rib.

2.The *anterior and lateral cutaneous branches* of the second to sixth intercostal nerves supply the skin below the level of the second rib. The intercostobrachial nerve T2 supplies the skin of the floor of the axilla and the upper half of the medial side of the arm (Fig. 3.3).
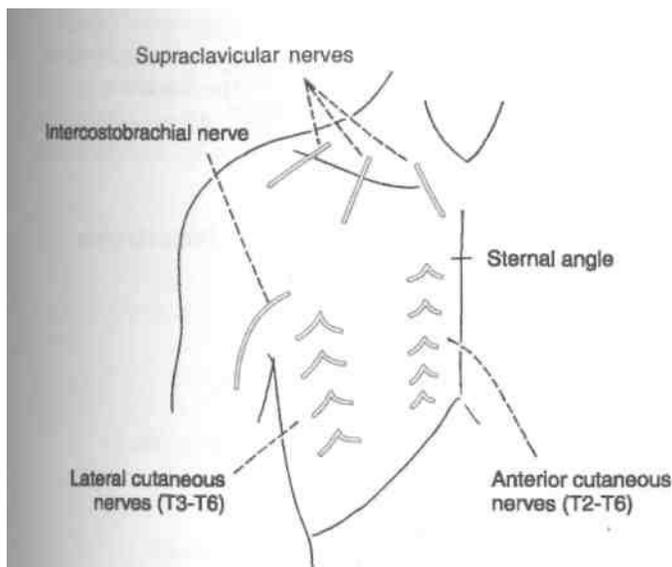
Fig. 3.3: Cutaneous nerves of the pectoral region.
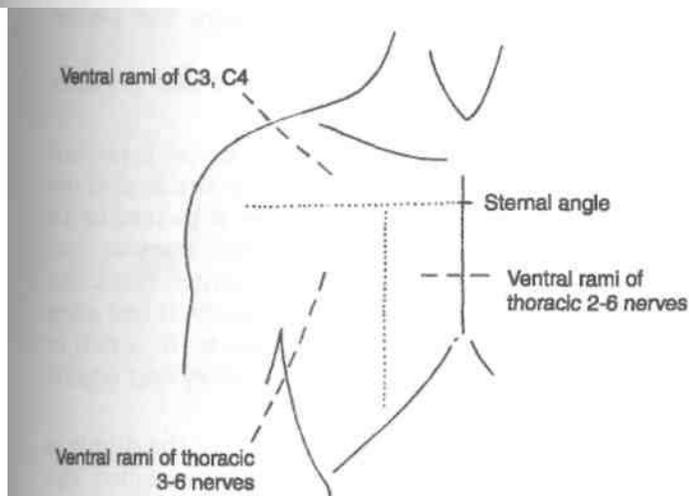
Fig. 3.4: Areas supplied by cutaneous nerves of the pectoral region.

It is of interest to note that the area supplied by spinal nerves C3 and C4 directly meets the area supplied by spinal nerves T2 and T3. This is because of the fact that the intervening nerves (C5, C6, C7, C8, Tl) have been 'pulled away' to supply the upper limb. It may also be noted that normally the areas supplied by adjoining spinal nerves overlap, but because of what has been said above there is hardly any overlap between the areas supplied by C3 and C4 above and T2 and T3 below (Fig. 3.4).

Cutaneous Vessels

The cutaneous vessels are very small. The anterior cutaneous nerves are accompanied by the *perforating branches of the internal thoracic artery.* The second, third and fourth of these branches are large in females for supplying the breast. The lateral cutaneous nerves are accompanied by the *lateral cutaneous branches of the posterior intercostal arteries.*

Platysma

The platysma is a thin, broad sheet of subcutaneous muscle. The fibres of the muscle arise from the deep fascia covering the pectoralis major; run upwards and medially crossing the clavicle and the side of the neck; and are inserted into the base of the mandible, and into skin over the posterior and lower part of the face. The platysma is supplied by the *facial nerve.* When the angle of the mouth is pulled down, the muscle contracts and wrinkles the skin of the neck. The platysma may protect the external jugular vein (which underlies the muscle) from external pressure.

THE BREAST/MAMMARY GLAND

The breast, or mammary gland, is the most important structure present in the pectoral region. Its anatomy is of great practical importance and has to be studied in detail.

The breast is found in both sexes, but is rudimentary in the male. It is well developed in the female after puberty. The breast is a modified sweat gland. It forms an important accessory organ of the female reproductive system, and provides nutrition to the newborn in the form of milk.

Situation

The breast lies in the superficial fascia of the pectoral region. A small extension called the axillary tail of Spence, pierces the deep fascia and lies in the axilla (Figs 3.5, 3.6).
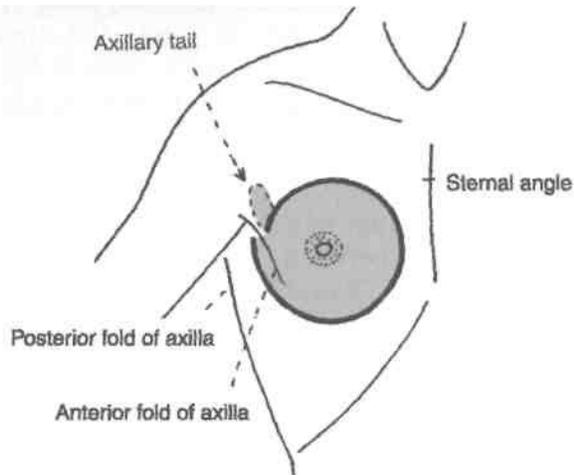
Fig. 3.5: Extent of the breast.
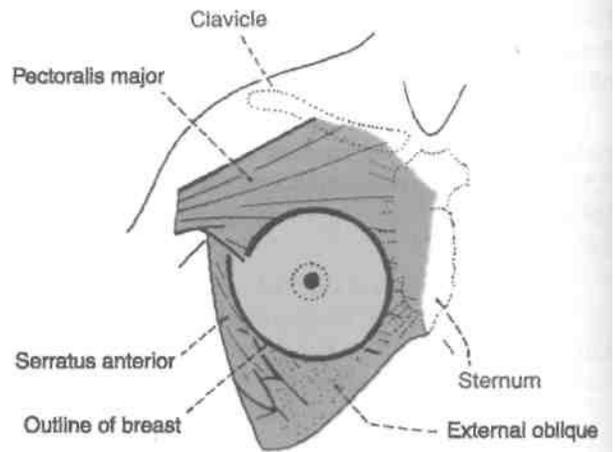
Fig. 3.7: Muscles situated deep to the breast.
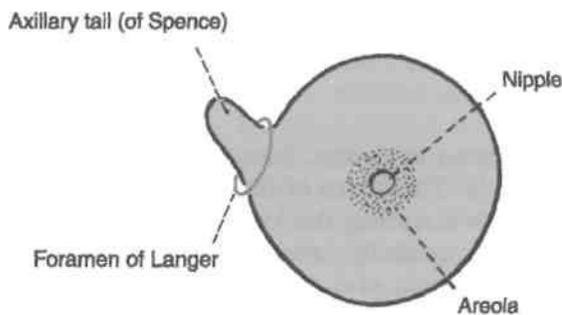
Fig. 3.6: Axillary tail of the breast, The foramen of Langer is an opening in the deep fascia.
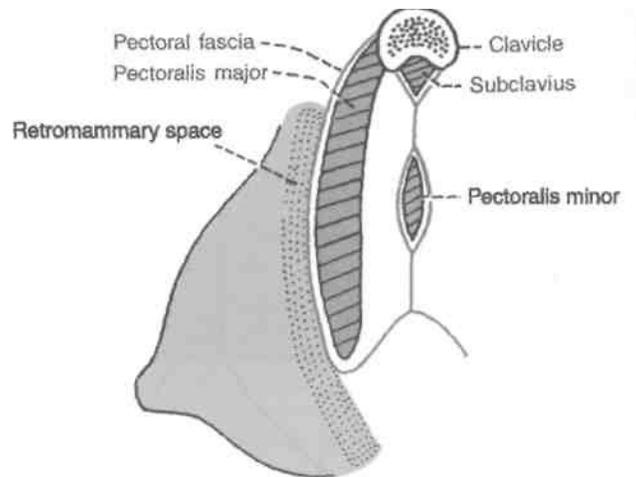
Extent

 (i) Vertically,, it extends from the second to the sixth rib.
 (ii) Horizontally, it extends from the lateral border of the sternum to the mid-axillary line.

Deep Relations

The deep surface of the breast is related to the following structures in that order (Figs 3.7, 3.8).

1.The breast lies on the deep fascia (pectoral fascia) covering the pectoralis major.

2.Still deeper there are the parts of three muscles, namely the pectoralis major, the serratus anterior, and the external oblique muscle of the abdomen.

3.The breast is separated from the pectoral fascia by loose areolar tissue, sometimes called the retromammary space. Because of the presence of this loose tissue the normal breast can be moved freely over the pectoralis major.

Structure of the Breast

The structure of the breast may be conveniently studied by dividing it into the skin, the parenchyma, and the stroma.

A. The skin: *It* covers the gland and presents the following features.

1.A conical projection called the *nipple* is present just below the centre of the breast at the level of the fourth intercostal space. The nipple is pierced by 15 to 20 lactiferous ducts. It contains circular and longitudinal smooth muscle fibres which can make the nipple stiff or flatten it, respectively. It has a few modified sweat and sebaceous glands. It is rich in its nerve supply and has many sensory end organs at the terminations of nerve fibres.

2.The skin surrounding the base of the nipple is pigmented and forms a circular area called the areo/a. This region is rich in modified sebaceous glands, particularly at its outer margin. These become enlarged during pregnancy and lactation to

Pectoral Region **41**

form raised tubercles of Montgomery. Oily secretions of these glands lubricate the nipple and areola, and prevent them from cracking during lactation. Apart from sebaceous glands the areola also contains some sweat glands and accessory mammary glands. The skin of the areola and nipple is devoid of hair, and there is no fat subjacent to it.

B. The parenchyma: *It* is made up of glandular tissue which secretes milk. The gland consists of 15 to 20 lobes. Each lobe is a cluster of alveoli, and is drained by a lactiferous duct. The lactiferous ducts converge towards the nipple and open on it. Near its termination each duct has a dilatation called a lactiferous sinus (Figs 3.9, 3.10).

Alveolar epithelium is cuboidal in the resting phase, and columnar during lactation. In distended alveoli, the cells may appear cuboidal due to stretching, but they are much larger than those in the resting phase. The *smaller ducts* are lined by columnar epithelium, the *larger ducts* by two or more layers of cells, and the terminal parts of the lactiferous ducts by stratified squamous keratinized epithelium. The passage of the milk from the alveoli into and along the ducts is facilitated by contraction of *myoepitheliocytes,* which are found both around the alveoli and around the ducts, lying between the epithelium and the basement membrane.

C. The stroma: It forms the supporting framework of the gland. It is partly fibrous and partly fatty.

The fibrous stroma forms septa, known as the suspensory ligaments (of Cooper) which anchor the skin and gland to the pectoral fascia (Fig. 3.11).

The fatty stroma forms the main bulk of the gland. It is distributed all over the breast, except beneath the areola and nipple.

Blood Supply

The mammary gland is extremely vascular. It is supplied by branches of the following arteries (Fig. 3.12).
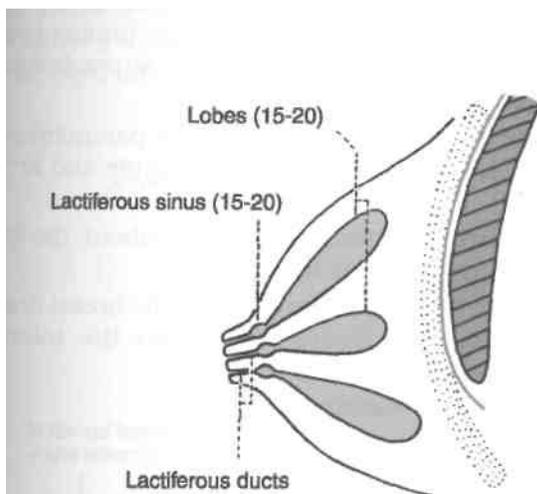
Fig. 3.9: *Lobes of the mammary gland.*
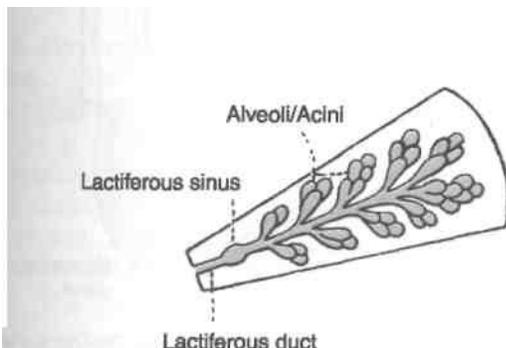
Fig. 3.10: *Structure of one lobe of the mammary gland.*
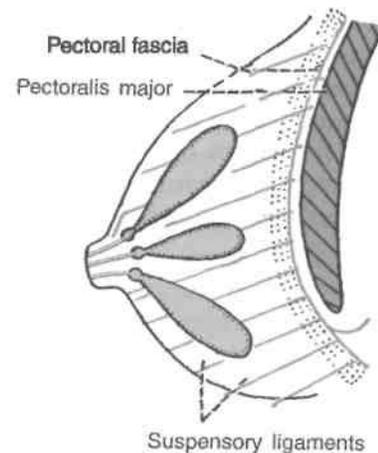
Fig. 3.11: *Suspensory ligaments of the breast.*
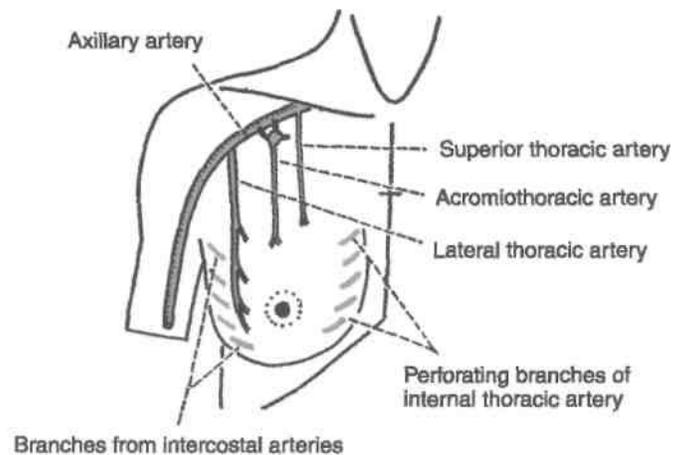
Fig. 3.12: *Arterial supply of the breast.*

1.Internal thoracic artery, a branch of the subclavian artery, through its perforating branches.

2.The lateral thoracic, superior thoracic and acromiothoracic (thoracoacromial) branches of the axillary artery.

3.Lateral branches of the posterior intercostal arteries.

The arteries converge on the breast and are distributed from the anterior surface. The posterior surface is relatively avascular.

The veins follow the arteries. They first converge towards the base of the nipple where they form an anastomotic venous circle, from where veins run in superficial and deep sets.

1.The superficial veins drain into the internal thoracic vein and into the superficial veins of the lower part of the neck.

2.The deep veins drain into the internal thoracic, axillary and posterior intercostal veins.

Nerve Supply

The breast is supplied by the anterior and lateral cutaneous branches of the 4th to 6th intercostal nerves. The nerves convey sensory fibres to the skin, and autonomic fibres to smooth muscle and to blood vessels. The nerves do not control the secretion of milk. Secretion is controlled by the hormone prolactin, secreted by the pars anterior of the hypophysis cerebri.

Lymphatic Drainage

Lymphatic drainage of the breast assumes great importance to the surgeon because, carcinoma of

the breast spreads mostly along lymphatics to the regional lymph nodes. The subject can be described under two heads, the lymph nodes, and the lymphatics.

Lymph Nodes

Lymph from the breast drains into the following lymph nodes (Fig. 3.13).

1. The axillary lymph nodes, chiefly the anterior (or pectoral) group. The posterior, lateral, central and apical groups of nodes also receive lymph from the breast either directly or indirectly.

2. The internal mammary (parasternal) nodes which lie along the internal thoracic vessels.

3. Some lymph from the breast also reaches the supraclavicular nodes, the cephalic (deltopectoral) node, the posterior intercostal nodes (lying in front of the heads of the ribs), the subdiaphragmatic and subperitoneal lymph plexuses.

Lymphatic Vessels

A. The *superficial lymphatics* drain the skin over the breast except for the nipple and areola. The lymphatics pass radially to the surrounding lymph nodes (axillary, internal mammary, supraclavicular and cephalic).

B. The *deep lymphatics* drain the parenchyma of the breast. They also drain the nipple and areola (Fig. 3.14).

Some further points *of* interest about the lymphatic drainage are as follows.

1. About 75% of the lymph from the breast drains into the axillary nodes; 20% into the internal
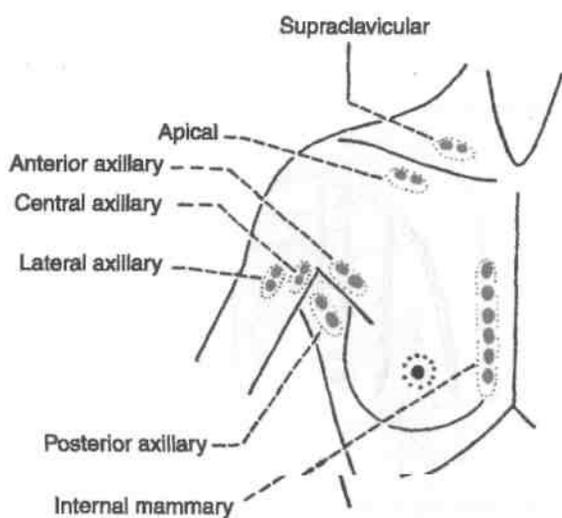
Fig. 3.13: Lymph nodes draining the breast.
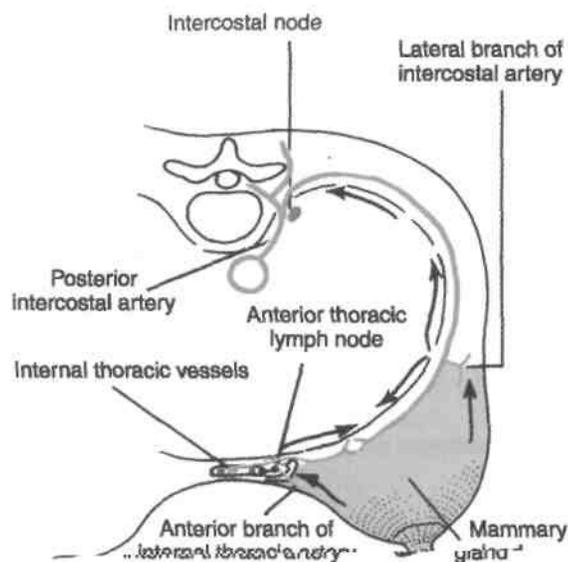
Fig. 3.14: The routes of lymph from the breast. The arrows sh the direction of lymph flow.

Development of the Breast

1. The breast develops from an ectodermal thickening, called the *mammary ridge, milk* line, or line of Schultz (Fig 3.17). This ridge extends from the axilla to the groin. It appears during the fourth week of intrauterine life, but in human beings it disappears over most of its extent persisting only in the pectoral region. The gland is ectodermal, and the stroma mesodermal in origin.

2. The persisting part of the mammary ridge is converted into a *mammary pit.* Secondary buds (15–20) grow down from the floor of the pit. These buds

mammary nodes; and 5% into the posterior intercostal nodes. Among the axillary nodes, the lymphatics end mostly in the anterior group (closely related to the axillary tail) and partly in the posterior and apical groups. Lymph from the anterior and posterior groups passes to the central and lateral groups, and through them to the apical group. Finally it reaches the supraclavicular nodes.

1. The internal mammary nodes drain the lymph not only from the inner half of the breast, but from the outer half as well.

2. A plexus of lymph vessels is present deep to the areola. This is the subareolar plexus (of Sappy) (Fig. 3.15).

Subareolar plexus and most of lymph from the breast drains into the anterior or pectoral group of lymph nodes.

3.The lymphatics from the deep surface of the breast pass through the pectoralis major muscle and the clavipectoral fascia to reach the apical nodes, and also to the internal mammary nodes (Fig. 3.16).

4.Lymphatics from the lower and inner quadrants of the breast may communicate with the subdiaphragmatic and subperitoneal lymph plexuses after crossing the costal margin and then piercing the anterior abdominal wall through the upper part of the linea alba.

Fig. 3.16: Deep lymphatics of the breast passing to the apical lymph nodes.

divide and subdivide to form the lobes of the gland. The entire system is first solid, but is later canalized. At birth or later, the nipple is everted at the site of the original pit.

1. Growth of the mammary glands, at puberty, is caused by oestrogens. Apart from oestrogens, development of secretory alveoli is stimulated by progesterone and by the prolactin hormone of the hypophysis cerebri.

2. Developmental anomalies of the breast are: (a) *amastia* (absence of the breast); (b) *athelia* (absence of nipple); (c) *polymastia* (supernumerary breasts); (d) *polythelia* (supernumerary nipples); (e) *gynae-comastia* (development of breasts in a male). Gynae-comastia occurs in Klinefelter's syndrome.

Human Milk

Human milk is composed of about 88% water, 7% lactose, 4% fat, and 1% protein (caseins and lactal-
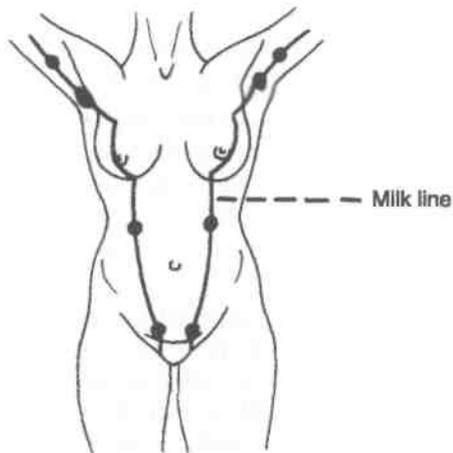
Fig. 3.17: *Milk line with possible positions of accessory nipples.*

bumin). It also contains various ions (calcium, phosphate, sodium, potassium and chloride), vitamins and antibodies of IgA variety.

Milk secreted in the later part of pregnancy, and for a few days after parturition is known as *colostrum*. It is rich in fat and poor in nutrients, the fat being contained in colostral corpuscles. It is rich in immunoglobulins.

Under the influence of maternal oestrogens, the infant's breast may secrete milk during the first one or two weeks after birth, a fat-free fluid called 'witch's milk'.

Lactation in mothers is active for about 5-6 months after parturition and then diminishes progressively, so that the infant is weaned by about 9 months of age.

CLINICAL ANATOMY

mm

The breast is a frequent site of carcinoma (cancer). Several anatomical facts are of importance in diagnosis and treatment of this condition. Abscesses may also form in the breast and may require drainage. The following facts are worthy of note.

1. Incisions into the breast are usually made radially to avoid cutting the lactiferous ducts.

2. Cancer cells may infiltrate the suspensory ligaments. The breast then becomes fixed. Contraction of the ligaments can cause retraction or puckering (folding) of the skin.

3. Infiltration of lactiferous ducts and their consequent fibrosis can cause retraction of the nipple.

4. Obstruction of superficial lymph vessels by cancer cells may produce oedema of the skin giving rise to an appearance like that of the skin of an orange (peau *d' orange* appearance).

5. Because of communications of the superficial lymphatics of the breast across the midline, cancer may spread from one breast to the other.

6. Because of communications of the lymph vessels with those in the abdomen, cancer of the breast may spread to the liver, and cancer cells may 'drop* into the pelvis producing secondaries there.

7. Apart from the lymphatics cancer may spread through the veins. In this connection, it is important to know that the veins draining the breast communicate with the vertebral venous plexus of veins. Through these communications cancer can spread to the vertebrae and to the brain.

DEEP PECTORAL FASCIA

The deep fascia covering the pectoralis major muscle is called the pectoral fascia. It is thin and closely attached to the muscle by numerous septa passing between the fasciculi of the muscle. It is attached *superiorly to* the clavicle, and *anteriorly to* the sternum. *Superolaterally,* it passes over the infraclavicu-lar fossa and deltopectoral groove to become continuous with the fascia covering the deltoid. *Inferolaterally,* the fascia curves round the inferolateral border of the pectoralis major to become cotinuous with the axillary fascia. *Inferiorly,* it is continuous with the fascia over the thorax and the rectus sheath.

The pectoral fascia is connected with the clavipectoral fascia by a septum passing deep along the deltopectoral groove. The cephalic vein, the deltoid branch of the thoraco-acromial artery, and one or two deltopectoral lymph nodes lie in the deltopectoral groove, under the deep fascia on the medial side of the septum.

MUSCLES OF THE PECTORAL REGION

Muscles of the pectoral region are described in Tables 3.1 and 3.2. Some additional features are given below.

A. Pectoralis Major

7. Structures under Cover of Pectoralis Major

(a)*Bones and cartilages:* sternum, ribs, and costal cartilages.

(b)*Fascia:* clavipectoral.

(c)*Muscles:* subclavius, pectoralis minor, serratus anterior, intercostal, and upper parts of the biceps and coracobrachialis.

(d)Vessels: axillary.

(e)*Nerves:* cords of brachial plexus with their branches.

2. Bllaminar Tendon of Pectoralis Major

The muscle is inserted by a bilaminar tendon into the lateral lip of the intertubercular sulcus of the hu-merus.

The anterior lamina is thicker and shorter than the posterior. It receives two strata of muscle fibres: superficial fibres arising from the clavicle and deep fibres arising from the manubrium (Fig. 3.18).

The posterior lamina is thinner and longer than the anterior lamina. It is formed by fibres from the front of the sternum, 2nd to 6th ribs and their costal cartilages and from the aponeurosis of the external oblique muscle of the abdomen. Out of these only the

Table 3.1: Muscles of the pectoral region: origin, insertion and nerve supply

Muscle	Origin from	Insertion into	Nerve supply
Pectoralis major (Fig. 3.18)	(i) Anterior surface of medial half of clavicle (ii) Half the breadth of anterior surface of manubrium and sternum upto 6th costal cartilages (iii) Second to sixth costal cartilages (iv) Aponeurosis of the external oblique muscle of abdomen	It is inserted by a bilaminar tendon on the lateral lip of the bicipital groove The two laminae are continuous with each other interiorly	Medial and lateral pectoral nerves
Pectoralis minor (Fig. 3.19)	(i) 3, 4, 5 ribs, near the costochondral junction (ii) Intervening fascia covering external intercostal muscles	Medial border and upper surface of the coracoid process	Medial and lateral pectoral nerves
Subclavius (Fig. 3.20)	First rib at the costochondral junction	Subclavian groove in the middle one-third of the clavicle	Nerve to subclavius from upper trunk of brachial plexus

fibres from the sternum and aponeurosis are twisted around the lower border of the rest of the muscle. The twisted fibres form the anterior axillary fold. These fibres pass upwards and laterally to get inserted successively higher into the posterior lamina of the tendon. Fibres arising lowest, find an opportunity to get inserted the highest and form a crescentic fold which fuses with the capsule of the shoulder joint.

Fig. 3.18: (A) The origin and Insertion of the pectoralis major muscle. (B) The bilaminar insertion of the pectoralis major. The anterior lamina is formed by the clavicular and manubrlal fibres; the rest of the sternocostal and abdominal fibres form the posterior lamina. Part of the posterior lamina is twisted upside down.

3. Variation

Superficial to the pectoralis major, some muscle fibres may pass vertically from the lower costal cartilages and rectus sheath to blend above with the sternocleidomastoid, or to be attached to the upper sternum or costal cartilages. These fibres constitute the *sternalis* muscle or the *rectus sternalis.*

4. Clinical Testing

(i) The clavicular head of the pectoralis major can be
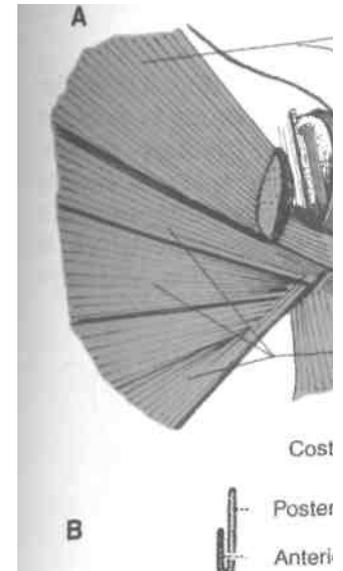
tested by attempting to lift a heavy table/rod. The sternocostal head can be tested by trying to depress a heavy table/rod.

Table 3.2: Muscles of the pectoral region: actions

Muscle	Actions

Pectoralis major	1. Acting as a whole the muscle causes:
	    (i) Adduction and (ii) Medial rotation of the shoulder (arm)
	1. Clavicular part produces (iii) Flexion of the arm
	2. Sternocostal part is used in (iv) Extension of flexed arm against resistance
	    (v) Climbing

Pectoralis minor	1. Draws the scapula forward, (with serratus anterior) 1. Depresses the point of the shoulder 2. Helps in forced inspiration
Subclavius	Steadies the clavicle during movements of the shoulder

(ii) The clavicular head can also be tested by flexing the arm to a right angle; the sternocostal head by extending the flexed arm against resistance.

(iii) Press the fists against each other (Fig. 3.21).

B. Pectoralis Minor

1.The costal origin of the pectoralis minor is variable. Most commonly it arises from the 3rd to 5th ribs near their costochondral junctions (Fig. 3.19). The origin may be prefixed (from 2nd to 4th ribs) or postfixed (from 4th to 6th ribs).

2.The tendon of insertion of the pectoralis minor may cross the coracoid process to blend with the coracoacromial ligament, or may pass through this ligament to blend with the coracohumeral ligament, thus reaching the humerus.

3.*Variation:* Rarely, some separated fibres of the pectoralis minor pass from the first rib to the coracoid process. These fibres constitute the *pectoralis minimus* muscle.

DISSECTION

Identify the extensive pectoralis major muscle in the pectoral region and the prominent deltoid muscle on the lateral aspect of the shoulder joint and upper arm. Demarcate the deltopectoral groove by removing the deep fascia. Now identify the cephalic vein, a small artery and few lymph nodes in the groove.

Clean the fascia over the pectoralis major muscle and look for its attachments. Divide the clavicular head of the muscle and reflect it laterally. Medial and lateral pectoral nerves will be seen supplying the muscle. Make a vertical incision 5 to 6 cm from the lateral border of sternum and reflect its sternocostal head laterally. Identify the pectoralis minor muscle under the central part of the pectoralis major. Note clavipectoral fascia extending between pectoralis minor muscle and the clavicle bone. Identify the structures piercing the clavipectoral fascia: these are cephalic vein, acromiothoracic artery, and lateral pectoral nerve. If some fine vessels are also seen, these are the lymphatic channels. Also, identify the serratus anterior muscle showing serrated digitations on the side of the chest wall.

Clavipectoral Fascia

Clavipectoral fascia is a fibrous sheet situated deep to the clavicular portion of the pectoralis major muscle. It extends from the clavicle above to the axillary fascia below (Fig. 4.2). Its upper part splits

Fig. 3.19: *The pectoralis minor.*
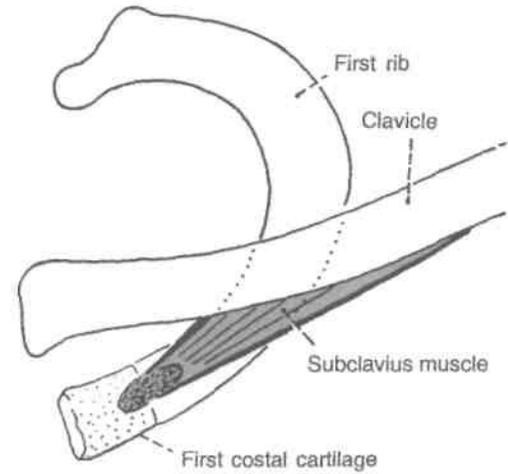
Fig. 3.20: *The subclavius muscle.*

to enclose the subclavius muscle (Fig. 3.20). The posterior lamina is fused to the investing layer of the deep cervical fascia and to the axillary sheath. Inferiorly, the clavipectoral fascia splits to enclose the pectoralis minor muscle. Below this muscle it continues as the suspensory ligament which is attached to the dome of the axillary fascia, and helps to keep it pulled up.

Fig. 3.21: *Pectoralis major being tested.*

Medially the fascia is attached to the first rib and to the costoclavicular ligament. Laterally, it is attached to the coracoid process and blends with the coracoclavicular ligament.

The upper part of the fascia is thick and is called the costocoracoid ligament.

The clavipectoral fascia is pierced by the following structures: (i) Lateral pectoral nerve; (ii) cephalic vein; (iii) thoracoacromial vessels; and (iv) lymphatics passing from the breast and pectoral region to the apical group of axillary lymph nodes.

Serratus Anterior

Serratus anterior muscle is not strictly a muscle of the pectoral region, but it is convenient to consider it here.

Origin

Serratus anterior muscle arises by eight digitations from the upper eight ribs, and from the fascia covering the intervening intercostal muscles (Figs 3.22, 3.23).

Insert/on

The muscle is inserted into the costal surface of the scapula along its medial border. The first digitation is inserted from the superior angle to the root of the spine. The next two or three digitations are inserted lower down on the medial border. The lower four or five digitations are inserted into a large triangular area over the inferior angle.

Fig. 3.23: Horizontal section through the axilla showing the position of the serratus anterior.

Nerve Supply
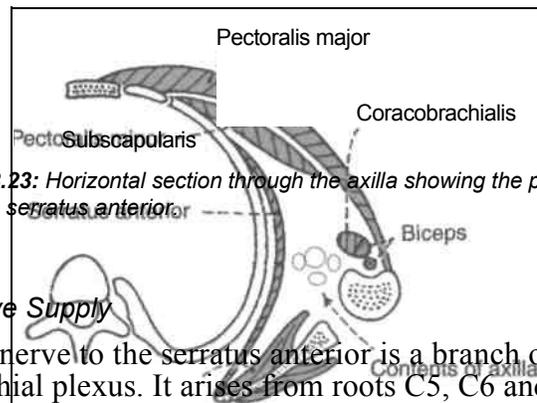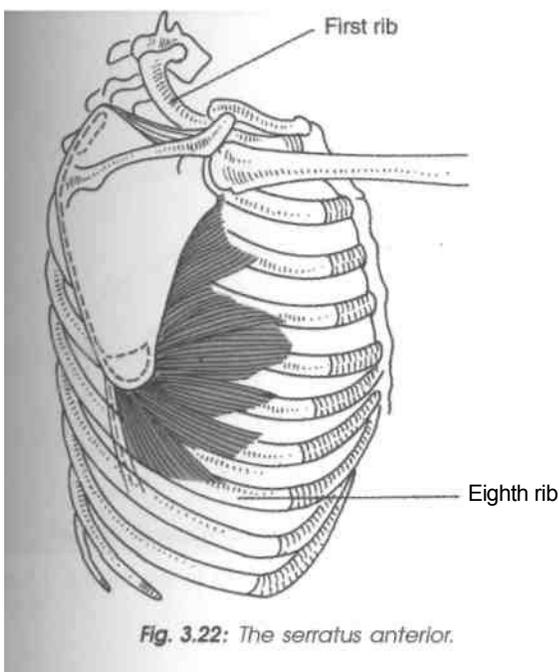
The nerve to the serratus anterior is a branch of the brachial plexus. It arises from roots C5, C6 and C7.

Actions

1.Along with the pectoralis minor, the muscle pulls the scapula forwards around the chest wall to protract the upper limb (in pushing and punching movements).

2.The fibres inserted into the inferior angle of the scapula pull it forwards and rotate the scapula so that the glenoid cavity is turned upwards. In this action, the serratus anterior is helped by the trape-zius which pulls the acromion upwards and backwards.

When the muscle is paralysed the medial margin of the scapula gets raised specially when 'pushing movements' are attempted. This is called 'winging of the scapula'.

1.The muscle steadies the scapula during weight carrying.

2.It helps in forced inspiration.

Additional Features

1.Paralysis of the serratus anterior produces 'winging of scapula' in which the inferior angle and the medial border of the scapula are unduly prominent. The patient is unable to do any pushing action, nor can he raise his arm above the head. Any attempt to do these movements makes the inferior angle of the scapula still more prominent.

2.*Clinical testing:* Forward pressure with the hands against a wall, or against resistance offered by the examiner makes the inferior angle of the scapula prominent (winging of scapula) if the serratus anterior is paralysed (Fig. 4.10).

Fig. 3.22: The serratus anterior.

3. Electromyography has disproved the popular view that the serratus anterior is an accessory muscle of respiration.

References and Additional Reading

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The Axilla

T*he axilla or armpit is a pyramidal space situated between the upper part of the arm and the chest wall. It resembles a four-sided pyramid, and has (i) an apex, (ii) a base, and (iii) 4 walls—anterior, posterior, medial and lateral.

The axilla is disposed obliquely in such a way that the apex is directed upwards and medially towards the root of the neck, and the base is directed downwards.

BOUNDARIES

1. *Apex:* It is directed upwards and medially towards the root of the neck.

It is truncated (not pointed), and corresponds to a triangular interval bounded anteriorly by the clavicle, posteriorly by the superior border of the scapula, and medially by the outer border of the first rib. This passage is called the cervicoaxillary canal (Fig. 4.1). The axillary artery and the brachial plexus enter the axilla through this canal.

2. *Base or floor:* It is directed downwards, and is formed by skin and fasciae.

3. *Anterior wall:* It is formed by the following:

(i) The pectoralis major in front (Fig. 4.2), and

(ii) The clavipectoral fascia enclosing the pectoralis
minor and the subclavius; all deep to the pectoralis major.

4. *Posterior wall:* It is formed by :

(i) Subscapularis above (Fig. 4.3).

(ii) Teres major and latissimus dorsi below.

5. *Medial wall:* It is formed by :

(i) Upper four ribs with their intercostal muscles, (ii) Upper part of the serratus anterior muscle.

6. *Lateral wall:* It is very narrow because the anterior and posterior walls converge on it. It is formed by :

(i) Upper part of the shaft of the humerus in the
region of the bicipital groove, and (ii) Coracobrachialis and short head of the biceps.

Fig. 4.1: Boundaries of the apex of the axilla (cervicoaxillary canal).

Fig. 4.2: Anterior and posterior walls of the axilla.

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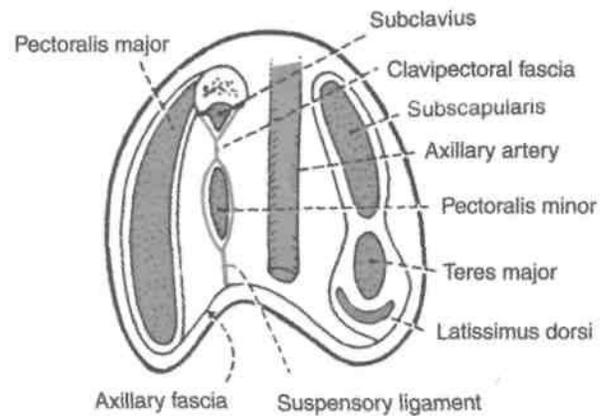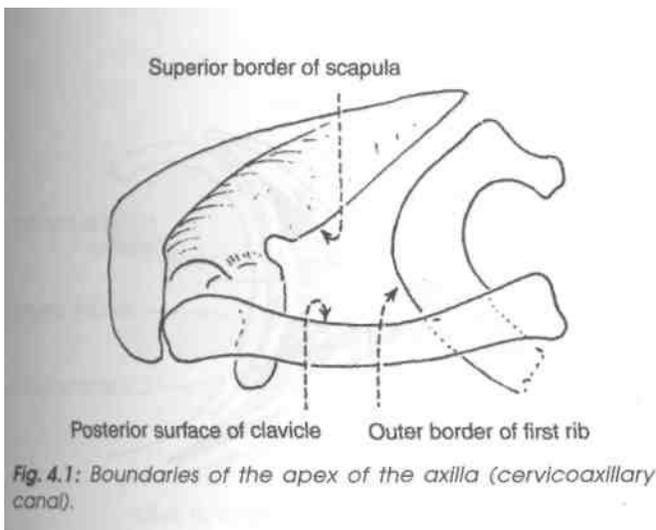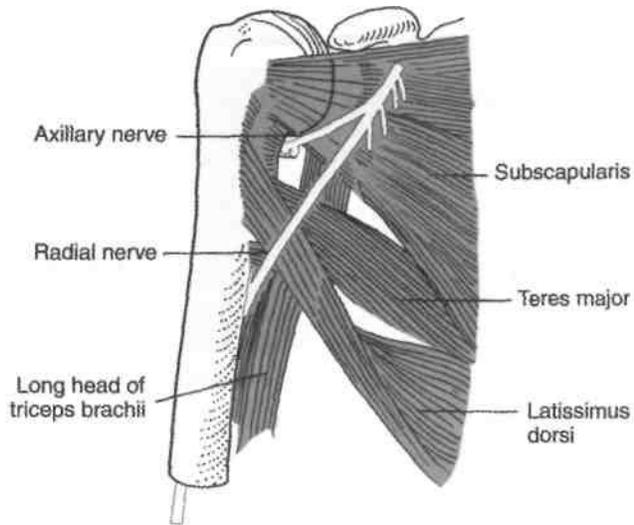
Fig. 4.3: The posterior wall of axilla.
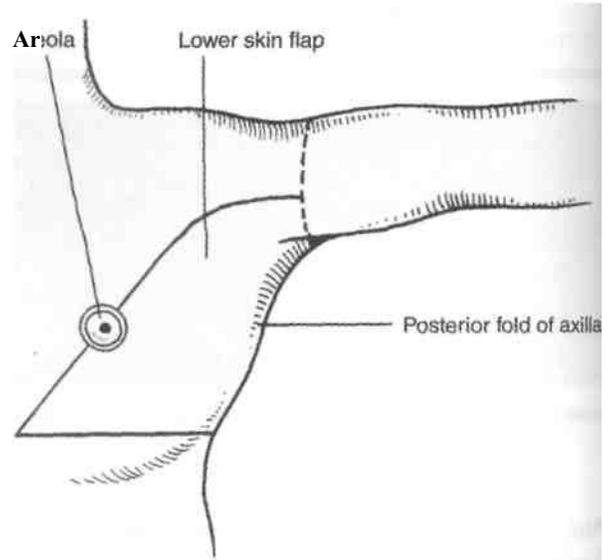
Fig. 4.4: Dissection of axilla.

DISSECTION

Place a rectangular wooden block under the neck and shoulder region of cadaver (Fig. 4.4). Ensure that the block supports the body firmly. Abduct the limb at right angles to the trunk; and strap the wrist firmly on slab projecting toward your side. Reflect the lower skin flap till the posterior axillary fold made up by the subscapularis, teres major, and latissimus dorsi muscles is seen. Clean the fat, and remove the lymph nodes and superficial veins to reach depth of the armpit. Identify two muscles arising from the tip of the coracoid process of scapula; Out of these, the short head of biceps brachii muscles lies on the lateral side and the coracobrachialis on the medial side. The pectoral muscles with the clavipectoral fascia form anterior boundary of the region. Look for upper three intercostal muscles and serratus anterior muscle which make the medial wall of axilla. Clean and identify the axillary vessels. Trace the course of the branches of the axillary artery.

CONTENTS OF THE AXILLA

1. Axillary artery and its branches (Fig. 4.5).
2. Axillary vein and its tributaries.
3. Infraclavicular part of the brachial plexus.
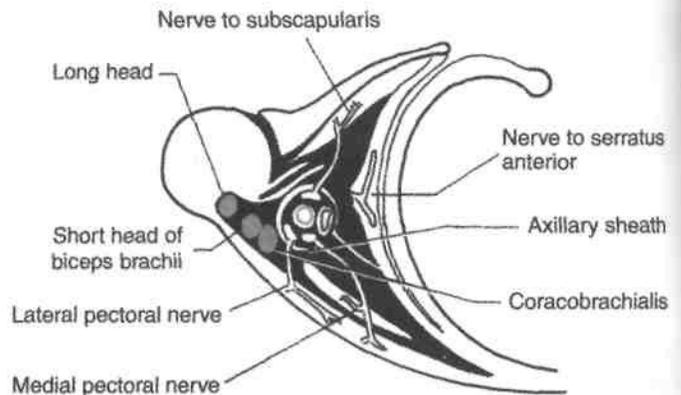
Fig. 4.5: Walls and contents of axilla.

4. Five groups of axillary lymph nodes and the associated lymphatics.
5. The long thoracic and intercostobrachial nerves.

6.Axillary fat and areolar tissue in which the other contents are embedded.

Layout

1. Axillary artery and the brachial plexus of nerves I run from the apex to the base along the lateral wall of the axilla, nearer to the anterior wall than the! posterior wall.

2. The thoracic branches of the axillary artery lie I in contact with the pectoral muscles, the lateral thoracic vessels running along the lower border of the pectoralis minor.

3. The subscapular vessels run along the lower border of the subscapularis. The subscapular nerve and the thoracodorsal nerve (nerve to latissimus dorsi) cross the anterior surface of the muscle. The circumflex scapular vessels wind round the lateral border of the scapula. The axillary nerve and the posterior circumflex humeral vessels pass backwards close to the surgical neck of the humerus.

1.The medial wall of the axilla is avascular, except for a few small branches from the superior thoracic artery. However, the long thoracic nerve (or nerve to the serratus anterior) descends on the surface of the muscle, and the intercostobrachial nerve pierces the anterosuperior part of the medial wall and crosses the spaces to reach the medial side of the arm.

2.The axillary lymph nodes are 20 to 30 in number, and are arranged in five sets. The anterior group lies along the lower border of the pectoralis minor, on the lateral thoracic vessels. The posterior group lies along the lower margin of the posterior wall along the subscapular vessels. The lateral group lies posteromedial to the axillary vein. The central group lies in the fat of the axilla. The apical group lies behind and above the pectoralis minor, medial to the axillary vein.

^THE

The plexus consists of roots, trunks, divisions, cords and branches (Figs 4.6, 4.7).

1. Roots: These are constituted by the anterior primary rami of spinal nerves C5, 6, 7, 8 and Tl, with contributions from the anterior primary rami of C4
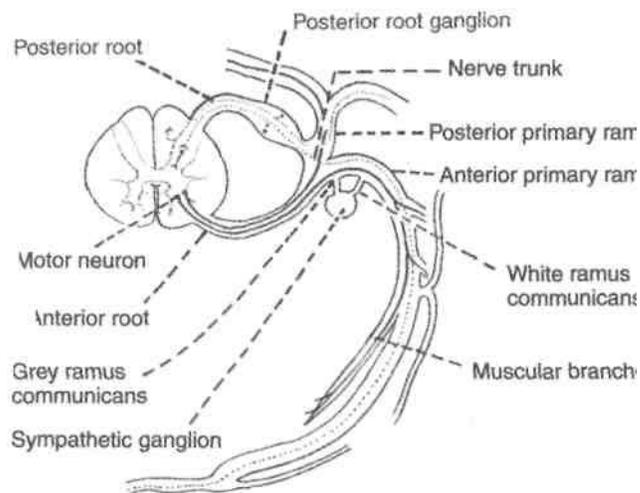
Fig. 4.6: Diagram of a spinal nerve.

and T2 (Fig. 5.2). The origin of the plexus may shift by one segment either upward or downward, resulting in a prefixed or postfixed plexus respectively. In a prefixed plexus, the contribution by C4 is large and that from T2 is often absent. In a postfixed plexus, the contribution by Tl is large, T2 is always present, C4 is absent, and C5 is reduced in size. The roots join to form trunks as follows:

ROOTS

Suprascapular nerve

J__TRUNKS   ^ ^ — Dorsal scapular nerve
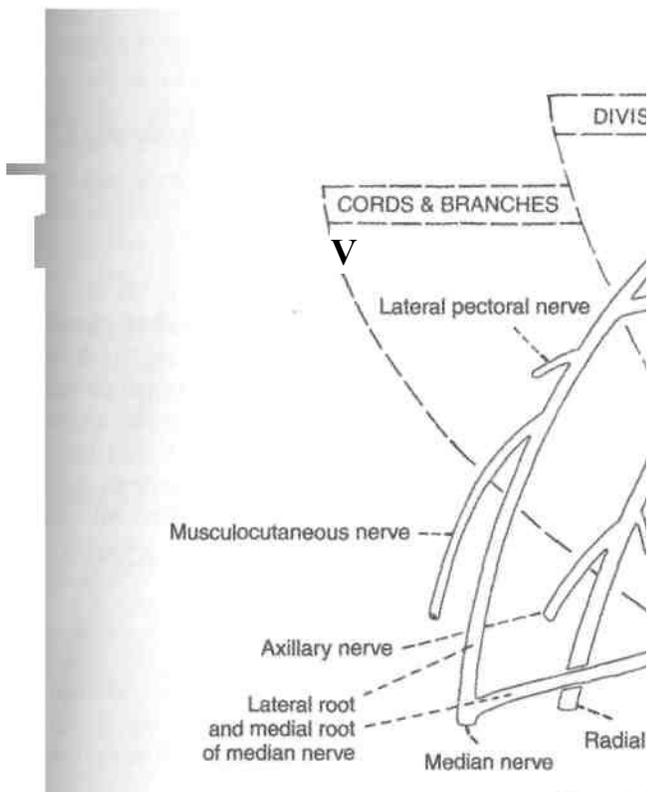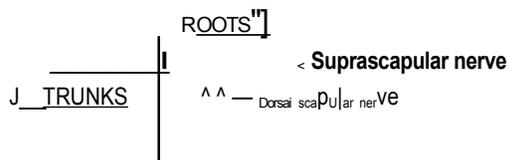
Fig. 4.7: The brachial plexus.

1.***Trunks:*** Roots C5 and C6 join to form the *upper* trunk. Root C7 forms the *middle* trunk. Roots C8 and Tl join to form the *lower* trunk.

2.***Divisions of the trunks:*** Each trunk divides into ventral and dorsal divisions (which ulimately supply the anterior and posterior aspects of the limb). These divisions join to form cords.

3.***Cords:*** (i) The lateral cord is formed by the union of the ventral divisions of the upper and middle trunks.

(ii) The medial cord is formed by the ventral division of the lower trunk.

(iii) The posterior cord is formed by union of the dorsal divisions of all the three trunks.

DISSECTION

After cleaning the branches of the axillary artery, proceed to clean the brachial plexus. It is made up by the ventral primary rami of the lower four cervical (C5-C8) and the first thoracic (Tl) nerves. The first and second parts of the axillary artery are related to the cords; and third part is related to the branches of the plexus. Study the description of the brachial plexus before proceeding further.

A. Branches of the Roots

1.Nerve to serratus anterior (long thoracic nerve) I (C5, 6, 7)

2.Nerve to rhomboideus (dorsal scapular nerve) I (C5)

B. Branches of the Trunks

These arise only from the upper trunk which gives • two branches.

1.Suprascapular nerve (C5, 6)

2.Nerve to subclavius (C5, 6)

C. Branches of the Cords

(a) *Branches of Lateral Cord*

1.Lateral pectoral (C5-C7)
2.Musculocutaneous (C5-C7)
3.Lateral root of median (C5-C7)

(b) *Branches of Medial Cord*

1. Medial pectoral (C8, Tl)
1.Medial cutaneous nerve of arm (C8, Tl)
2.Medial cutaneous nerve of forearm (C8, Tl) I
3.Ulnar (C7, C8, Tl). C7 fibres reach by a I communicating branch from lateral root of I median nerve.
4.Medial root of median (C8, Tl)

(c) *Branches of Posterior Cord*

1.Upper subscapular (C5, C6)
2.Nerve to latissimus dorsi (thoracodorsal) (C6, C7, C8)
3.Lower subscapular (C5, C6)
4.Axillary (circumflex) (C5, C6)
5.Radial (C5-C8, Tl)

In addition to the branches of the brachial plexus, the upper limb is also supplied, near the trunk, by the supraclavicular branches of the cervical plexus, and by the intercostobrachial branch of the second intercostal nerve. Sympathetic nerves are distributed through the brachial plexus. The arrangement of the various nerves in the axilla will be studied with the relations of the axillary artery.

CLINICAL ANATOMY

Injuries to roots, trunks and cords of the brachial plexus may produce characteristic defects, which are described here. Injury to the individual nerves are dealt with each nerve.

Erb's Paralysis

Site of injury. The region of the upper trunk of the brachial plexus is called Erb's point (Fig. 4.8). Six nerves meet here. Injury to the upper trunk causes Erb's paralysis (Fig. 4.9).

Causes of injury. Undue separation of the head from the shoulder, which is commonly encountered in: (i) birth injury, (ii) fall on the shoulder, and (iii) during anaesthesia.

Nerve roots involved. Mainly C5 and partly C6.

Muscles paralysed. Mainly biceps, deltoid, brachialis and brachioradialis. Partly supraspinatus, infraspinatus and supinator.

Deformity (position of the limb)

Arm: Hangs by the side; it is adducted and medially rotated.

Forearm: Extended and pronated.

The deformity is known as 'policeman's tip hand' or 'porter's tip hand'.

Disability. The following movements are lost.

1. Abduction and lateral rotation of the arm (shoulder).

1. Flexion and supination of the forearm.

2. Biceps and supinator jerks are lost.

3. Sensations are lost over a small area over the lower part of the deltoid.

Klumpke's Paralysis

Site of injury. Lower trunk of the brachial plexus.

Cause of injury. Undue abduction of the arm, as in clutching something with the hands after a fall from a height, or sometimes in birth injury.

Nerve roots involved. Mainly Tl and partly C8.

Muscles Paralysed

1. Intrinsic muscles of the hand (Tl).

2. Ulnar flexors of the wrist and fingers (C8).

Deformity (position of the hand). Claw hand due to the unopposed action of the long flexors and extensors of the fingers. In a claw hand there is hyperextension at the metacarpophalangeal joints and flexion at the interphalangeal joints.

Disability

1. Claw hand.

2. Cutaneous anaesthesia and analgesia in a narrow zone along the ulnar border of the forearm and hand.

3. Horner's syndrome—ptosis, miosis, anhydrosis, enophthalmos, and loss of ciliospinal

reflex—may be associated. (This is because of injury to sympathetic fibres to the head and neck that leave the spinal cord through nerve Tl.)

1. Vasomotor changes: The skin areas with sensory loss is warmer due to arteriolar dilation. It is also drier due to the absence of sweating as there is loss of sympathetic activity.

2. Trophic changes: Long-standing case of paralysis leads to dry and scaly skin. The nails crack easily with atrophy of the pulp of fingers.

/Injury to the Nerve to Serratus Anterior (Nerve of iBell> M < (§)

i *Causes:* 1. SiMden pressure on the shoulder from above. 2. Carrying heavy loads on the shoulder. *Deformity:* Winging of the scapula, i.e. excessive prominence of the medial border of the scapula. Normally, the pull of the muscle keeps the medial border against the thoracic wall.)

Disability

1. Loss of pushing and punching actions. During attempts at pushing, there occurs winging of the scapula (Fig. 4.10).

2. Arm cannot be raised beyond 90° (i.e. overhead abduction which is performed by the serratus anterior is not possible).

Injury to Lateral Cord

Cause: Dislocation of humerus.

Nerves involved:

1. Musculocutaneous.

2. Lateral root of median.

Muscles paralysed:

1. Biceps and coracobrachialis.

2. All muscles supplied by the median nerve, : except those of the hand.

! *Deformity and disability:*

1. Midprone forearm.

2. Loss of flexion of forearm.

3. Loss of flexion of the wrist.

4. Sensory loss on the radial side of the forearm.

5. Vasomotor and trophic changes as above.

Injury to Medial Cord

Cause: Subcoracoid dislocation of humerus.

Nerves involved:

1. Ulnar.

2. Medial root of median.

Muscles paralysed:

r

Fig. 4.10: The 'winging' of the right scapula.

Fig. 4.11: The extent and parts of the axillary artery.
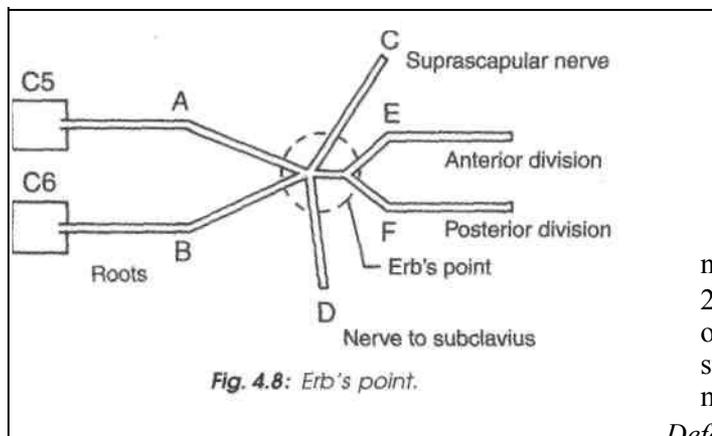
Fig. 4.8: Erb's point.

1.1.Muscles supplied by ulnar nerve.

2.Five muscles of the hand supplied by the median nerve.

Deformity and disability:

1.Claw hand.
2.Sensory loss on the ulnar side of the forearm and hand.
3.Vasomotor and trophic changes as a bone.

Axillary Artery

Axillary artery is the continuation of the subclavian artery. It extends from the outer border of the first rib to the lower border of the teres major muscle. It continues as the brachial artery. Its direction varies with the position of the arm.

The pectoralis minor muscle crosses it and divides it into three parts (Fig. 4.11).

(i)   First part, superior (proximal) to the muscle.
(ii) Second part, posterior (or deep) to the muscle.
(iii) Third part, inferior (distal) to the muscle.

Surface Marking

Hold the arm at right angles to the trunk with the palm directed upwards. The artery is then marked as a straight line by joining the following two points, (i) Midpoint of the clavicle (Fig. 4.12).

Fig. 4.9: Erb's paralysis of left arm.
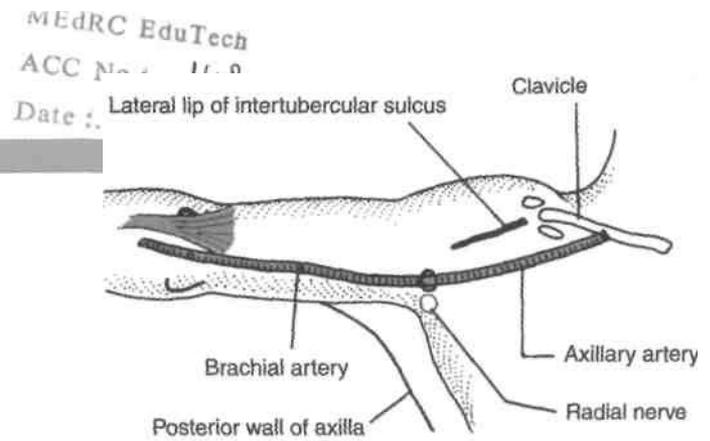
Fig. 4.12: Axillary and brachial arteries.

(ii) The second point at the junction of the anterior one-third and posterior two-thirds of the lateral wall of axilla at its lower limit where the arterial pulsations can be felt.

At its termination the axillary artery, along with the accompanying nerves, forms a prominence which lies behind another projection caused by the biceps and coracobrachialis.

Relations of First Part

Anteriorly

(i) Skin.
(ii) Superficial fascia, platysma and supraclavicular nerves.
(iii) Deep fascia.
(iv)   Clavicular part of the pectoralis major.
(v) Clavipectoral fascia with cephalic vein, lateral pectoral nerve, and thoracoacromial vessels.
(vi) Loop of communication between the lateral and medial pectoral nerves.

Posteriorly

(i) First intercostal space with the external intercostal muscle. (ii) First and second digitations of the serratus anterior with the nerve to serratus anterior. (iii) Medial cord of brachial plexus with its medial pectoral branch (Fig. 4.13).

laterally

Lateral and posterior cords of the brachial plexus.

Media///

Axillary vein

The first part of the axillary artery is enclosed (together with the brachial plexus) in the axillary sheath, derived from the prevertebral layer of deep cervical fascia.

Relations of Second Part

Anteriorly

(i) Skin.

(ii) Superficial fascia.

(iii) Deep fascia.

(iv) Pectoralis major.

(v) Pectoralis minor (Fig. 4.13).

Posteriorly

(i)   Posterior cord of brachial plexus. (ii)   Coracobrachialis.

Ventral rami ("roots")
Trunk
Divisions
Lateral cord
Coracoid process

6
7
8
1

Posterior cord
Axillary artery
Medial cord
Pectoralis minor

Lateral root
of median

Axillary nerve
Musculocutaneous nerve

Ulnar nerve
Median nerve
Radial nerve
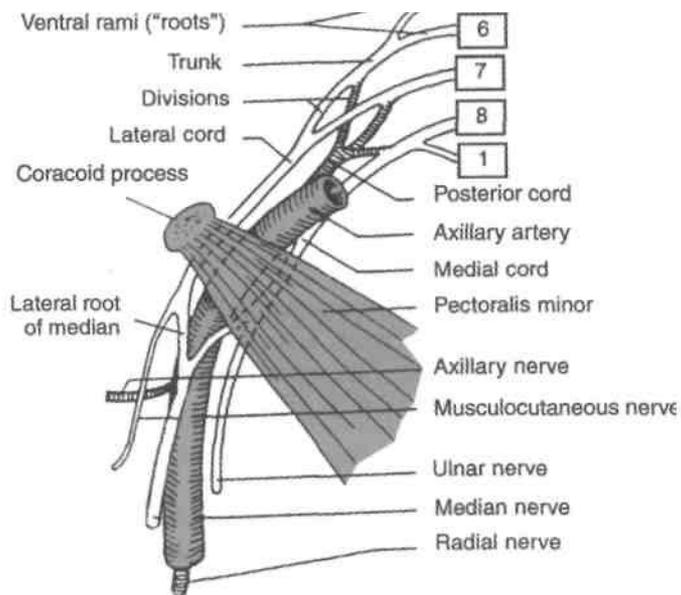
Fig. 4.13: Relation of the brachial plexus to the axillary artery.

Medially

(i) Medial cord of brachial plexus, (ii) Medial pectoral nerve, (iii) Axillary vein.

Laterally

Lateral cord of brachial plexus.

Relations of Third Part

Anteriorly

(i) Skin.
(ii) Superficial fascia, (iii) Deep fascia.
(iv) In the upper part there are the pectoralis major and medial root of the median nerve.

Posteriorly

(i) Radial nerve.
(ii) Axillary nerve in the upper part, (iii) Subscapularis in the upper part, (iv) Tendons of the latissimus dorsi and the teres major in the lower part.

Laterally

(i) Coracobrachialis.
(ii) Musculocutaneous nerve in the upper part, (iii) Lateral root of median nerve in the upper part, (iv) Trunk of median nerve in the lower part.

Medially

(i) Axillary vein, (ii) Medial cutaneous nerve of the forearm and

ulnar nerve, between the axillary artery and vein (Fig. 4.14). (iii) Medial cutaneous nerve of arm, medial to the

axillary vein.

Branches of Axillary Artery

The axillary artery gives six branches. One branch arises from the first part, two branches from the second part, and three branches from the third part. These are as follows (Fig. 4.15).

7. Superior Thoracic Artery

Superior thoracic artery is a very small branch which may not be found during dissection. It arises from the first part of the axillary artery (near the subclavius), but may arise from the thoracoacromial artery. It runs downwards, forwards and medially, passes between the two pectoral muscles, and ends by supplying these muscles and the thoracic wall.

2. Thoracoacromial (Acromiothoracic) Artery

Thoracoacromial artery is a branch from the second part of the axillary artery. It emerges at the upper border of the pectoralis minor, pierces the clavipectoral fascia, and soon divides into four
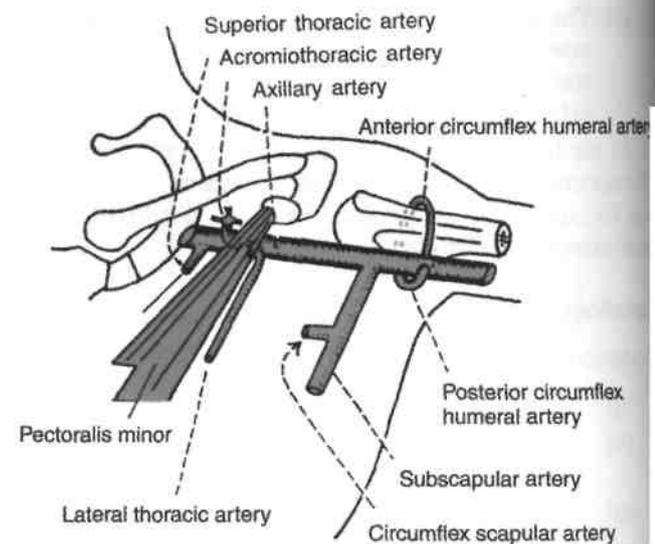
Fig. 4.15: The branches of the axillary artery.

terminal branches: (a) the *pectoral branch* passes between the pectoral muscles, and supplies these! muscles as well as the breast; (b) the *deltoid branch* runs in the deltopectoral groove, along with the cephalic vein; (c) The *acromial branch* (which may sometimes arise from the deltoid branch) crosses the coracoid process and ends by joining the anastomosis over the acromion; and (d) the *clavicular branch runs* superomedially deep to the pectoralis major, and supplies the sternoclavicular joint and subclavius.
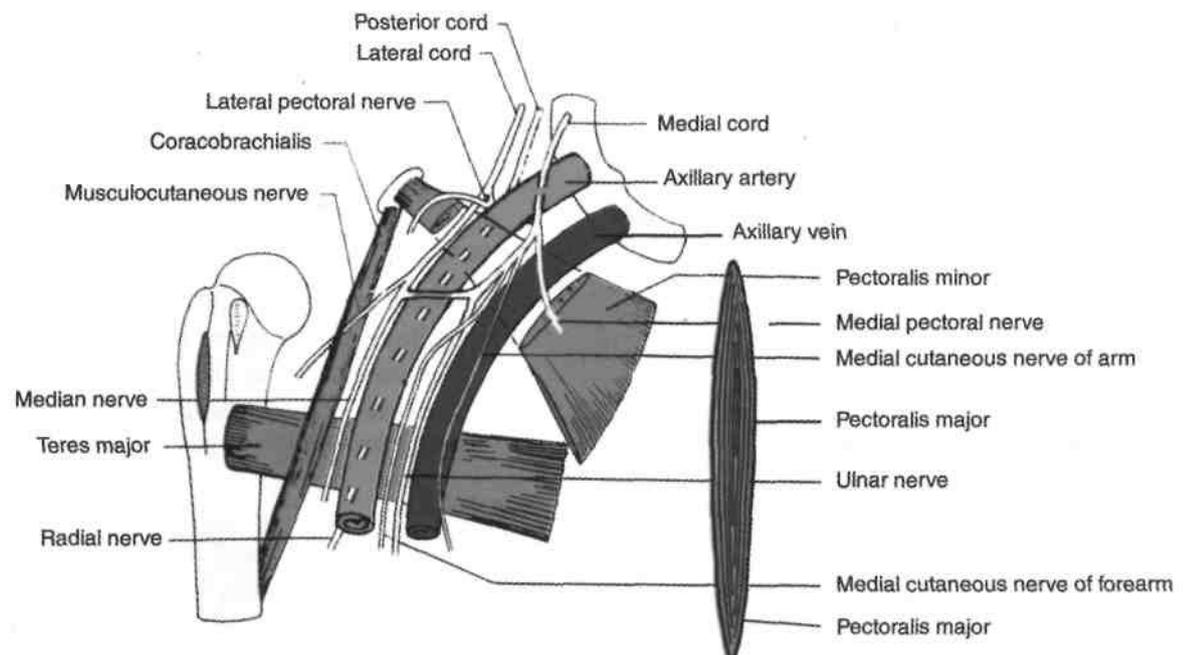
Fig. 4.14: Axillary vessels and related nerves.

3. Lateral Thoracic Artery

Lateral thoracic artery is a branch of the second part of the axillary artery. It emerges at, and runs along, the lower border of the pectoralis minor in close relation with the anterior group of axillary lymph nodes. In females, the artery is large and gives off the lateral mammary branches to the breast.

4. Subscapular Artery

Subscapular artery is the largest branch of the axillary artery, arising from its third part. It runs along the lower border of the subscapularis to terminate near the inferior angle of the scapula. It supplies the latissimus dorsi and the serratus anterior. It gives off a large branch, the *circumflex scapular artery,* which is larger than the continuation of the main artery. This branch passes through the triangular intermuscular space, winds round the lateral border of the scapula deep to the teres minor, and gives a branch to the Subscapular fossa (infrascapular branch), and another branch to the infraspinous fossa, both of which take part in the anastomosis round the scapula (Fig. 7.12).

5. Anterior Circumflex Humeral Artery

Anterior circumflex humeral artery is a small branch arising from the third part of the axillary artery, at the lower border of the subscapularis. It passes laterally in front of the intertubercular sulcus of the humerus, and anastomoses with the posterior circumflex humeral artery, to form an arterial circle round the surgical neck of the humerus. It gives off an ascending branch which runs in the intertubercular sulcus, and supplies the head of the humerus and shoulder joint.

6. Posterior Circumflex Humeral Artery

Posterior circumflex humeral artery is much larger than the anterior artery. It arises from the third part of the axillary artery at the lower border of the subscapularis, often close to its anterior counterpart. It runs backwards, accompanied by the axillary nerve, passes through the quadrangular intermuscular space, and ends by anastomosing with the anterior circumflex humeral artery round the surgical neck of the humerus (Fig. 7.6). It supplies the shoulder joint, the deltoid, and the muscles bounding the quadrangular space. It gives off a descending branch which anastomoses with the ascending branch of the profunda brachii artery.

Anastomosis and Collateral Circulation

The branches of the axillary artery anastomose with one another and with branches derived from neighbouring arteries (internal thoracic, intercostal, suprascapular, deep branch of transverse cervical, profunda brachii). When the axillary artery is blocked, a collateral circulation is established through the anastomosis round the scapula which links the first part of the subclavian artery with the third part of the axillary artery (apart from communications with the posterior intercostal arteries) (Fig. 7.12).

Variations

1. An additional 'alar thoracic' branch may arise from the second part of the axillary artery. This branch supplies axillary fat and lymph nodes.
2. Occasionally, the last three branches and the profunda artery may arise by a common trunk. In such cases, the branches of the brachial plexus surround this trunk instead of the axillary artery.
3. The posterior circumflex humeral artery may arise from the profunda artery. It then passes backwards below (not above) the teres major.
4. Sometimes the axillary artery divides into the radial and ulnar arteries, and occasionally gives off the anterior interosseous artery of the forearm.

Axillary Vein

The axillary vein is the continuation of the basilic vein. The axillary vein is joined by the venae comitantes of the brachial artery a little above the lower border of the teres major. It lies on the medial side of the axillary artery (Fig. 4.14). At the outer border of the first rib it becomes the subclavian vein. In addition to the tributaries corresponding to the branches of the axillary artery, it receives the cephalic vein in its upper part.

There is no axillary sheath around the vein, which is free to expand during times of increased blood flow. Occasionally amuscular band called the axillary arch overlies the vein. It may compress the vein and cause spontaneous thrombosis.

Axillary Lymph Nodes

The axillary lymph nodes are scattered in the fibro-fatty tissue of the axilla. They are divided into five groups.

1. The nodes of the *anterior (or pectoral)* group lie along the lateral thoracic vessels (i.e. along the lower border of the pectoralis minor). These nodes are in direct contact with the axillary tail of the breast. They receive lymph from the upper half of the anterior wall of the trunk, and from the major part of the breast (Fig. 4.16).

2. The nodes of the *posterior (or scapular)* group lie along the Subscapular vessels, on the posterior fold
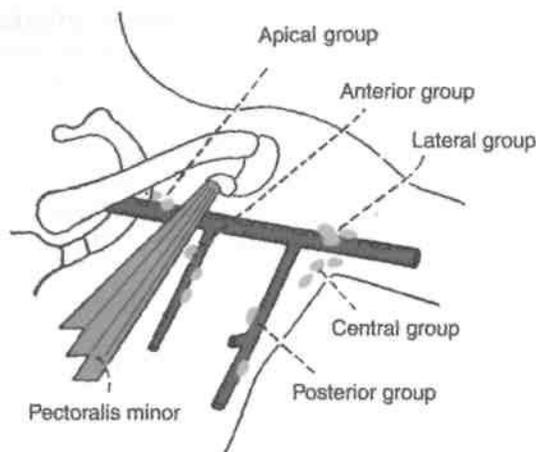
Fig. 4.16: The axillary lymph nodes.

of the axilla. They receive lymph from the posterior wall of the upper half of the trunk, and from the axillary tail of the breast.

1. The nodes of the *lateral group* lie along the upper part of the humerus, medial to the axillary vein. They receive lymph from the upper limb.

2. The nodes of the *central group* lie in the fat of the upper axilla. They receive lymph from the preceding groups and drain into the apical group. They receive some direct vessels from the floor of the axilla. The intercostobrachial nerve is closely related to them.

3. The nodes of the *apical or infraclavicular group* lie deep to the clavipectoral fascia, along the axillary vessels. They receive lymph from the central group, from the upper part of the breast, and from the thumb and its web. The lymphatics from the thumb accompany the cephalic vein.

CLINICAL ANATOMY

1. The axilla has abundant axillary hair. Infection of the hair follicles and sebaceous glands gives rise to boils which are common in this area.

2. The axillary lymph nodes drain lymph not only from the upper limb but also from the breast and the anterior and posterior body walls above the level of the umbilicus. Therefore, infections or

malignant growths in any part of their territory c drainage give rise to involvement of the axillar lymph nodes. Examination of these lymph node; is, therefore, important in clinical practice.

3. An abscess in the axilla may arise from infection and suppuration of particular groups oi lymph nodes. Spread of the abscess is as usual, governed by the arrangement of the fascia! planes and the fibrous sheaths.

When suppuration occurs superficial to the clavipectoral fascia, between the pectoral muscles, the pus points either at the anterior axillary fold, or in the deltopectoral groove. When suppuration takes place deep to the clavipectoral fascia, behind the pectoralis minor, the pus surrounds the neurovascular bundle and commonly ascends into the neck (this being the line of least resistance); but rarely it may descend along the vessels into the arm.

An axillary abscess should be incised through the floor of the axilla, midway between the anterior and posterior axillary folds, and nearer to the medial wall in order to avoid injury to the main vessels running along the anterior, posterior and lateral walls.

1. The axillary sheath is derived from the prevertebral layer of the deep cervical fascia. It encloses the axillary artery and the brachial plexus. Inferiorly it may extend up to the elbow. A cold abscess originating from the cervical vertebrae may track down through this sheath, and point on the lateral wall of the axilla along the course of the neurovascular bundle.

2. Axillary arterial pulsations can be felt against the lower part of the lateral wall of the axilla.

3. In order to check bleeding from the distal part of the limb (in injuries, operations and amputations) the artery can be effectively compressed against the humerus in the lower part of the lateral wall of the axilla.

4. Next to the popliteal artery, the axillary artery is the second most common artery of the body to be lacerated by violent movements. Occasionally, it is ruptured during reduction of an old dislocation of the shoulder.

The Back
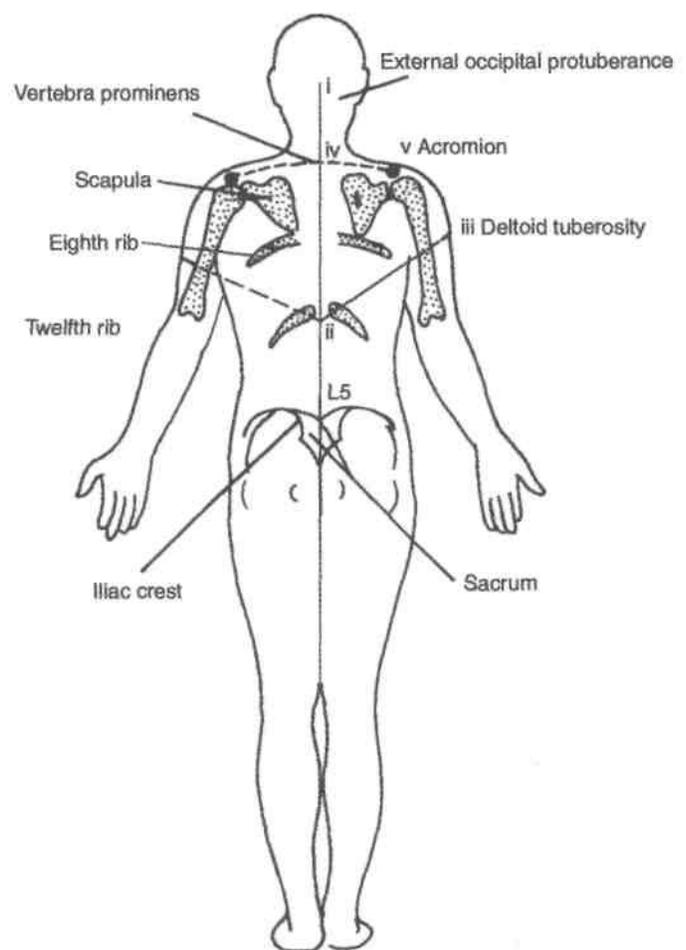
Fig. 5.1: Surface landmarks and lines of dissection.

T*his chapter deals mainly with structures which connect the upper limb with the back of the trunk.

SURFACE LANDMARKS

1.The scapula (or shoulder blade) is placed on the posterolateral aspect of the upper part of the thorax. It extends from the second to the seventh ribs. Although it is thickly covered by muscles most of its outline can be felt in the living subject. The *acromion* lies at the top of the shoulder. The crest *of the spine* of the scapula runs from the acromion medially and slightly downwards to the medial border of the scapula. The *medial border* and the *inferior angle* of the scapula can also be palpated (Fig. 5.1).

2.The *eighth rib* is just below the inferior angle of the scapula. The lower ribs can be identified on the back by counting down from the eighth rib.

3.The *iliac crestis* a curved bony ridge lying below the waist. The anterior end of the crest is the *anterior superior iliac spine*. The *posterior superior iliac spine* is felt in a shallow dimple above the buttock, about 5 cm from the median plane.

4.The *sacrum* lies between the right and left dimples mentioned above. Usually three *sacral spines* are palpable in the median plane.

5.The *coccyx* lies between the two buttocks in the median plane.

6.The spine of the seventh cervical vertebra or vertebra prominens is readily felt at the root of the neck. Higher up on the back of the neck the second cervical spine can be felt about 5 cm below the external occipital protuberance. Other spines that can be recognized are T3 at the level of root of the spine of the scapula, L4 at the level of the highest point of the iliac crest, and S2 at the level of the posterior superior iliac spine.

7. The junction of the back of the head with that of the neck is indicated by the external occipital protuberance and the superior nuchal lines. The *external occipital protuberance* is a bony projection felt in the median plane on the back of the head at the upper end of the nuchal furrow (running vertically on the back of the neck). The *superior nuchal lines* are

indistinct curved ridges which extend on either side from the protuberance to the mastoid process. The nuchal furrow extends to the external occipital protuberance, above, and to the spine of C7 below.

SKIN AND FASCIAE OF THE BACK   ~

Man mostly lies on his back. Therefore, the skin and fasciae of the back are adapted to sustain pressure of the body weight. Accordingly, the skin is thick and fixed to the underlying fasciae; the superficial fascia containing variable amount of fat, is thick and strong and is connected to overlying skin by connective tissue; and the deep fascia is dense in texture.

DISSECTION

Identify the external occipital protuberance (i) of the skull. Draw a line in the midline from the protuberance to the spine of the last thoracic (T12) vertebra (ii). Make incision along this line (Fig. 5.1). Extend the incision from its lower end to the deltoid tuberosity (iii) on the humerus which is present on lateral surface about the middle of the arm. Note that the arm is placed by the side of the trunk. Make another incision along a horizontal line from seventh cervical spine (iv) to the acromion process of scapula (v).

Cutaneous Nerves

The cutaneous nerves of the back are derived from the posterior primary rami of the spinal nerves. Their distribution extends up to the posterior axillary lines. The following points may be noted :

1. The posterior primary rami of the spinal nerves CI, C7, C8, L4 and L5 do not give off any cutaneous branches. All twelve thoracic and five sacral nerves, however, give cutaneous branches (Figs 5.2, 5.3, 14.3).

2. Each posterior primary ramus divides into medial and lateral branches, both of which supply the erector spinae muscles, but only one of them, either medial or lateral, continues to become the cutaneous nerves. In the upper half of the body (up to T6), the medial branches, and in the lower half of the body (below T6) the lateral branches, of the posterior primary rami provide the cutaneous branches. Each cutaneous nerve divides into a smaller medial and a larger lateral branch before supplying the skin.

3. The posterior primary rami supply the intrinsic muscles of the back and the skin covering them. The
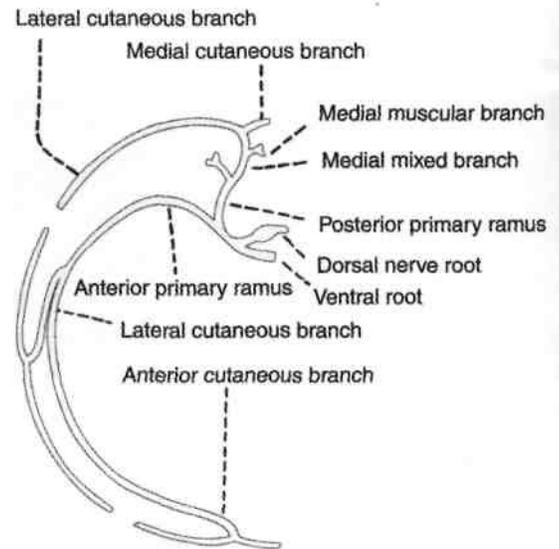
Fig. *5.2: Course and branches of a typical thoracic nerve.*
Fig. *5.3: Diagram of a typical thoracic nerve, with sympathetic ganglion.*
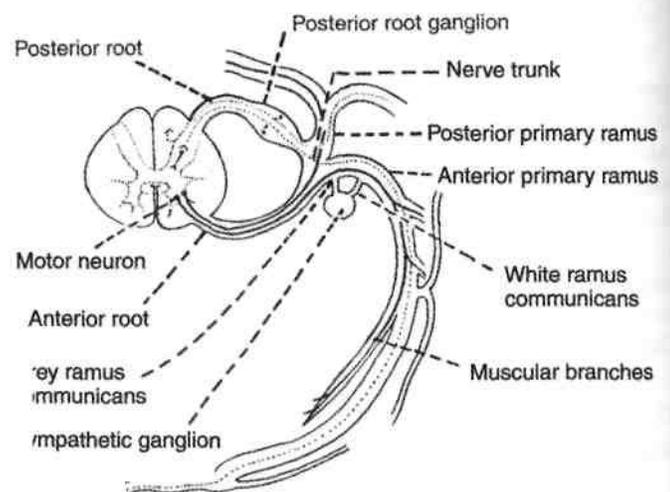
cutaneous distribution extends further laterally than the extensor muscles.

4. No posterior primary ramus ever supplies skin or muscles of a limb. The cutaneous branches of the posterior primary rami of nerves LI, L2, L3 (S1-S3) are exceptions in this respect: they turn downwards unlike any other nerve and supply the skin of the gluteal region.

MUSCLES CONNECTING THE UPPER LIMB WITH THE VERTEBRAL COLUMN

Muscles connecting the upper limb with the vertebral column are the trapezius (Fig. 5.4), the latissimus dorsi, the levator scapulae, and the rhomboideus
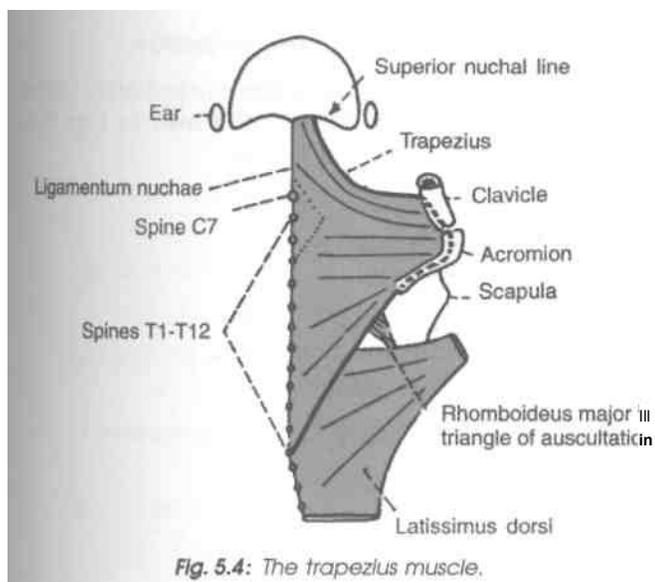
Fig. 5.4: The trapezius muscle.

minor and rhomboideus major. The attachments of these muscles are given in Table 5.1, and their nerve supply and actions in Table 5.2.

DISSECTION

Identify the attachments of trapezius muscle in the upper part of back; and that of latissimus dorsi in the lower part. Cut vertically through trapezius 5 cm lateral to the vertebral spines. Divide the muscle horizontally between the clavicle and spine of scapula; and reflect it laterally to identify the *accessory nerve* and its accompanying blood vessels the *superficial cervical artery.*

Look for the *suprascapular vessels* and *nerve,* deep to trapezius muscle, towards the scapular notch. Cut through levator scapulae muscle midway between its two attachments and clean the dorsal scapular nerve (supplying the rhomboideus) and accompanying blood vessels. Identify rhomboideus minor from rhomboideus major muscle. Pull the medial or inner scapular border away from the chest wall for looking at the serra-tus anterior muscle. Define attachments of latissimus dorsi muscle.

Table 5.1: Attachments of muscles connecting the upper limb to the vertebral column (Figs 5.4, 5.6)

Muscle	Origin from:	Insertion into:
1. Trapezius The right and left muscles together from a trapezium that covers the upper half of the back	(i) Medial one-third of superior nuchal line (ii) External occipital protuberance (iii) Ligamentum nuchae (iv) C7 spine (v) T1-T12 spines (vi) Corresponding supraspinous ligaments	(i) Upper fibres into the posterior border of lateral one-third of clavicle (ii) Middle fibres, into the medial margin of the acromion and upper lip of the crest of spine of the scapula (iii) Lower fibres, on the deltoid tubercle (apex of triangular area) at the medial end of the spine, with a bursa intervening
2. Latissimus dorsi It covers a large area of the lower back, and is overlapped by the trapezius	(i) Posterior one-third of the outer lip of iliac crest (ii) Posterior layer of lumbar fascia; thus attaching the muscle to the lumbar and sacral spines (iii) Spines of T7-T12 (iv) Lower four ribs (v) Inferior angle of the scapula	The muscle winds round the lower border of the teres major, and forms the posterior fold of the axilla, The tendon is twisted upside down and is inserted into floor of the intertubercular sulcus
3. Levator scapulae	(i) Transvers processes of C1, C2 (ii) Posterior tubercles of the transverse processes of C3, C4	Superior angle and upper part of medial border (up to triangular area) of the scapula
4. Rhomboideus minor	(i) Lower part of ligamentum nuchae (ii) Spines C7 and T1	Base of the triangular area at the root of the spine of the scapula,
5. Rhomboideus major	(i) Spines of T2, T3, T4, T5 (ii) Supraspinous ligaments	Medial border of scapula below the root of the spine

Additional Features of Muscles of the Back

A. Trapezius

1.Developmentally the trapezius is related to the sternocleidomastoid. Both of them develop from branchial arch mesoderm and are supplied by the spinal accessory nerve.

2.The principal action of the trapezius is to rotate the scapula during abduction of the arm beyond 90°. Clinically the muscle is tested by asking the patient to shrug his shoulder against resistance (Fig. 5.5).
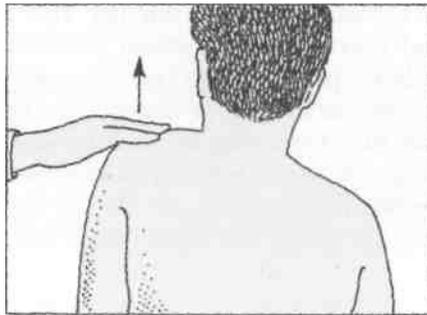
Fig. 5.5: Test for trapezius muscle.

Structures Under Cover of the Trapezius

A large number of structures lies immediately un cover of the trapezius. They are shown in Figs i 5.7 and 5.8 and are listed below.

A. Muscles

1.Semispinals capitis.
2.Splenius capitis.
3.Levator scapulae (Fig. 5.6).
4.Inferior belly of omohyoid.
5.Rhomboideus minor.
6.Rhomboideus major.
7.Supraspinatus.
8.Infraspinatus.
9.Latissimus dorsi.
10. Serratus posterior superior.

B. Vessels

1.Suprascapular artery and vein
2.Superficial branch of the transverse cervici artery (superficial cervical) and accompanying vein (Figs 5.7, 5.8).
3.Deep branch of transverse cervical artery (doi sal scapular) and accompanying veins.

Table 5.2: Nerve supply and actions of muscles connecting the upper limb to the vertebral column

Muscle	Nerve supply	Actions
/ Trapezius N—' tfMa jK\"T$) i	(i) Spinal part of accessory nerve is motor A (") Branches from C3, C4 are proprioceptive/	(i) Upper fibres act with levator scapulae, and elevate the scapula: as in shrugging (ii) Middle fibres act with rhomboideus, and retract the scapula (iii) Upper and lower fibres act with serratus anterior, and rotate the scapula forwards round the chest wall thus playing an important role in abduction of the arm beyond 90° (Fig. 5.9). (iv) Steadies the scapula
Latissimus dorsi rowing, climbing, pulling, folding the arm behind the back, and j j |	Thoracodorsal nerve (C6, C7, C8) (Nerve to latissimus dorsi)	(i) Adduction, extension, and medial rotation of the shoulder as in swimming, scratching the opposite scapula (ii) Helps in violent expiratory effort like coughing, sneezing, etc. (iii) Essentially a climbing muscle (iv) Hold inferior angle of the scapula in place
Levator scapulae /	(i) A branch from dorsal scapular nerve (C5) (ii) C3,C4 branches are proprioceptive	(i) Helps in elevation of scapula. (ii) Steadies the scapula during movements of the arm
Rhomboideus minor	Dorsal scapular nerve (C5)	
Rhomboideus major	Dorsal scapular nerve (C5) -'	These muscles retract the scapula and steady it

Fig. 5.6: The latissimus dorsi, the levator scapulae, the rhomboideus minor, and the rhomboideus major muscles.

Fig. 5.8: Transverse section showing the arrangement of structures on the back.
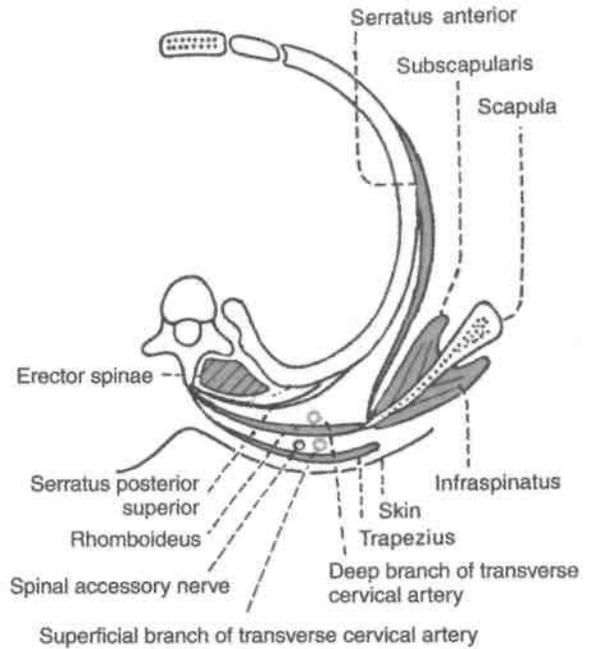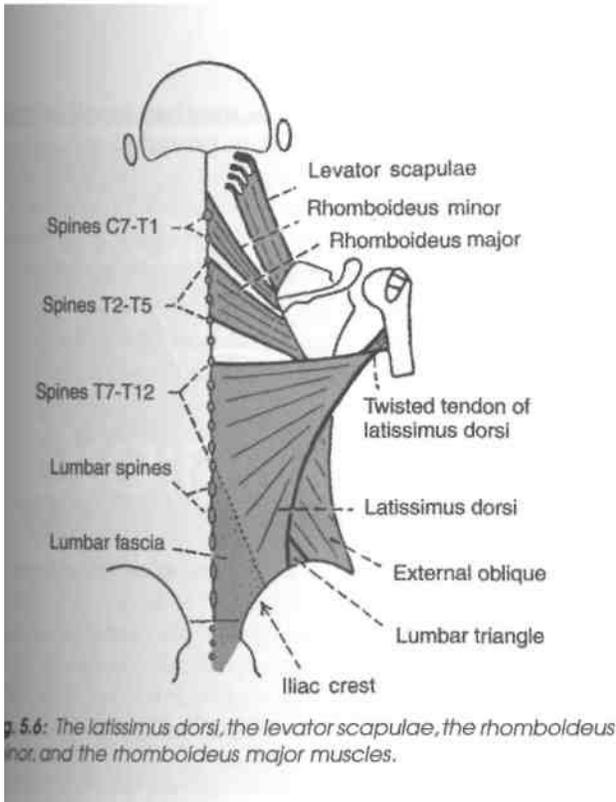
QU——v"i------™   Outline of trapezius

i y

\S   Spinal accessory nerve

Levator scapulae ,   Vv/^Transverse cervical artery

Rhomboideus minor ₛj^   ■Vf   *"'\\

Rhomboideus major „ Mm   x ^ V-^^T^x   !

- » / / Suprascapular nerve and artery
- **/ /**
  - o / Inferior belly of omohyoid

Middle fibres of trapezius _

v \ \

i   \   /   Serratus anterior

Lower fibres of trapezius

Fig. 57: *Some of the structures under cover of the trapezius muscle.*

Fig. 5.9: *Rotation of the scapula during abduction of the arm beyond 90 degrees, brought about by the trapezius and the serratus anterior muscles.*

C. *Nerves*
  1. Spinal root of accessory nerve.
  2. Suprascapular nerve.
  3. C3, C4 nerves.
  4. Posterior primary rami of C2-C6 and T1-T12 pierce the muscle to become cutaneous nerves.
D. Bursa
  A bursa lies over the smooth triangular area at the root of the spine of the scapula.

6. *Latissimus Dorsi*

  1. The latissimus dorsi develops in the extensor compartment of the limb. Thereafter it migrates to its wide attachment on the trunk, taking its nerve supply (thoracodorsal nerve) along with it.
  2. It is developed in animals that suspend themselves by their arms (brachiators like apes, monkeys, etc.). The complexity of the muscle is indicated by the occasional presence in man of the

axillary arch and dorsoepitrochlearis brachii normally present in apes.

The *axillary arch* is a muscular slip which arises from the edge of the latissimus dorsi in the posterior fold of the axilla. It crosses the axilla in front of the vessels and nerves of the region and joins the tendon of the pectoralis major, or of the coracobrachialis or of the biceps. It is present in about 7% of subjects.

A fibrous or muscular slip may connect the lower border of the latissimus dorsi to the long head of the triceps. When muscular, it is called the dorsoepitrochlearis brachii.

3. The latissimus dorsi is tested clinically by feeling the contracting muscle in the posterior fold of the axilla after asking the patient to cough.

C. Triangle of Auscultation

Triangle of auscultation is a small triangular interval bounded medially by the lateral border of the trapezius, laterally by the medial border of the scapula, and inferiorly by the upper border of the latissimus dorsi. The floor of the triangle is formed by the seventh rib, sixth and seventh intercostal spaces, and the rhomboideus major. This is the only part of the back which is not covered with muscles. Respiratory sounds heard through a stethoscope are said to be better heard over this triangle than elsewhere on the back. On the left side, the cardiac orifice of the stomach lies deep to the triangle, and in days before X-rays were discovered the sounds of swallowed liquids were auscultated over this triangle.

D. Lumbar Triangle of Petit

Lumbar triangle of Petit is another small triangle surrounded by muscles. It is bounded medially by I the lateral border of the latissimus dorsi, laterally by the posterior border of the external oblique muscle of the abdomen, and inferiorly by the iliac crest (which forms the base). The occasional hernia at this site is called *lumbar hernia.*

After completing the dissection of the back, the limb with clavicle and scapula is detached from the trunk.

For detachment of the limb, muscles which need to be incised are trapezius, levator scapulae, rhomboideus minor and major, serratus anterior, latissimus dorsi and sternocleidomastoid. The sternoclavicular joint is opened to free clavicle from the sternum. Upper limb with clavicle and scapula are removed en bloc.

Additional Reading

JAVADEKAR BS (1971). Axillary arch muscle. *Journal ol Anatomical Society of India,* 20: 115-116.

VARE AM and INDURKAR GM (1965). Some anomalous findings in the axillary musculature. *Journal of Anatomical Society of India,* 14: 34-36.

■Cutaneous Nerves, Superficial!

I Drainage of the Upper Limb I

The superficial fascia seen after the reflection of skin contains cutaneous nerves, cutaneous or superficial veins and lymphatics. The cutaneous nerves are the continuation of the spinal nerves and carry sympathetic fibres for supplying the sweat glands, arterioles in the dermis and arrector pilorum muscles in relation to the hair follicle. Thus, the effects of sympathetic on the skin are sudomotor, vasomotor and pilomotor respectively. The nerves also cany sensation of pain, touch, temperature and pressure. Superficial veins are seen along with the cutaneous nerves. These are utilised for giving intra-venous transfusions, cardiac catheterisation and taking blood samples. Lymphatic vessels are not easily seen in ordinary dissection.

CUTANEOUS NERVES OF THE UPPER LIMB

The skin of the upper limb is supplied by 15 sets of cutaneous nerves (Table 6.1). Out of these only one set (supraclavicular) is derived from the cervical plexus, and another nerve (intercostobrachial) is derived from the second intercostal nerve. The

DISSECTION

Give one horizontal incision in the arm at its junction of upper one-third and lower two-thirds segments (Fig. 3.2). Make a vertical incision through ; the centre of arm and forearm till the wrist where another transverse incision is given. Reflect the skin on either side on the front as well as on the back of the limb. Use this huge skin flap to cover ; the limb after the dissection.

remaining 13 sets are derived from the brachial plexus through the musculocutaneous, median, ulnar, axillary and radial nerves. Some branches arise directly from the medial cord of the plexus. It should be noted as follows:

(a)The areas of distribution of peripheral cutaneous nerves do not necessarily correspond with those of individual spinal segments. (Areas of the skin supplied by individual spinal segments are called dermatomes). This is so because each cutaneous nerve contains fibres from more than one ventral ramus (of a spinal nerve); and each ramus gives fibres to more than one cutaneous nerve.

(b)Adjacent areas of skin supplied by different cutaneous nerves overlap each other to a considerable extent. Therefore, the area of sensory loss after damage to a nerve is much less than the area of distribution of the nerve. The anaesthetic area is surrounded by an area in which the sensations are somewhat altered.

(c)In both the upper and lower limbs, the nerves of the anterior surface have a wider area of distribution than those supplying the posterior surface.

The individual cutaneous nerves, from above down-wards, are described below with their root values. Figure 6.1 shows the cutaneous nerves of the upper limb.

1.The *supraclavicular nerves* (C3, C4) are branches of the cervical plexus. They pierce the deep fascia in the neck, descend superficial to the clavicle, and supply: (a) the skin of the pectoral region up to the level of the second rib; and (b) skin covering the upper half of the deltoid.

2.The *upper lateral cutaneous nerve of the arm* (C5, C6) is the continuation of the posterior branch

Table 6.U Cutaneous nerves of the upper limb

Region	Nerve	Root value	Parent nerve
skin over upper part of deltoid	Supraclavicular	C3, C4	
ARM			
1. Upper medial part			Intercostobrachial
2. Lower medial part	Medial cutaneous nerve of arm	T2 TO	2nd intercostal
4. Lower lateral part			
5. Posterior aspect	Lower lateral cutaneous nerve of arm		
	Upper lateral cutaneous nerve of arm	C5	Radial nerve
FOREARM			
1. Medial side	Medial cutaneous nerve of forearm	C8, T1	Medial cord
2. Lateral side	Lateral cutaneous nerve of forearm	C5, C6	Musculocutaneous
3. Posterior side	Posterior cutaneous nerve of forearm	C6, C7, C8	Radial nerve
PALM			
1. Lateral two-thirds	Palmar cutaneous branch of median	C6, C7	Median
2. Medial one-third	Palmar cutaneous branch of ulnar	C8	Ulnar
DORSUM OF HAND			
1. Medial half including proximal phalanges of medial 2½ digits	Dorsal branch of ulnar	C8	Ulnar
2. Lateral half including proximal phalanges of lateral 2½ digits	Superficial terminal branch of radial	C6, C7	Radial
DIGITS			
Palmar aspect, and dorsal aspect of middle and distal phalanges			
1. Lateral 3½ digits	Palmar digital branch of median	C7	Median
2. Medial 1½ digits	Palmar digital branch of ulnar	C8	Ulnar

Fig. 6.1: The cutaneous nerves of the upper limb.

Supraclavicular

Upper lateral cutaneous nerve of arm

Intercostobrachial — Posterior cutaneous nerve of arm

Medial cutaneous nerve of arm

Lower lateral cutaneous nerve of arm

Medial cutaneous nerve of forearm

Posterior cutaneous nerve of forearm

Lateral cutaneous nerve of forearm

Ulnar nerve

Radial nerve

Median nerve

Anterior surface   **Posterior surface**
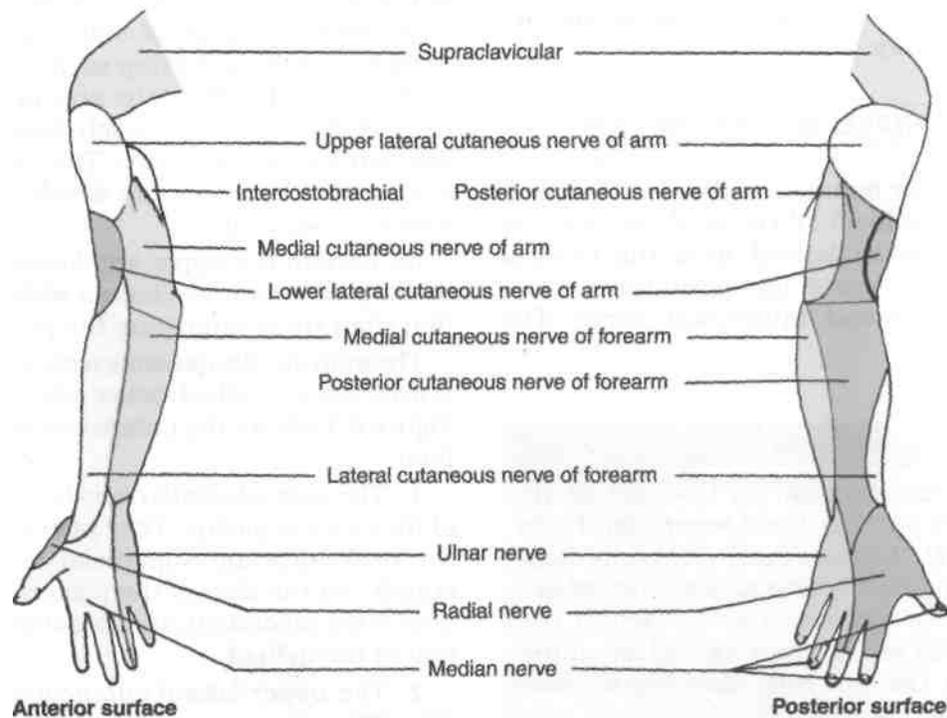
of the axillary nerve. It pierces the deep fascia at the lower part of the posterior border of the deltoid, runs horizontally forwards, and supplies the skin covering the lower half of the deltoid and the upper part of the long head of the triceps.

1. The *lower lateral cutaneous nerve of the arm* (C5, C6) is abranch of the radial nerve given off in the radial groove. It perforates the lateral head of the triceps and then pierces the deep fascia just below the insertion of the deltoid. It supplies the skin of the lower half of the lateral side of the arm.

2. The *intercostobrachial nerve* (T2) is the lateral cutaneous branch of the second intercostal nerve. It crosses the axilla, pierces the deep fascia at the upper part of the medial side of the arm, and supplies the skin of the upper half of the medial and posterior parts of the arm. The size of this nerve is inversely proportional to that of the medial cutaneous nerve of the arm. A second intercostobrachial nerve (T3) may be present to reinforce the first one.

3. The *medial cutaneous nerve of the arm* (Tl, T2) is the smallest branch of the medial cord of the brachial plexus. First it descends on the medial side of the axillary vein, and communicates with the intercostobrachial nerve. It then descends on the medial side of the basilic vein, pierces the deep fascia at the middle of the medial side of the arm, and supplies the skin of the lower half (or one-third) of the medial side of the arm. The intercostobrachial nerve may partially or completely replace this nerve.

4. The *posterior cutaneous nerve of the arm* (C5) is a branch of the radial nerve given off in the axilla. It crosses the intercostobrachial nerve posteriorly, pierces the deep fascia below the posterior fold of the axilla, and supplies the skin of the back of the arm from the insertion of the deltoid to the olecranon.

5. The *lateral cutaneous nerve of the forearm* (C5, C6) is the continuation of the musculocutaneous nerve. It pierces the deep fascia just lateral to the tendon of the biceps 2-3 cm above the bend of the elbow. It divides into anterior and posterior branches, and supplies the skin of the lateral side of the forearm, extending anteriorly to a small part of the ball of the thumb.

6. The *medial cutaneous nerve of the forearm (C8,* Tl) is a branch of the medial cord of the brachial plexus. It runs along the medial side of the axillary and brachial arteries, pierces the deep fascia at the middle of the medial side of the arm (with the basilic vein) and supplies the skin of the medial side of the forearm. Near the axilla it gives off a filament which supplies the skin covering the biceps.

7. The *posterior cutaneous nerve of the forearm* (C6-C8) arises from the radial nerve, in the radial groove, in common with the lower lateral cutaneous

nerve of the arm. It perforates the lateral head of the triceps, and pierces the deep fascia a little below the middle of the forearm. After giving some branches to the lateral side of the arm, it descends posterior to the lateral epicondyle and supplies the skin of the back of the forearm.

10. The *median nerve* gives off two sets of cutane
ous branches in the hand.

(a)The *palmar cutaneous branch* (C6-C8) arises a short distance above the wrist, pierces the deep fascia at the middle of the upper margin of the wrist and supplies skin over the lateral two-thirds of the palm including that over the thenar eminence.

(b)*Palmar digital branches* (C6-C8) are five in number and arise in the palm. The medial two branches are common palmar digital nerves; each divides near a digital cleft to form two *proper palmar digital nerves*. The lateral three branches are proper palmar digital nerves for the medial and lateral sides of the thumb and for the lateral side of the index finger. The two nerves for the thumb may have a common origin. The various digital branches of the median nerve supply palmar skin of the lateral three and a half digits, the nail beds, and skin on the dorsal aspect of the middle and distal phalanges of the same digits.

11. The *ulnar nerve* gives off three sets of cutane
ous nerves in hand.

(a)The *palmar cutaneous branch* (C7, C8) arises in the middle of the forearm and descends over the ulnar artery. It pierces the deep fascia anterior to the wrist, and supplies skin of the medial one-third of the palm.

(b)The *palmar digital branches* of the ulnar nerve (C7, C8) are two in number. They arise from the superficial terminal branch of the ulnar nerve just distal to the pisiform bone. The medial of the two branches is a proper palmar digital nerve for the medial side of the little finger. The lateral branch is a common palmar digital nerve which divides into two proper digital nerves for supply of adjacent sides of the ring and little fingers.

(c)The *dorsal branch of the ulnar nerve* (C7, C8) arises about 5 cm above the wrist. It descends with the main trunk of the ulnar nerve almost to the pisiform bone. Here it passes backwards to divide into three (sometime two) dorsal digital nerves. Typically, the region of skin supplied by the dorsal branch covers the medial half of the back of the hand, and the skin on the dorsal aspect of the medial two and a half fingers. Sometimes the area is less (one-third of the back of the hand, and the medial one and a half fingers). Note that

the terminal parts of the dorsal aspect of the digits are supplied by the median nerve as described above.

12. The *superficial terminal branch of the radial nerve* (C6-C8) arises in front of the lateral epicondyle of the humerus. It descends through the upper two-thirds of the forearm lateral to the radial artery, and then passes posteriorly about 7 cm above the wrist. While winding round the radius it pierces the deep fascia and divides into four or five small dorsal digital nerves. In all, the superficial terminal branch supplies the skin of the lateral half (sometimes two-thirds) of the dorsum of the hand, and the dorsal surfaces of the lateral two and a half (sometimes three and a half) digits including the thumb, except for the terminal portions supplied by the median nerve.

Fig. 6.2: The body wall is supplied by (A) the posterior primary | rami, (B) the lateral branches of the anterior primary rami, arm (C) the anterior branches of the anterior primary rami of the spinal nerves, The limb buds develop from the area supplied by the lateral branches of the anterior primary rami.

THE DERMATOMES OF THE UPPER LIMB

Definition: The area of skin supplied by one spinal segment is called a dermatome. A typical dermatome extends from the posterior median line to the anterior median line on the side of the trunk (Fig. 5.2). However, in the limbs the dermatomes have migrated rather irregularly, so that the original uniform pattern is disturbed.

Embryological Basis

The early human embryo shows regular segmentation of the body. Each segment is supplied by the corresponding segmental nerve. In an adult, all structures, including the skin, developed from one segment, are supplied by their original segmental nerve. The limb may be regarded as extension of the body wall, and the segments from which they are derived can be deduced from the spinal nerves supplying them. The limb buds arise in the area of the body wall supplied by the lateral branches of anterior primary rami. The nerves to the limbs represent these branches (Fig. 6.2).

Important Features

1. The cutaneous innervation of the upper limb is derived:

(a) Mainly from segments C5-C8 and Tl of the spinal cord, and

(b) partly from the overlapping segments from above (C3, C4) as well from below (T2, T3). The additional segments are found only at the proximal end of the limb (Fig. 6.3).

2. Since the limb bud appears on the ventrolateral aspect of the body wall, it is invariably supplied by the anterior primary rami of the spinal nerves. Posterior primary rami do not supply the limb.
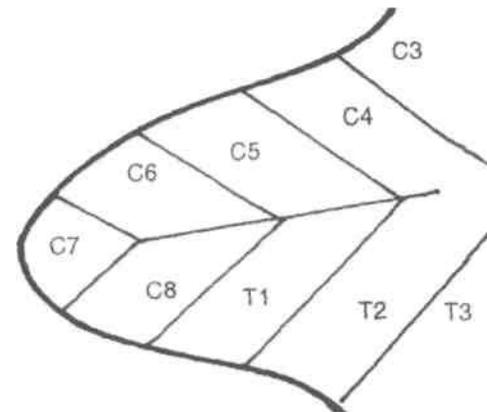
Fig. 6.3: The upper limb bud grows out opposite segments C5, C6, C7, C8 and Tl of the spinal cord.

It is possible that the ventral and dorsal divisions of the trunks of the brachial plexus represent the anterior and posterior branches of the lateral cutaneous nerves (Figs 6.4, 4.7, 5.2).

1. There is varying degree of overlapping of adjoining dermatomes, so that the area of sensory loss following damage to the cord or nerve roots is always less than the area of distribution of the dermatomes (Fig. 6.5).

2. Each limb bud has a cephalic and a caudal border, known as preaxial and postaxial borders, respectively. In the upper limb, the thumb and radius lie along the preaxial border, and the little finger and ulna along the postaxial border.

3. The dermatomes of the upper limb are distributed in an orderly numerical sequence (Fig. 6.6).

(i) Along the preaxial border from above downward, by segments C3-C6.

veins spiral, from the dorsal to the ventral surface of the limb.

1.The preaxial vein is longer than the postaxial. In other words, the preaxial vein drains into the deep (axillary) vein more proximally (at the root of the limb) than the postaxial vein which becomes deep in the middle of the arm.

2.The earlier a vein becomes deep the better because the venous return is then assisted by muscular compression. The load of the preaxial (cephalic) vein is greatly relieved by the more efficient postaxial (basilic) vein through a short circuiting channel (the median cubital vein situated in front of the elbow) and partly also by the deep veins through a perforator vein connecting the median cubital with the deep vein.

3.The superficial veins are accompanied by cutaneous nerves and superficial lymphatics, and not by arteries. The superficial lymph nodes lie along the veins, and the deep lymph nodes along the arteries.

4.The superficial veins are best utilised for intra-venous injections.

Individual Veins

Dorsal Venous Arch

Dorsal venous arch lies on the dorsum of the hand (Fig. 6.7). Its afferents (tributaries) include: (i) three dorsal metacarpal veins, (ii) a dorsal digital vein from the medial side of the little finger, (iii) a dorsal digital! vein from the radial side of the index finger, (iv) two dorsal digital veins from the thumb, and (v) most of! the blood from the palm through veins passing! around the margins of the hand and also by! perforating veins passing through the interosseous spaces. Pressure on the palm during gripping fails to impede the venous return due to the mode of drainageH of the palm into the dorsal venous arch. Its efferent™ are the cephalic and basilic veins.

Cephalic Vein

Cephalic vein is the preaxial vein of the upper limb (cf. great saphenous vein of the lower limb).

It begins from the lateral end of the dorsal venous arch.

It runs upwards: (i) through the roof of the ana J tomical snuffbox, (ii) winds round the lateral border! of the distal part of the forearm, (iii) continues upwards in front of the elbow and along the lateral border of the biceps brachii, (iv) pierces the deep fascia at the lower border of the pectoralis major, (v) runs in the deltopectoral groove up to the infraclav-icular fossa, where (vi) it pierces the clavipectoral fascia and joins the axillary vein.

At the elbow, the greater part of its blood is drained into the basilic vein through the median cubital vein,
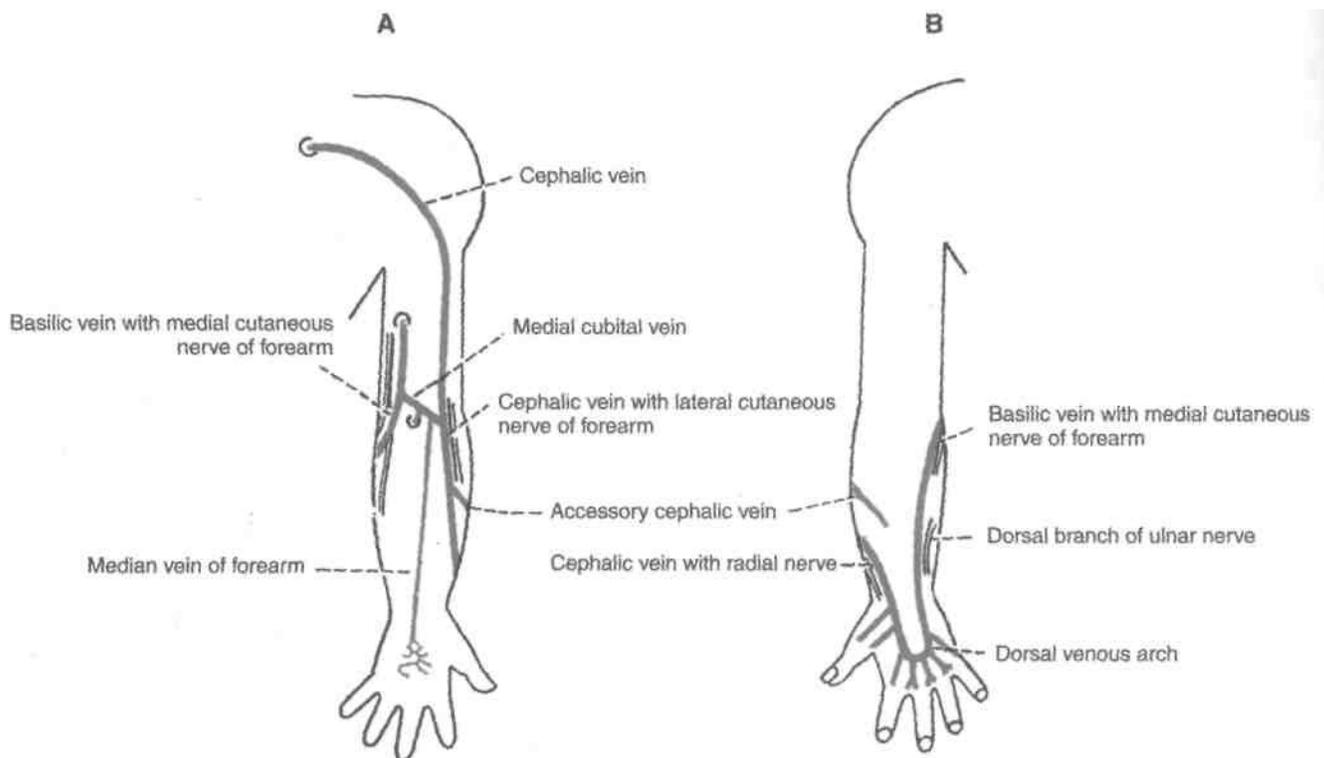
Fig. 6.7: The superficial veins of the upper limb.
A — On the front, B — On the back of the limb.

and partly also into the deep veins through the perforator vein.

It is accompanied by the lateral cutaneous nerve of the forearm, and the terminal part of the radial nerve.

An accessory cephalic vein is sometimes present. It ends by joining the cephalic vein near the elbow.

Basilic Vein
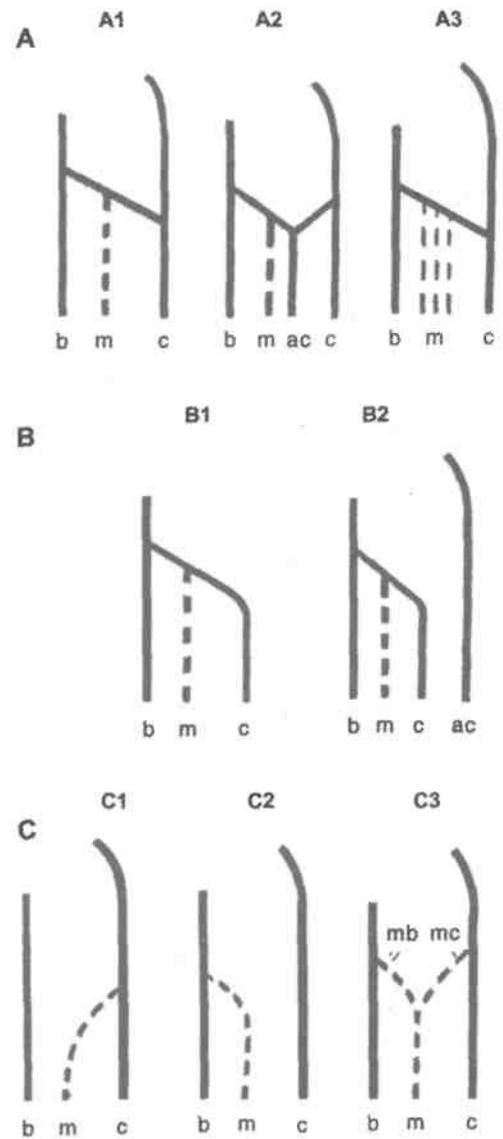
Figs 6.8A to C: *Some variations in the cubital veins. b = basilic vein; c = cephalic vein; ac = accessory cephalic vein; m = median vein of the forearm; mc = median cephalic vein; mb = median basilic vein.*

CLINICAL ANATOMY

1. The median cubital vein is the vein of choice for intravenous injections, for withdrawing blood from donors, and for cardiac catheterisation, because it is fixed by the perforator and does not slip away during piercing. When the median cubital vein is absent, the basilic or median basilic vein is

Basilic vein is the postaxial vein of the upper limb (cf. short saphenous vein of the lower limb).

It begins from the medial end of the dorsal venous arch.

It runs upwards: (i) along the back of the medial border of the forearm, (ii) winds round this border near the elbow, (iii) continues upwards in front of the elbow (medial epicondyle) and along the medial margin of the biceps brachii up to the middle of the arm where (iv) it pierces the deep fascia, and (v) runs along the medial side of the brachial artery up to the lower border of teres major where it becomes the axillary vein.

About 2.5 cm above the medial epicondyle of the humerus, it is joined by the median cubital vein.

It is accompanied by the posterior branch of the medial cutaneous nerve of the forearm and the terminal part of the dorsal branch of the ulnar nerve.

Median **Cubital Vein**

Medial cubital vein is a large communicating vein which shunts blood from the cephalic to the basilic vein.

It begins from the cephalic vein 2.5 cm below the bend of the elbow, runs obliquely upward and medially, and ends in the basilic vein 2.5 cm above the medial epicondyle. It is separated from the brachial artery by the bicipital aponeurosis.

It may receive tributaries from the front of the forearm (median vein of the forearm) and is connected to the deep veins through a perforator vein which pierces the bicipital aponeurosis. The perforator vein fixes the median cubital vein and thus makes it ideal for intravenous injections.

Median **Vein of the Forearm**

Median vein of the forearm begins from the palmar venous network, and ends in any one of the veins in front of the elbow. Sometimes it divides into median cephalic and median basilic veins which join the cephalic and basilic veins respectively; this pattern replaces the median cubital vein. *Variations in cubital veins*

1. The cephalic and basilic veins are connected by the median cubital vein in 70% of subjects (Fig. 6.8A).
2. The whole cephalic vein drains into the basilic vein in 20% of cases (Fig. 6.8B).

3. The cephalic and basilic veins remain separate in 10% of subjects (Fig. 6.8C).
For further details of variations see Fig. 6.8.

preferred over the cephalic because the former is a more efficient channel.

2. The cephalic vein frequently communicates with the external jugular vein by means of a small vein which crosses in front of the clavicle. In operations for removal of the breast (in carcinoma), the axillary lymph nodes are also removed, and it sometimes becomes necessary to remove a segment of the axillary vein also. In these cases, the communication between the cephalic vein and the external jugular vein enlarges considerably and helps in draining blood from the upper limb.

In case of fracture of the clavicle, the rupture of the communicating channel may lead to formation of a large haematoma, i.e. collection of blood.

LYMPH NODES AND LYMPHATIC DRAINAGE

When circulating blood reaches the capillaries, part of its fluid content passes through them into the surrounding tissue as *tissue fluid.* Most of this tissue fluid re-enters the capillaries at their venous ends. Some of it is, however, returned to the circulation through a separate set of *lymphatic vessels.* These vessels begin as lymphatic capillaries which drain into larger vessels. Along the course of these lymph vessels there are groups of *lymph nodes.* Lymph vessels are difficult to see and special techniques are required for their visualization. Lymph nodes are small bean-like structures that are usually present in groups. These are not normally palpable in the living subject. However, they often become enlarged in disease, particularly by infection or by malignancy in the area from which they receive lymph. They then become palpable and examination of these nodes provides valuable information regarding the presence and spread of disease. It is, therefore, of importance for the medical student to know something of the lymphatic drainage of the different parts of the body.

Lymph Nodes

The main lymph nodes of the upper limb are the axillary lymph nodes. These have been described in Chapter 4. Other nodes are as follows.

1. The infraclavicular nodes lie in or on the clavipectoral fascia along the cephalic vein. They drain the upper part of the breast, and the thumb with its web.

2. The deltopectoral node lies in the deltopectoral groove along the cephalic vein. It is a displaced node of the infraclavicular set, and drains similar structures.

1. The superficial cubital or supratrochlear nodes lie just above the medial epicondyle along the basilic I vein. They drain the ulnar side of the hand and forearm.

2. A few other deep lymph nodes lie in the following regions:

(ij along the medial side of the brachial artery; (ii)

at the bifurcation of the brachial artery (deep

cubital lymph node); and (iii) occasionally

along the arteries of the forearm. I

Lymphatics

Superficial Lymphatics

Superficial lymphatics are much more numerous than the deep lymphatics. They collect lymph from the skin and subcutaneous tissues. Most of them ultimately drain into the axillary nodes, except for; (i) a few vessels from the medial side of the forearm which drain into the superficial cubital nodes, and (ii) a few vessels from the lateral side of the forearm which drain into the deltopectoral or infraclavicular nodes.

The dense palmar plexus drains mostly into the lymph vessels on to the dorsum of the hand, where these continue with the vessels of the forearm. Lymph vessels of the back of forearm and arm curve round their medial and lateral surfaces ascend up to reach the floor of the axilla. Thus there is a vertical area of *'lymphshed'* in the middle of back of forearm and arm (Fig. 6.9).

Deep Lymphatics

Deep lymphatics are much less numerous than the superficial lymphatics. They drain structures lying deep to the deep fascia. They run along the main blood vessels of the limb, and end in the axillary nodes. Some of the lymph may pass through the deep lymph nodes present along the axillary vein as mentioned above (Figs 6.10, 6.11).

CLINICAL ANATOMY

1. Inflammation of lymph vessels is known as *lymphangitis.* In acute lymphangitis, the vessels may be seen through the skin as red, tender (= painful to touch) streaks.

2. Inflammation of lymph nodes is called *lymphadenitis.* It may be acute or chronic. The nodes enlarge and become palpable and painful.

3. Obstruction to lymph vessels can result in accumulation of tissue fluid in areas of drainage.

Axillary lymph nodes

Tributaries from cutaneous plexus

Dense palmar plexus

Lymph shed on the back

Vessels passing to the front

Anterior view

Posterior view
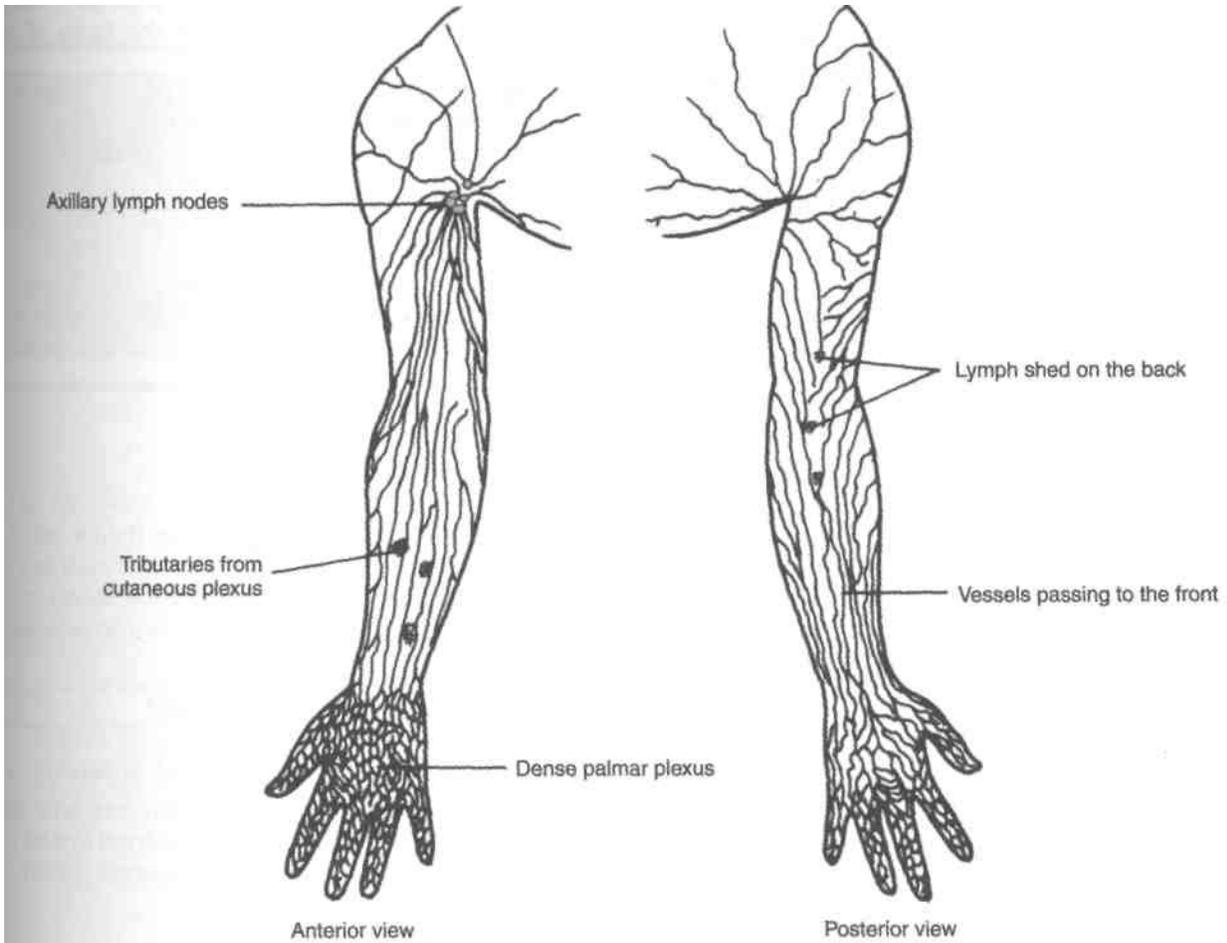
Fig. 6.9: The superficial lymphatics of the upper limb.

Supraclavicular

Apical

Anterior axillary

Central axillary

Lateral axillary

Posterior axillary
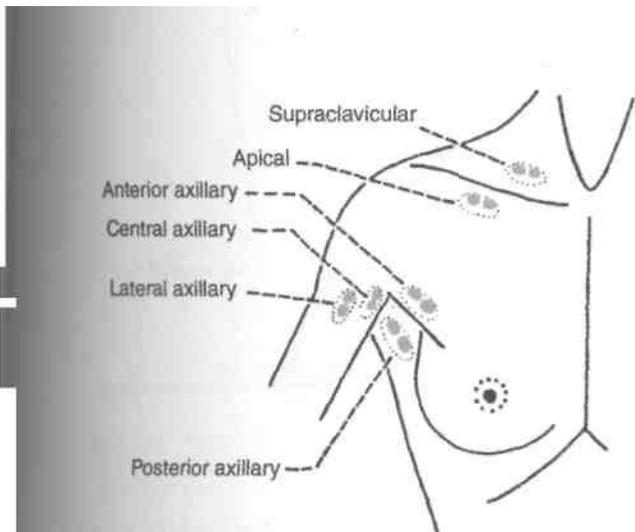
Fig. 6.10: Lymph nodes in relation to walls of the axilla.

Apical group

Anterior group

Lateral group

Central group

Posterior group

Pectoralis minor
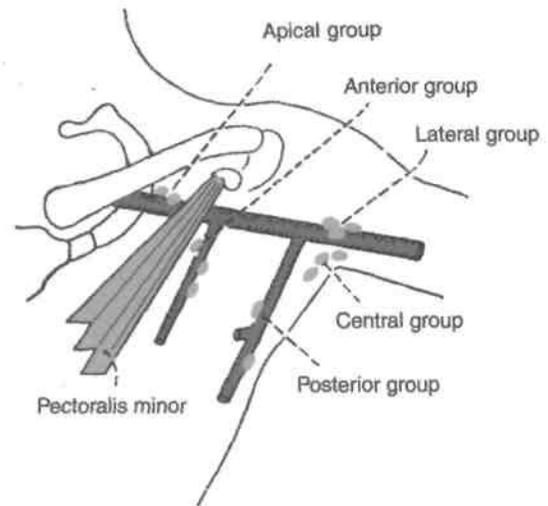
Fig. 6.11: Lymph nodes in relation to the axillary vein.

This is called *lymphoedema.* This may be caused by carcinoma, infection with some parasites like

,.., . . *f* ,,. , i <-i t.

iilana, or because oi surgical removal of lymph nodes

References and Additional Reading

HALIM A and ABDI SHM (1974). Superficial venous patterns in the cubital region of Indians. *Anatomical Record,* 178: 631-636.

^Gm JJ *and* GARRETr FD f^1948>- *The* segmental distriJ ^n of th<~ ^taneous "^J? the limbs of maa| *Anatomical Record,* 102:409-437.

TEWARI SP, SINGH SP and SINGH S (1971). The arrangement! of superficial veins in the cubital fossa in Indian subjects. *Journal of Anatomical Society of India,* 20:99-102.

The Shoulder or Scapular Region

T*he shoulder or scapular region comprises struc-tures which are closely related to and surround the shoulder joint. For a proper understanding of the region revise some features of the scapula and the upper end of the humerus. Note the following:

<u>1</u>　　　　　**SURFACE LANDMARKS**

1. Following *bony landmarks* are palpable:

(a) The acromion, crest of the spine, its medial and lateral borders, and inferior angle of the scapula can be felt through the skin (Fig. 7.1).

Fig. 7.1: Surface landmarks — Shoulder, axilla, arm and elbow regions (posterior aspect).

(b) The upper half of the humerus is covered on its anterior, lateral and posterior aspects by the deltoid muscle. This muscle is triangular in shape and forms the rounded contour of the shoulder.

(c) The greater tubercle of the humerus forms the most lateral bony point of the shoulder.

2- The *skin* covering the shoulder region is sup-plied by:

(a) The lateral supraclavicular nerve, over the upper half of the deltoid;

(b) the upper lateral cutaneous nerve of the arm, over the lower half of the deltoid; and

(c) the dorsal rami of the upper thoracic nerves, over the back, i.e. over the scapula.

1. The *superficial fascia* contains (in addition to moderate amounts of fat and cutaneous nerves) the inferolateral part of the platysma arising from the deltoid fascia.

2. The deep fascia covering the deltoid sends numerous septa between its fasciculi. The sub-scapularis, supraspinatus and infraspinatus fasciae provide origin to a part of the respective muscle.

MUSCLES OF THE SCAPULAR REGION

These are the deltoid, the supraspinatus, the infraspinatus, the teres minor, the subscapularis, and the teres major. The deltoid is described below. The other muscles are described in Tables 7.1 and 7.2.

The Deltoid

Origin

1. The anterior border of the lateral one-third of the clavicle (Fig. 7.2).

2. The lateral border of the acromion.

3. Lower lip of the crest of the spine of the scapula.

Table 7.1: Attachments of muscles of scapular region (except deltoid)

: Muscle	Origin from	Insertion into
\ 1. Supraspinatus	Medial two-thirds of the supraspinous fossa of the scapula	Upper impression of the greater tubercle of the humerus
2. Infraspinatus	Medial two-thirds of the infraspinous fossa of the scapula	Middle impression on the greater tubercle of the humerus
| 3. Teres minor	Upper two-thirds of the dorsal surface of the lateral border of the scapula	Lowest impression on the greater tubercle of the humerus
1.Subscapularis (multipennate)	Medial two-thirds of the subscapular fossa	Lesser tubercle of the humerus
2.Teres major	Lower one-third of the dorsal surface of lateral border and inferior angle of the scapula	Medial lip of the bicipital groove of the humerus

Table 7.2: Nerve supply and actions of muscles of scapular region (except deltoid)

! Muscle	Nerve supply	Actions
j Supraspinatus !• (Fig. 7.4)	Suprascapular nerve (C5, C6)	(i) The supraspinatus initiates abduction of the arm and carries it up to 15° (ii) Along with other short scapular muscles it steadies the head of the humerus during movements of the arm, so that the latter does not slip out of the glenoid cavity
I Infraspinatus	Suprascapular nerve (C5, C6)	(i) Lateral rotator of arm (ii) See supraspinatus
| Teres minor	Axillary nerve (C5, C6)	Same as infraspinatus
I Subscapularis (Fig. 7.5)	Upper and lower subscapular nerves	Medial rotator and adductor of arm
\ Teres major	Lower subscapular nerve	Same as subscapularis

Insertion

The deltoid tuberosity of the humerus.

Nerve Supply Axillary

nerve (C5, C6).

Structure

The acromial part of deltoid is an example of a multipennate muscle. Many fibres arise from four septa of origin that are attached above to the acromion. The fibres converge on to three septa of insertion which are attached to the deltoid tuberosity (Fig. 7.2). A multipennate arrangement allows a large number of muscle fibres to be packed into a relatively small volume. As the strength of contraction of a muscle is proportional to the number of muscle fibres present in it (and not on their length),

a multipennate muscle is much stronger than other muscles having the same volume.

Actions

1.The acromial fibres are powerful abductors of the arm at the shoulder joint from 15°-90°.
2.The anterior fibres are flexors and medial rotators of the arm.
3.The posterior fibres are extensors and lateral rotators of the arm.

Structures Under Cover of the Deltoid
Bones

(i) The upper end of the humerus, (ii)
The coracoid process.

Spine of scapula
Clavicle
Acromion
Posterior fibres
Anterior fibres
Intermuscular septum
of origin

Supraspinatus
Teres minor
Infraspinatus
Insertions into humerus
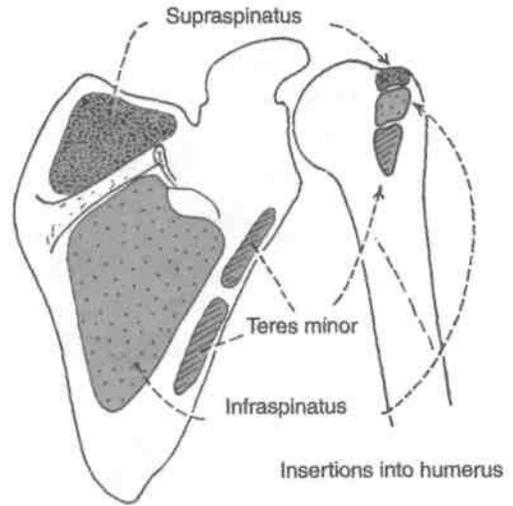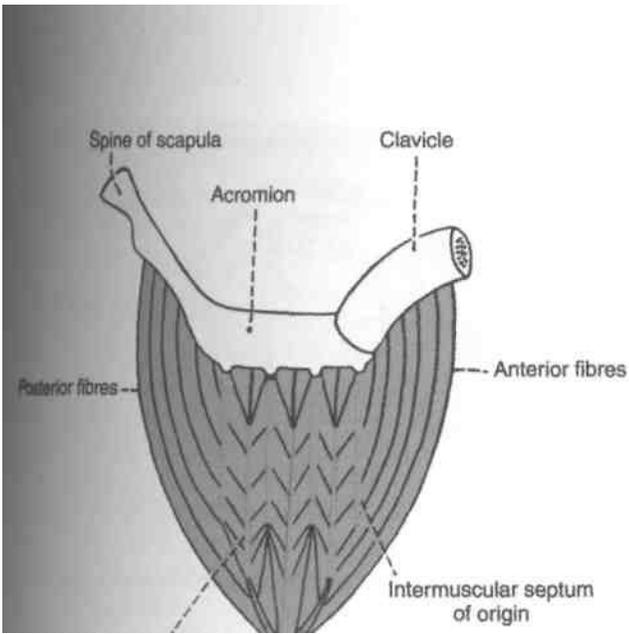
Intermuscular septum   Deltoid tuberosity of insertion

Fig. 7.2: The origin and insertion of the deltoid muscle.

Fig. 7.3: *The origin and insertion of the supraspinatus, infraspinatus and teres minor muscles.*

Muscles

Insertions of

(i) Pectoralis minor on coracoid process. (ii) Supraspinatus, infraspinatus, and teres minor (on the greater tubercle of the humerus) (Fig. 7.3). (iii) Subscapularis on lesser tubercle of humerus
(Fig. 7.4).

(iv) Pectoralis major, teres major and latissimus dorsi on the intertubercular sulcus of the humerus (Fig. 7.5).

Origin of:

(i) Coracobrachialis and short head of biceps from the coracoid process.

(ii) Long head of the biceps from the supraglenoid tubercle.

(iii) Long head of the triceps from the infraglenoid tubercle.

(iv) The lateral head of the triceps from the upper end of the humerus.

Fig. 7.4: *The subscapularis r*
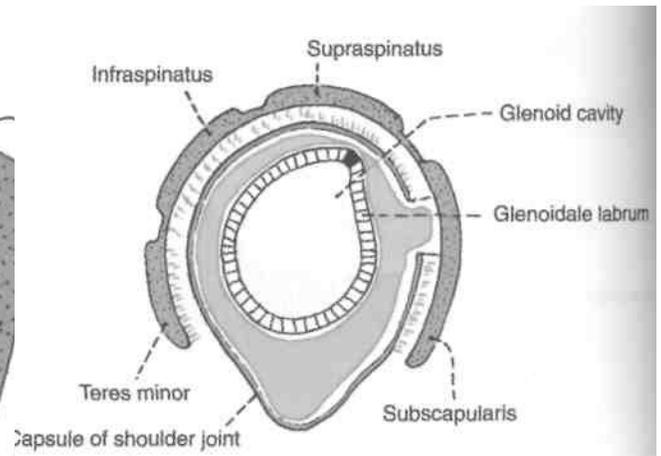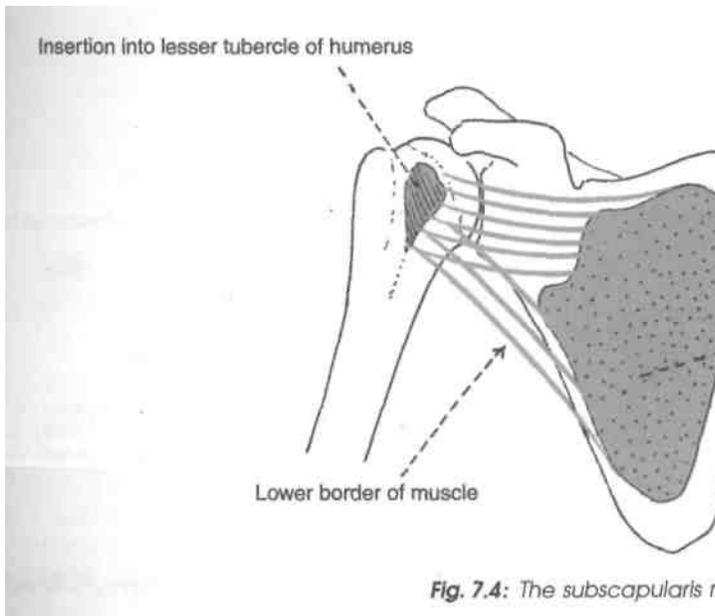
Fig. 7.7: *The musculotendinous cuff of the shoulder.*
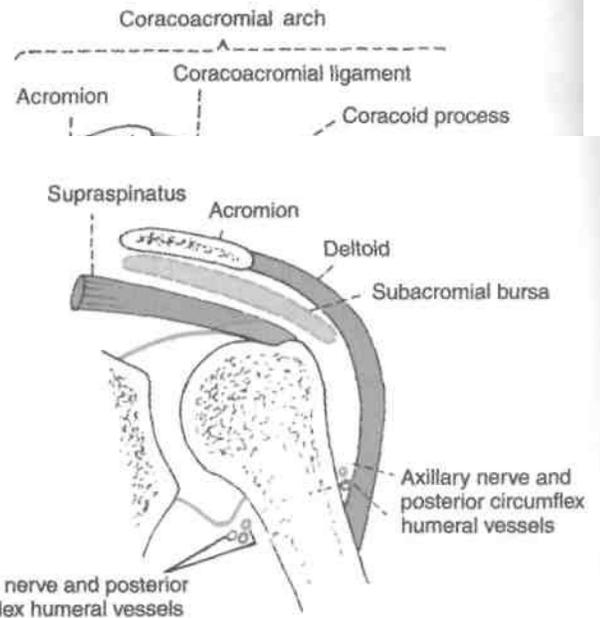
Fig. 7.9: *The subacromial bursa as seen in coronal section.*

Pectoralis major   Tendon of long
'   head of biceps
Coracobrachialis and short head of biceps v   i   nelfoid
                    Latissimus dorsi   \   \   /   /
                    Teres major.   \   A'NSтV   \£\ Subscapulans   N~-^s&»^~-^i \   \   \

Infraspinatus
Humerus

Fig. 7.5: Horizontal section of the deltoid region showing arrangement of the muscles in and around the bicipital groove.

Vessels

(i) Anterior circumflex humeral, (ii) Posterior circumflex humeral (Fig. 7.6).

Nerve

Axillary (Fig. 7.6).
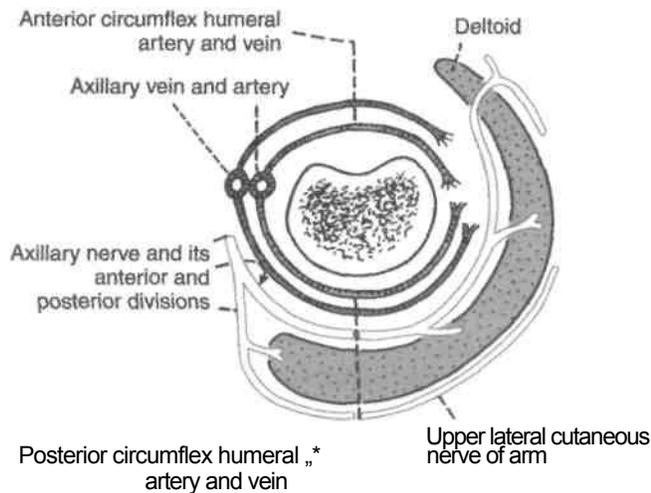
Fig. 7.6: Horizontal section of the deltoid region showing the nerves and vessels around the surgical neck of humerus.

Joints and Ligaments

(i) Musculotendinous cuff of the shoulder (Fig. 7.7). (ii) thoracoacromial ligament.

Bursae

All bursae around the shoulder joint, including the subacromial or subdeltoid bursa (Figs 7.8, 7.9).

Define the margins of the deltoid muscle covering the shoulder joint region (Fig. 7.10). Reflect the part of the muscle arising from spine of scapula downwards. Separate the infraspinatus muscle from teres major and minor muscles which run from the lateral scapular border towards humerus. Axillary nerve accompanied with posterior circumflex humeral vessels lies on the deep aspect of the deltoid muscle. These structures should be traced towards quadrangular intermuscular space; through which these pass. The quadrangular space is bounded by teres minor above and teres major below; by the long head of triceps muscle medially and the surgical neck of humerus laterally. Identify the nerve to the teres minor muscle.

Another intermuscular space, the upper triangular space should be dissected. It is bounded by the lateral border of scapula medially, long head of triceps laterally, and teres major muscle below. Now the remaining two-thirds of deltoid muscle can be reflected towards its insertion. Identify subscapularis muscle anteriorly. Define the attachments. Cut through the infraspinatus muscle at the neck of scapula and reflect it on both sides. Dissect and identify the arteries taking part in the anastomosis around scapula. These are suprascapular along upper border, deep branch of transverse cervical (dorsal scapular) along medial border and circumflex scapular along lateral border of scapula. Look for the structures covered with deltoid muscle.

Identify a lower triangular space which is bounded above by the lower border of teres major muscle, medially by the long head and laterally by the lateral head of triceps brachii muscle. The radial nerve and profunda brachii vessels pass through the space.

iisculotendinous Cuff of the Shoulder or Rotator iff

Musculotendinous cuff of the shoulder is a fibrous sheath formed by the four flattened tendons which blend with the- capsule of the shoulder joint and strengthen it. frhe muscles which form the cuff arise from the scapula and are inserted into the lesser and greater tubercles of the humerus. They are the subscapularis, the supraspinatus, the infraspina-

tus and the teres minor (Fig. 'kSu Their tendons, while crossing the shoulder joint, ^become flattened and blend with each other on one hand, and with the capsule of the joint on the other hand, before reaching their points of insertion.

The cuff gives strength to the capsule of the shoulder joint all around except interiorly. This explains why dislocations of the humerus occur most commonly in a downward direction.

Subacromial Bursa

Subacrominal bursa is the largest bursa of the body, situated below the coracoacromial arch and the deltoid muscle. Below the bursa there are the tendon of the supraspinatus and the greater tuberosity of the humerus (Figs 7.8, 7.9).

The subacromial bursa is of great value in the abduction of the arm at the shoulder joint, (i) It protects the supraspinatus tendon against friction with the acromion, (ii) During overhead abduction the greater tuberosity of the humerus passes under the acromion: this is facilitated by the presence of this bursa.

1.Intramuscular injections are often given into the deltoid. They should be given in the lower half of the muscle to avoid injury to the axillary nerve.

2.The deltoid muscle is tested by asking the patient to abduct the arm against resistance applied with one hand, and feeling for the contracting muscle with the other hand.

3.In subacromial bursitis, pressure over the deltoid below the acromion with the arm by the side causes pain. However, when the arm is abducted pressure over the same point causes no pain, because the bursa disappears under the acromion (Dawbarn's sign). Subacromial or subdeltoid bursitis is usually secondary to inflammation of the supraspinatus tendon. In this condition there is pain in the shoulder on abduction and medial rotation of the arm.

4.The tendon of the supraspinatus may undergo degeneration. This can give rise to calcification and even spontaneous rupture of the tendon.

Intermuscular Spaces

Three intermuscular spaces are to be seen in the scapular region (Figs 7.10, 7.11). These are:
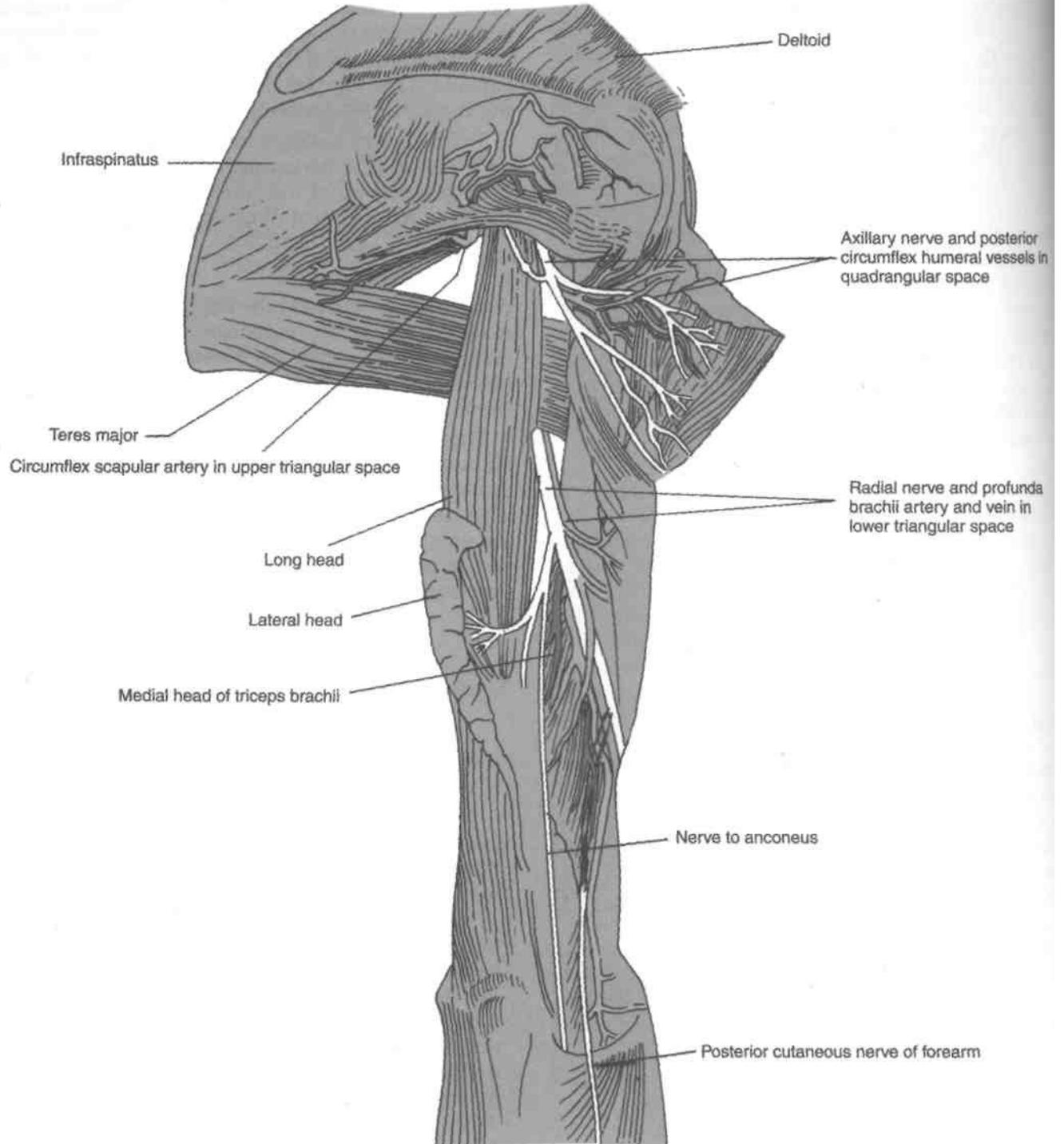
Fig. 7.10: The scapular region.

Labels in figure:
- Deltoid
- Infraspinatus
- Axillary nerve and posterior circumflex humeral vessels in quadrangular space
- Teres major
- Circumflex scapular artery in upper triangular space
- Radial nerve and profunda brachii artery and vein in lower triangular space
- Long head
- Lateral head
- Medial head of triceps brachii
- Nerve to anconeus
- Posterior cutaneous nerve of forearm

Quadrangular Space

Boundaries: *Superior.* (i) Subscapularis in front, (ii) Capsule of the shoulder joint, (iii) Teres minor behind. *Inferior.* Teres major.

Fig. 7.11: *The intermuscular spaces in the scapular region, including the quadrangular, upper triangular and lower triangular spaces.*
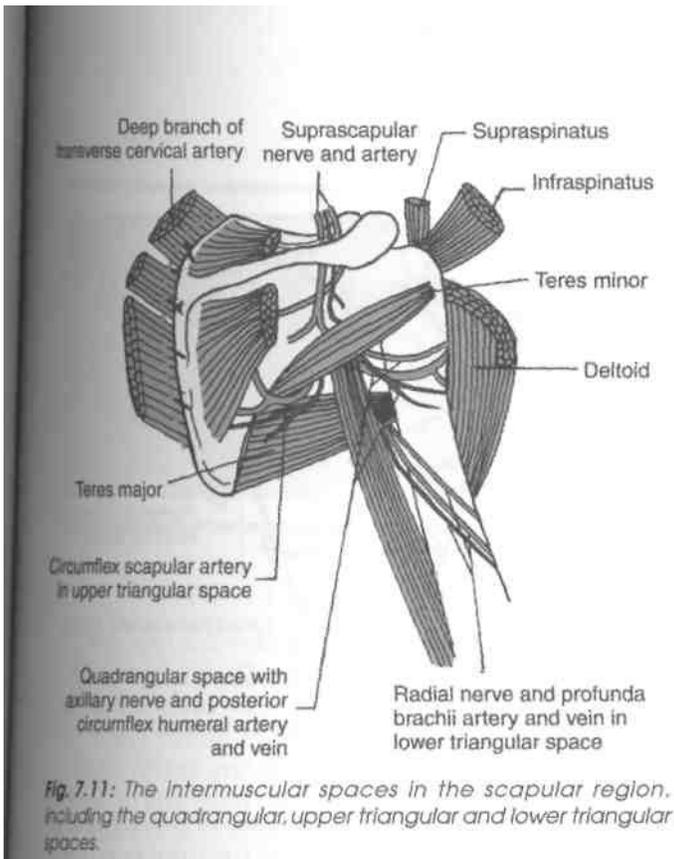
Upper Triangular Space

Boundaries: *Medial.* Teres minor.
Lateral. Long head of the triceps.
Inferior. Teres major.

Contents: Circumflex scapular artery. It interrupts the origin of the teres minor and reaches the infraspinous fossa for anastomosis with the suprascapular artery.

Lower Triangular Space

Boundaries: *Medial.* Long head of the triceps.
Lateral. Medial border of humerus.
Superior. Teres major.

Contents: (i) Radial nerve.
(ii) Profunda brachii vessels.

AXILLARY OR CIRCUMFLEX NERVE

Axillary or circumflex nerve is an important nerve because it supplies the deltoid muscle which is the main abductor of the arm. Surgically it is important, because it is commonly involved in dislocations of the shoulder and in fractures of the surgical neck of the humerus.

The axillary nerve is a branch of the posterior cord of the brachial plexus (C5, C6).

Surface Marking

Axillary or circumflex nerve is marked as a horizontal line on the deltoid muscle, 2 cm above the midpoint between the.tip of the acromion process and the insertion of the deltoid (Fig. 8.21).

Intramuscular injections in the deltoid are given in the lower part of the muscle nearer to its insertion to avoid injury to the nerve and its accompanying vessels.

Root Value

Its root value is ventral rami of cervical 5, 6 segments of spinal cord.

Course and Relations

(A) In the lower part of the axilla, the nerve runs downwards behind the third part of the axillary artery. Here it lies on the subscapularis muscle. It is related medially to the median nerve, and laterally to the coracobrachialis.

The nerve leaves the axilla by winding round the lower border of the subscapularis in close relation to the lowest part of the capsule of the shoulder joint, and enters the quadrangular space.

(B) The nerve then passes backwards through the quadrangular space. Here it is accompanied by the posterior circumflex humeral vessels and has the following relations (Figs 7.10, 7.11).

Superiorly

(i) Subscapularis.
(ii) Lowest part of the capsule of the shoulder joint, (iii) Surgical neck of humerus (Fig. 7.6).

Interiorly Teres

major.

Medially

Long head of the triceps.

In the quadrangular space, the nerve divides into anterior and posterior branches in relation to the deltoid muscle (Fig. 7.6).

(C) The anterior branch is accompanied by the posterior circumflex humeral vessels. It winds round the surgical neck of the humerus, deep to the deltoid, reaching almost up to the anterior border of the muscle. It supplies the deltoid and the skin over its anteroinferior part.

(DJ The posterior *branch supplies* the teres minor and the posterior part of the deltoid. The nerve to the teres minor bears a pseudoganglion, fibrous tissue

and fat without any neurons (Fig. 7.10). The posterio branch then pierces the deep fascia at the lower par of the posterior border of the deltoid and continues a; the upper lateral cutaneous nerve of the arm.

Branches and Distribution

Muscular

To the deltoid and the teres minor. The nerve to tb teres minor bears a pseudoganglion.

Cutaneous

The upper lateral cutaneous nerve of the arm sup plies the skin covering the lower half of the deltoi< and the upper part of the long head of the tricep; (Fig. 6.1).

Articular

An articular branch is given to the shoulder joint The branch arises from the trunk of the axillary nerve and enters the joint just below the subscapularis.

Vascular

Sympathetic fibres along the axillary nerve suppl the posterior circumflex humeral artery.

CLINICAL ANATOMY

The axillary nerve may be damaged by dislocation of the shoulder or by the fracture of the surgical neck of the humerus. The effects produced are: (i)   Deltoid is paralysed, with loss of the power
of abduction upto 90° at the shoulder, (ii)   The rounded contour of the shoulder is lost, and the greater tubercle of the humerus becomes prominent. (Ill)   There is sensory loss over the lower half of the deltoid.

ANASTOMOSIS AROUND THE SCAPULA

Anastomoses around the body of the scapula The anastomoses occurs in the three fossae, subscapular, supraspinous and infraspinous. It is formed by:

(a)The suprascapular artery, a branch of the thyrocervical trunk;

(b)the deep branch of the transverse cervical artery, another branch of the thyrocervical trunk;

(c)the circumflex scapular artery, a branch of the subscapular artery which arises from the third part of the axillary artery.

Fig. 7.12: *Anastomosis around the scapula.*
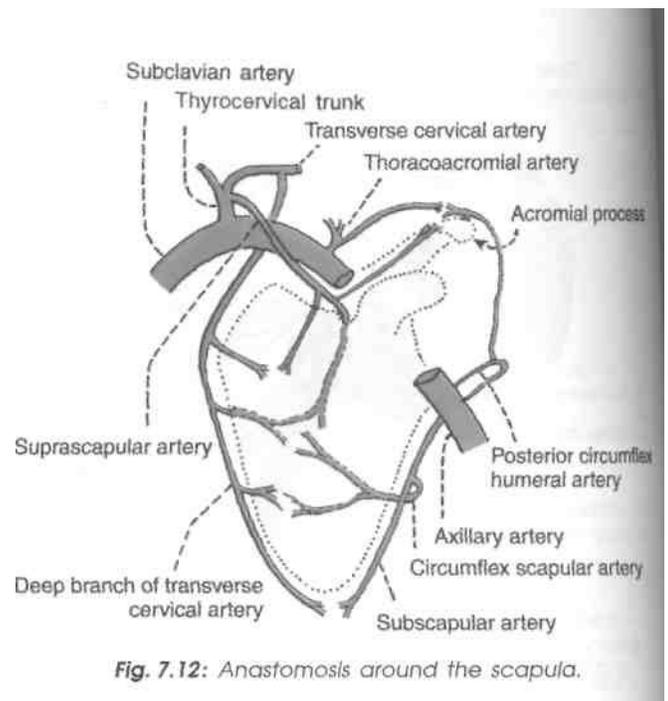
Note that this is an anastomoses between the first | part of the subclavian artery and the third part of the axillary artery.

Anastomoses over the acromion process

It is formed by:

(a)The acromial branch of the thoracoacromial artery;

(b)the acromial branch of the suprascapular artery; and

(c)the acromial branch of the posterior circumflex humeral artery.

Note that this also is an anastomoses between the first part of the subclavian artery and the third part of the axillary artery (Fig. 7.12).

CLINICAL ANATOMY

These anastomoses provide a collateral circulation through which blood can flow to the limb when the distal part of the subclavian artery, or the proximal part of the axillary artery is blocked. The shoulder girdle and the shoulder joint are parts of the scapular region. They are described in Chapter **10.**

Additional Reading

ATHAWALE MC and JOSHI MM (1975). Additional head of subscapularis muscle. *Journal of Anatomical Society of India,* 24:82.

The Arm

T^he arm extends from the shoulder joint till the elbow joint. The skeleton of the arm is a 'solo' bone, the humerus. Medial and lateral intermuscular septa divide the arm into an anterior or flexor compartment and a posterior or extensor compartment, to give each compartment its individuality and freedom of action. Since the structures in the front of arm continue across the elbow joint into the cubital fossa, the cubital fossa is also included in this chapter. The arm is called brachium, so most of the structures in this chapter are named accordingly, like brachialis, coracobrachialis and brachial
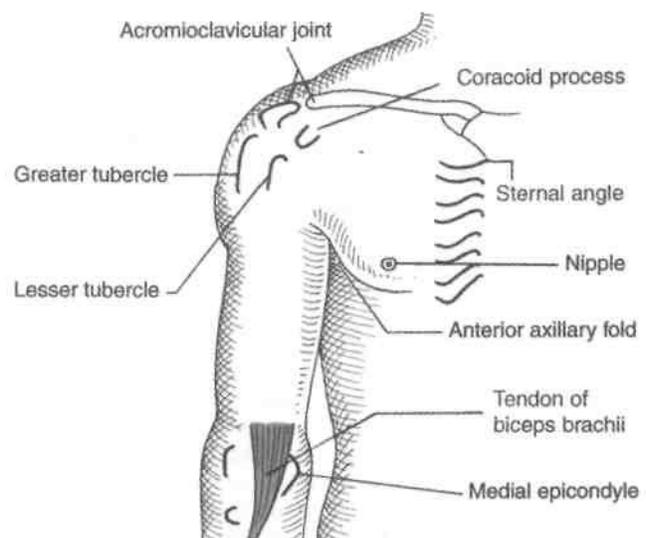
Fig. 8.1: *Surface landmarks — front of upper arm.*

artery.

SURFACE LANDMARKS

The following landmarks can be felt in the living subject.

1.The *greater tubercle of the humerus* is the most lateral bony point in the shoulder region. It can be felt just below the acromion, deep to the deltoid when the arm is by the side of the trunk (Fig. 8.1).

2.The *shaft of the humerus* is felt only indistinctly because it is surrounded by muscles in its upper half. In the lower half, the humerus is covered anteriorly by the biceps and brachialis, and posteriorly by the triceps.

3.The *medial epicondyle* of the humerus is a prominent bony projection on the medial side of the elbow. It is best seen and felt in a midflexed elbow.

4.The *lateral epicondyle of the humerus* is less prominent than the medial. It can be felt in the upper part of the depression on the posterolateral aspect of the elbow in the extended position of the forearm.

5.The medial and lateral *supracondylar ridges* are better defined in the lower portions of the medial

and lateral borders of the humerus. They can be felt in the lower one-fourth of the arm as upwards continuations of the epicondyles.

1.The *deltoid* forms the rounded contour of the shoulder. The apex of the muscle is attached to the deltoid tuberosity located at the middle of the anterolateral surface of the humerus.

2.The *coracobrachialis* forms an inconspicuous rounded ridge in the upper part of the medial side of the arm. Pulsations of the brachial artery can be felt, and often seen, in the depression behind it.

3.The *biceps brachii* muscle is overlapped above by the pectoralis major and by the deltoid. Below these muscles the biceps forms a conspicuous elevation on the front of the arm. Upon flexing the elbow the contracting muscles becomes still more prominent. The tendon of the biceps can be felt in front of the elbow. The tendon is a guide to the brachial artery which lies on the its medial side.

9. The brachial artery can be felt in front of the elbow joint just medial to the tendon of the biceps. Brachial pulsations are used in recording the blood pressure.

1.The ulnar nerve can be rolled by the palpating finger behind the medial epicondyle of the humerus.

2.The superficial cubital veins can be made more prominent by applying tight pressure round the arm and then contracting the forearm muscles by clenching and unclenching the fist a few times. The cephalic vein runs upwards along the lateral border of the biceps. The basilic vein can be seen along the lower half of the medial border of the biceps. The cephalic and basilic veins are connected together in front of the elbow by the median cubital vein which runs obliquely upwards and medially.

COMPARTMENTS OF THE ARM

The arm is divided into anterior and posterior compartments by extension of deep fascia which are called the *medial and lateral intermuscular septa* (Fig. 8.2). These septa provide additional surface for the attachment of muscles. They also form planes along which nerves and blood vessels travel. The septa are well defined only in the lower half of the arm and are attached to the medial and lateral borders and supracondylar ridges of the humerus. The medial septum is pierced by the ulnar nerve and the superior ulnar collateral artery; the lateral septum is pierced by the radial nerve and the anterior descending branch of the profunda brachii artery.
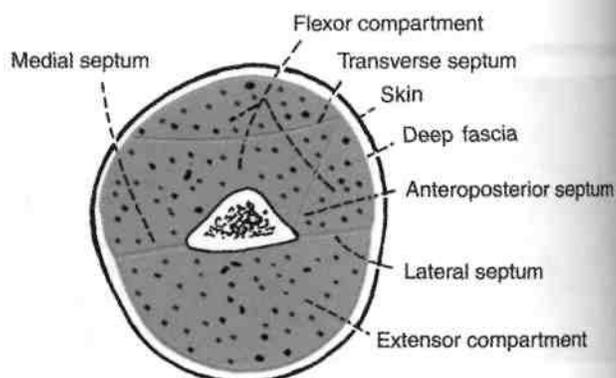
Fig. 8.2: *Transverse section through the distal one-third of the arm, showing the intermuscular septa and the compartments.*

Two additional septa are present in the anterior compartment of the arm. The *transverse septum* separates the biceps from the brachialis and encloses the musculocutaneous nerve. The *anteroposterior septum* separates the brachialis from the muscles attached to the lateral supracondylar ridge; it encloses the radial nerves and the anterior descending branch of the profunda brachii artery.

MUSCLES OF THE ANTERIOR COMPARTMENT OF THE ARM

Muscles of the anterior compartment of the arm are the coracobrachialis, the biceps brachii and the brachialis. They are described in Tables 8.1 and 8.2. Some additional points about the muscles are given:

Table 8.1: Attachments of muscles of the front of the arm

Muscle	Origin from	Insertion into
1. Coracobrachialis	(i) The tip of the coracoid process with the short head of the biceps	The middle 5 cm of the medial border of the humerus
2. Biceps brachii (Fig. 8.3)	It has two heads of origin (i) The short head arises with coracobrachialis from the tip of the coracoid process	(a) Posterior rough part of the radial tuberosity. The tendon is separated from the anterior part of the tuberosity by a bursa (Fig. 8.4)
	(ii) The long head arises from the supraglenoid tubercle of the scapula and from the glenoidal labrum. The tendon is intracapsular	(b) The tendon gives off an extension called the bicipital aponeurosis. This merges with the deep fascia of the forearm
3. Brachialis (Fig. 8.5)	(i) Lower half of the front of the humerus, including both the anteromedial and anterolateral surfaces and the anterior border. Superiorly the origin embraces the insertion of the deltoid.	(a) Ulnar tuberosity (b). Rough anterior surface of the coronoid process of the ulna.
	(ii) Medial and lateral intermuscular septa	

Origin of short head
from coracoid process

igin of long head from
supraglenoid tubercle

Muscle belly -----

Bicipital aponeurosis

Biceps tendon inserted
into radial tuberosity

Fig. 8.3: *The biceps brachii muscle.*

Bicipital aponeurosis ---

Biceps tendon

Bursa

Radial tuberosity
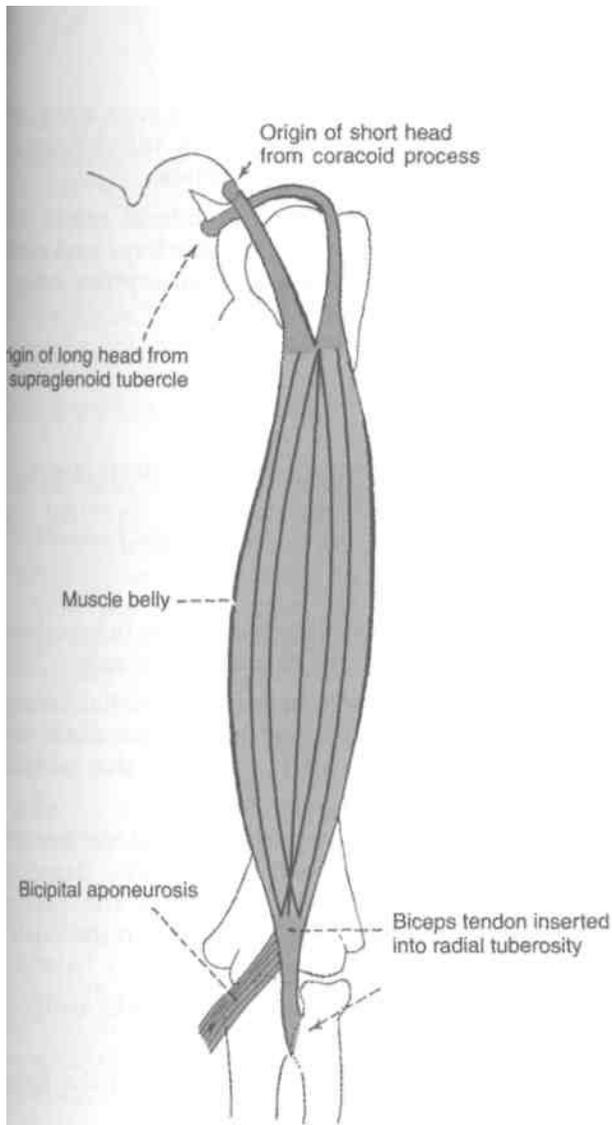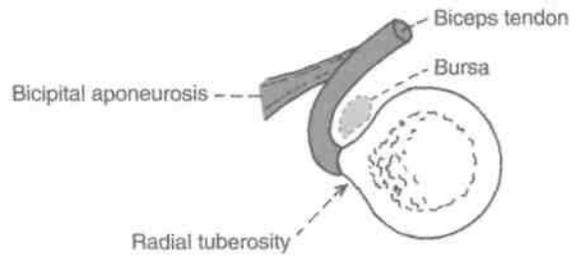
Fig. 8.4: *The precise mode of insertion of the biceps brachii muscle.*

Humerus ---

Origin from front of shaft of humerus and
from medial and lateral intermuscular septa

Radius ---

Insertion into front of
coronoid process and
tuberosity of ulna
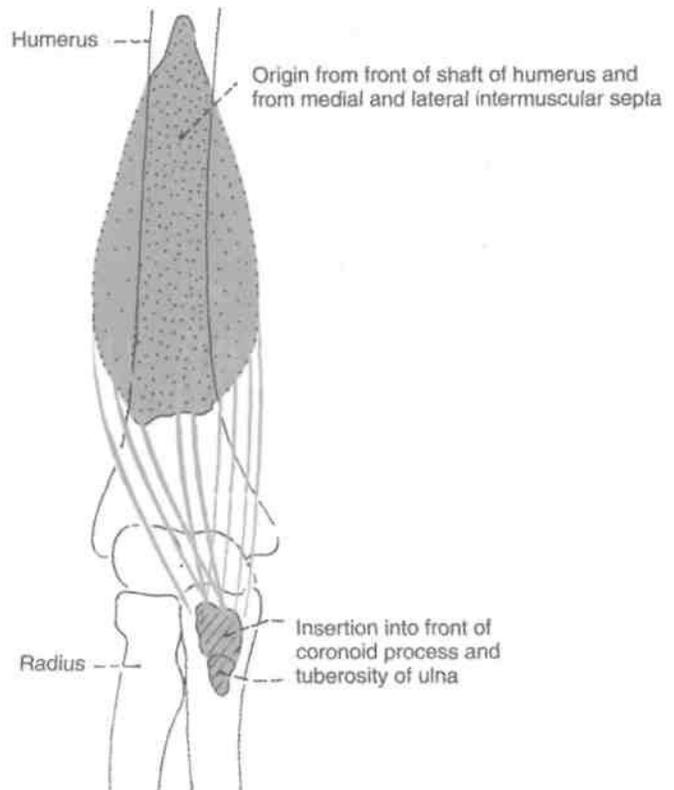
Fig. 8.5: *The origin and insertion of the brachialls muscle.*

Table 8.2: Nerve supply and actions of muscles of the front of the arm

Muscle	Nerve supply	Actions
(1. Coracobrachialis	Musculocutaneous nerve (C5-C7)	Flexes the forearm at the elbow joint)
1/ (l. Biceps brachii	Musculocutaneous nerve (C5, C6)	(i) It is strong supinator when the forearm is flexed. All screwing movements are done with it
		(ii) It is a flexor of the elbow
		(iii) The short head is a flexor of the arm.
		(iv) The long head prevents upwards displacement of the head of the humerus (v) It can be tested against resistance as shown in Fig. 8.6^
I /3. Brachialis	(i) Musculocutaneous nerve is moton	Flexes forearm at the elbow joint j
	(ii) Radial nerve is proprioceptive	J
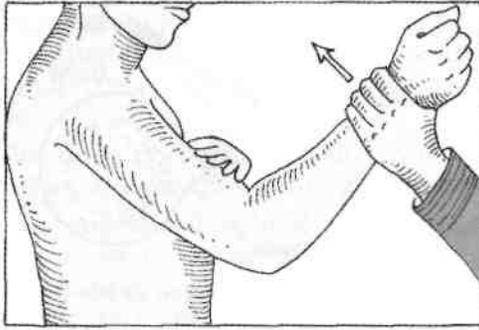
Fig. 8.6: *Testing biceps brachii against resistance.*

DISSECTION

Make an incision in the middle of deep fascia of the upper arm right down up to the elbowjoint. Reflect the flaps sideways. The most prominent muscle seen is the biceps brachii. Deep to this, another muscle called brachialis is seen easily. In the fascial septum between the two muscles lies the musculocutaneous nerve (a branch of the lateral cord of brachial plexus). Trace the tendinous long head of biceps arising from the supraglenoid tubercle and the short head arising from the tip of the coracoid process of scapula. Identify coraco-brachialis muscle on the medial side of biceps. Clean the branches of the nerve supplying all the three muscles dissected.

Additional Points about the Coracobrachialis

1.The muscle is pierced by the musculocutaneous nerve.
2.Morphologically it represents the medial compartment of the arm.
3.Its insertion is an important landmark; many transitions occur at this level.

Changes at the level of Insertion of Coracobrachialis

1.*Bone:* The circular shaft becomes triangular below this level.
2.*Fascial septa:* The medial and lateral intermuscular septa become better defined from this level down.
3.*Muscles*
  (i)   Deltoid is inserted at this level, (ii)   Upper end of origin of brachialis. (iii)   Upper end of origin of the medial head of triceps.
4. *Arteries*
  (i)   The brachial artery passes from the medial side of the arm to its anterior aspect.

  (ii) The profunda brachii artery runs in the spiral groove and divides into its anterior and posterior descending branches.
  (iii)   The superior ulnar collateral artery origi-nates from the brachial artery, and pierces the medial intermuscular septum with the ulnar nerve.
  (iv)   The nutrient artery of the humerus enters the bone.

5. *Veins*
  (i) The basilic vein pierces the deep fascia.
  (ii) Two venae comitants of the brachial artery may unite to form one brachial vein.

6. *Nerves*
  (i)   The median nerve crosses the brachial artery from the lateral to the medial side.
  (ii)   The ulnar nerve pierces the medial intermuscular septum with the superior ulnar collateral artery and goes to the posterior compartment.
  (iii)   The radial nerve pierces the lateral intermuscular septum with the anterior descending (radial collateral) branch of the profunda brachii artery and passes from the posterior to the anterior compartment.
  (iv)   The medial cutaneous nerve of the arm pierces the deep fascia.
  (v)   The medial cutaneous nerve of the forearm pierces the deep fascia.

Morphology of Coracobrachialis

The muscle is more important morphologically than functionally. It represents the *medial compartment of* the arm which is so well developed in the thigh. In some animals, the muscle is bicipital. In man, the upper two heads have fused, but the musculocutaneous nerve passes between the remnants of these two heads. The third and lowest head of the muscle has disappeared in man. Occasional persistence of the lower head is associated with the presence of the so called 'ligament of Struthers' which is a fibrous band extending from the trochlear spine to the medial epicondyle of the humerus. The third head of the coracobrachialis is inserted into this ligament. The lower part of the pronator teres muscle takes origin from the same ligament. The median nerve, or the brachial artery, or both pass subjacent to the ligament. The ligament of Struthers is, in fact, a part of the tendon of the dorsoepitrochlearis which is related to the latissimus dorsi.

The front or anterior compartment of the arm is homologous with the posterior and medial

compartments of the thigh. The flexor compartment of the thigh faces posteriorly because the lower limb rotates (during development) in a direction opposite to that of the upper limb. The medial (adductor) compartment of the arm has degenerated phylogenetically and is represented only by the coracobrachialis. However, the arm can be powerfully adducted by the large muscles in the anterior and posterior walls of the axilla, namely, the pectoralis major and the latissimus dorsi.

Additional Points *about Biceps Brachii*

I. Additional heads of biceps

(a)When present, the third head of the biceps arises from the upper and medial part of the brachialis, passes behind the brachial artery, and is inserted on the bicipital aponeurosis and the medial side of the bicipital tendon. At times the third head consists of two slips which pass in front and behind the brachial artery.

(b)A fourth head may arise from the lateral side of the humerus, or from the intertubercular sulcus.

(c)Other additional heads may occur.

1.The tendon of the long head of the biceps may be dislocated from the intertubercular sulcus. In such cases, the arm is fixed in abduction, but the head of the humerus is in normal position. The tendon is easily replaced by flexing the elbow and then rotating the limb.

2.*Bicipital aponeurosis:* This is a broad tendinous expansion from the medial side of the tendon of the biceps given off at the level of the bend of the elbow. It passes obliquely downwards and medially, crosses the brachial artery and fuses with the deep fascia covering the origin of flexors of the forearm. It separates the median cubital vein from the brachial artery, and may be pierced by the perforating vein of this region. The sharp concave upper border of the aponeurosis is easily felt when the supinated forearm is flexed against resistance.

3.The tendon of insertion of the biceps is twisted in such a way that its anterior part is formed by the short head, and the posterior part by the long head.

Additional **Points about the Brachialis**

Variations

(a) The muscle may be divided into two or more parts.

(a)It may fuse with the brachioradialis.

(b)It may send a tendinous slip to the radius, or to the bicipital aponeurosis.

The musculocutaneous nerve is the main nerve of the front of the arm, and continues below the elbow as the lateral cutaneous nerve of the forearm (Fig. 6.1). It is a branch of the lateral cord of the brachial plexus, arising at the lower border of the pectoralis minor (Fig. 4.7).

Surface Marking

Musculocutaneous nerve is marked by joining the following two points (Fig. 8.7).

(i) A point lateral to the axillary artery 3 cm above its termination, (ii) A point lateral to the tendon of the biceps brachii muscle 2 cm above the bend of the elbow. (Here it pierces the deep fascia and continues as the lateral cutaneous nerve of the forearm.)
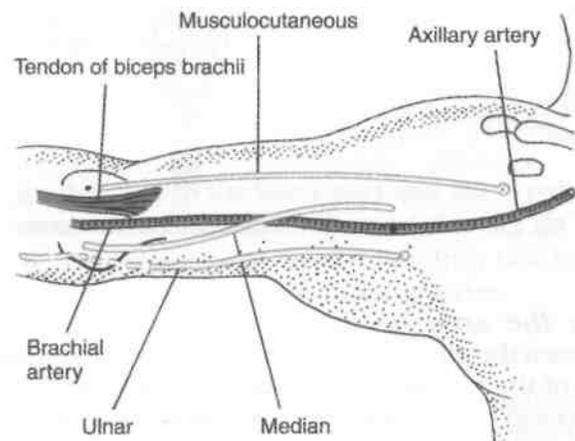
Fig. 8.7: Nerves in front of arm related to axillary and brachial arteries.

Root Value

The root value of musculocutaneous nerve is ventral rami of C5-C7 segments of spinal cord.

Course and Relations

In the lower part of the axilla: It accompanies the third part of the axillary artery and has the following relations.

Anteriorly. Pectoralis major.

Posteriorly. Subscapulars.

Medially. Axillary artery and lateral root of the median nerve (Fig. 4.13).

Laterally. Coracobrachialis (Fig. 4.14).

Musculocutaneous nerve leaves the axilla, and enters the front of the arm by piercing the coracobrachialis (Fig. 8.8).

Coracoid process

. Short head and long /, head of biceps brachii and its nerves

Lateral cord (C5,6,7) —\VJ \\ \M

Coracobrachialis and its nerve —■

Musculocutaneous nerve (C5-C7) -.-•'

Brachialis and its nerve ~-—

Biceps brachii-------

Opening in deep fascia

Lateral cutaneous nerve of forearm —S
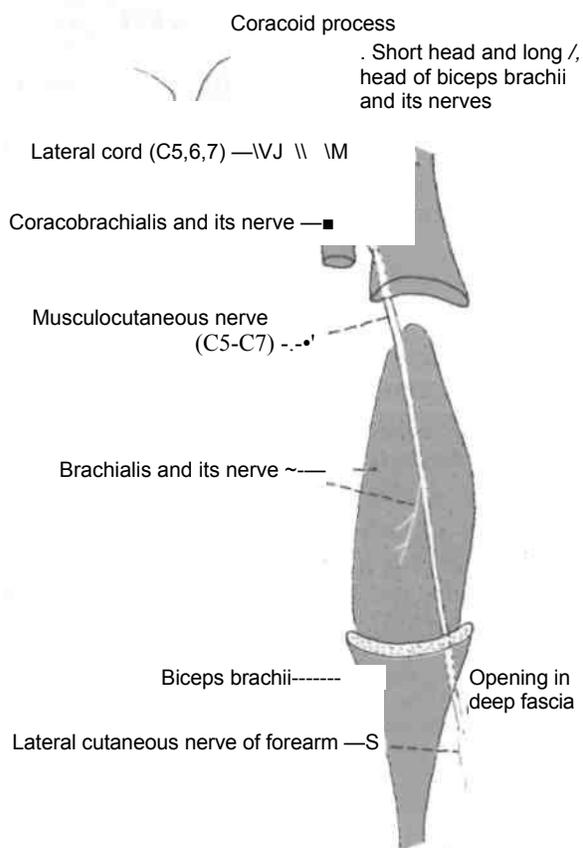
Fig. 8.8: The course of the musculocutaneous nerve.

In the arm: It runs downward and laterally between the biceps and brachialis to reach the lateral side of the tendon of the biceps. It ends by piercing the fascia 2 cm above the bend of the forearm.

Branches and Distribution

Muscular: It supplies the following muscles of the front of the arm:

 (i)   Coracobrachialis

 (ii) Biceps, long and short heads

 (iii) Brachialis (Figs 8.8, 8.9).

 / *Cutaneous:* Through the lateral cutaneous nerve of the forearm it supplies the skin of the lateral side of the forearm from the elbow to the wrist)

Articular branches: These supply: (a) the elbow joint through its branch to the brachialis; and (b) the humerus through a separate branch which enters the bone along with its nutrient artery.

Communicating branches. The musculocutaneous nerve communicates with the neighbouring nerve, namely, the superficial branch of the radial nerve, the posterior cutaneous nerve of the forearm, and the palmar cutaneous branch of the median nerve.

Variations

(1)Instead of piercing the coracobrachialis mufl culocutaneous nerve may pass behind it to reach the I interval between the biceps and the brachialis.

(2)Temporarily, it may either give fibres to, ofl receive fibres from, the median nerve.

DISSECTION

Dissect the brachial artery as it lies on the medial I side of the upper part of the arm medial to median I nerve (Fig. 8.10). IntaB lower half of the upper arm, the brachial artery is I seen lateral to the median nerve as the nedM crosses the brachial artery from lateral to medial I side. It lies on the medial side of humerus bone. I Note that the median nerve and brachial artery are I forming together a neurovascular bundle. Ulnar I nerve accompanied by the superior ulnar collateral branch of the brachial artery will be dissected later as it reaches the posterior (extensor) compartment of the upper arm after piercing the I medial intermuscular septum. Look for the radial I nerve on the posterior aspect of artery before it I enters the radial groove. Clean the branches of brachial artery and identify other arteries which I take part in the arterial anastomosis around the I elbow joint.

BRACHIAL ARTERY   I

Brachial artery is the continuation of the axillary I artery. It extends from the lower border of the teres I major muscle to a point in front of the elbow, at the I level of the neck of the radius, just medial to the I tendon of the biceps brachii.

Surface Marking

The brachial artery is marked by joining the following I two points.

(i)   A point at the junction of the anterior one-third and posterior two-thirds of the lateral wall of the axilla at its lower limit. Here the axillary artery ends and the brachial artery j begins (Fig. 8.7). (ii)   The second point, at the level of the neck of the radius medial to the tendon of the biceps brachii. Thus the artery begins on the medial side of the upper part of the arm, and runs downwards and slightly laterally to end in front of the elbow. At its termination it bifurcates into the radial and ulnar arteries.
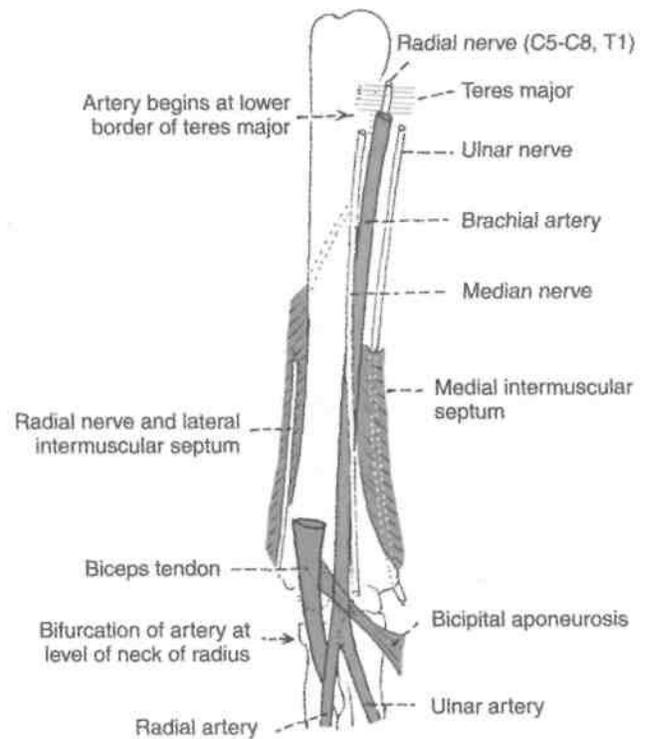
Fig. 8.10: *The course and relations of the brachial artery.*

branch arises in the lower part and takes part in the anastomosis round the elbow joint.

6. The artery ends by dividing into two terminal branches, the *radial* and *ulnar* arteries.

Variations

1. *High division.* Frequently the brachial artery divides at a higher level than usual into three trunks: radial, ulnar and common interosseous arteries. Most frequently the radial artery is given off at a higher level, and the continuation forms a common stem for the ulnar and common interosseous arter-

t Course and Relation

1.It runs downwards and laterally, from the medial side of the arm to the front of the elbow.

2.It is superficial throughout its extent and is accompanied by two venae comitantes (Fig. 8.9).

3.Anteriorly, in the upper part of the arm it is related to the medial cutaneous nerve of the forearm; in the middle of the arm it is crossed by the median nerve from the lateral to the medial side; and in front of the elbow it is covered by the bicipital aponeurosis and the median cubital vein (Fig. 8.10).

4.Posteriorly, it is related to (i) the triceps, (ii) the radial nerve and the profunda brachii artery, (iii) insertion of the coracobrachialis, and (iv) the brachialis.

5.Medially, in the upper part it is related to the ulnar nerve and the basilic vein, and the lower part to the median nerve (Fig. 8.10).

6.Laterally, it is related to the coracobrachialis, the biceps and the median nerve in its upper part; and to the tendon of the biceps at the elbow.

7.At the elbow, the structures from the lateral to the medial side are: (i) the radial nerve, (ii) the biceps tendon, (iii) the brachial artery, and (iv) the median nerve.

Branches

1.Unnamed *muscular* branches.

2.The *profunda brachii artery* arises just below the teres major and accompanies the radial nerve (Fig. 8.11).

3.The *superior ulnar collateral* branch arises in the upper part of the arm and accompanies the ulnar nerve.

4.A nutrient artery is given off to the humerus.

5.The *inferior ulnar collateral* (or supratrochlear)
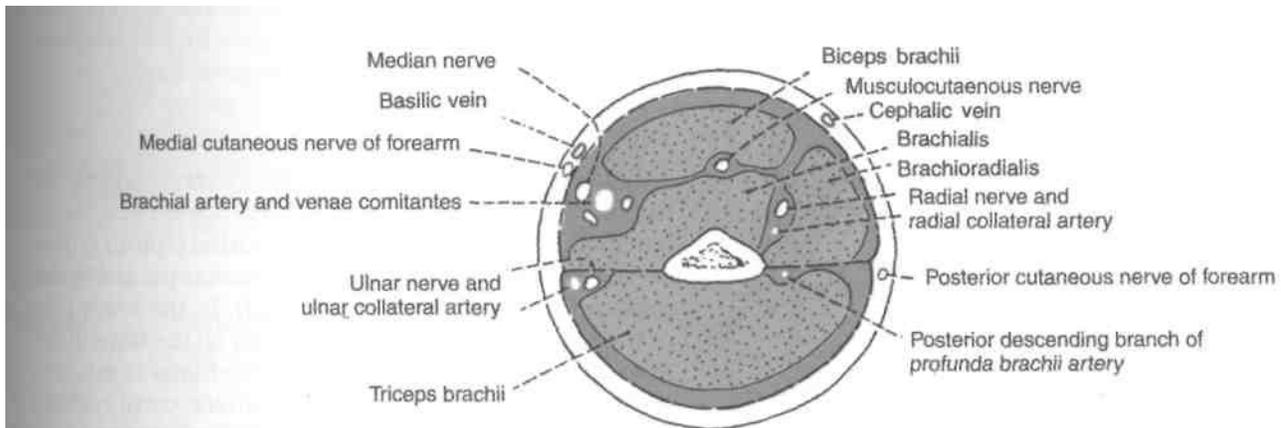
Fig. 8.9: Transverse section passing through the lower one-third of the arm.

Upper Limb

ies. Occasionally, the artery divides at a higher level into two trunks which reunite.
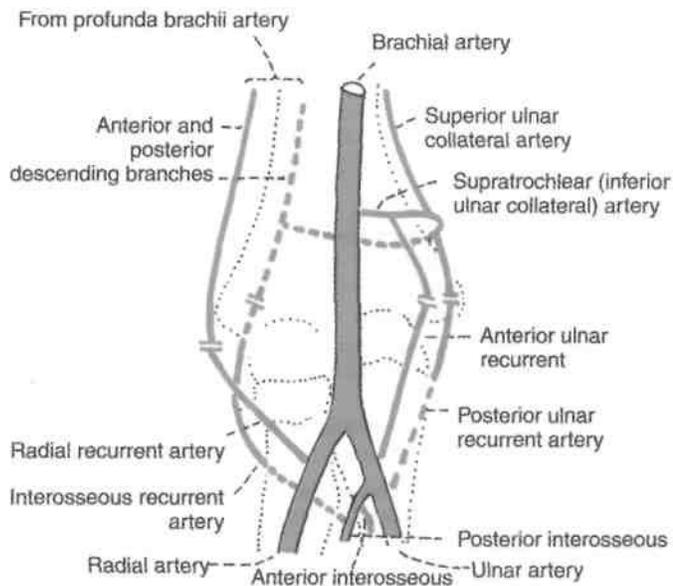
Fig. 8.11: Anastomosis around the elbow joint.

2. *Medial course.* Sometimes, the brachial artery descends towards the medial epicondyle. In such cases, it usually passes behind the supracondylar process of the humerus deep to a fibrous arch. Then it runs behind or through the pronator teres to the bend of the elbow.

CLINICAL ANATOMY

1. Brachial pulsations are felt or auscultated in front of the elbow just medial to the tendon of biceps while recording the blood pressure.
2. Although the brachial artery can be compressed anywhere along its course, it can be \ compressed most favourably in the middle of the arm, where it lies on the tendon of the coracobra-chialis.

ANASTOMOSIS AROUND THE ELBOW JOINT

Anastomoses around the elbow joint links the brachial artery with the upper ends of the radial and ulnar arteries. It supplies the ligaments and bones of the joint. The anastomosis can be subdivided into the following parts.

In front of the lateral epicondyle of the humerus, the anterior descending (radial collateral) branch of the profunda brachii anastomoses with the radial recurrent branch of the radial artery (Fig. 8.11).

Behind the lateral epicondyle of the humerus, the posterior descending branch of the profunda brachii

artery (above) anastomoses with the interosseous recurrent branch of the posterior interosseous artery (below).

In front of the medial epicondyle of the humerus, the inferior ulnar collateral branch of the brachial! artery, and occasionally a branch from the superior* ulnar collateral artery (above), anastomoses with the I anterior ulnar recurrent branch of the ulnar artery (below).

Behind the medial epicondyle of the humerus, the superior ulnar collateral branch of the brachial I artery (above) anastomoses with the posterior ulnar recurrent branch of the ulnar artery, and a branch from the inferior ulnar collateral artery (from the medial side).

LARGE NERVES IN THE ARM   ~|

Median Nerve

Median nerve is closely related to the brachial artery throughout its course in the arm (Fig. 8.10). In the upper part, it is lateral to the artery; in the middle of the arm, it crosses the artery from lateral to the medial side; and remains on the medial side of the artery right up to the elbow.

In the arm, the median nerve gives off a branch to the pronator teres just above the elbow and vascular branches to the brachial artery. An articular branch to the elbow joint arises at, or just below, the elbow (For course in forearm and hand see Chapter 9.)

Ulnar Nerve

Ulnar nerve runs on the medial side of the brachia artery up to the level of insertion of the coracobra chialis, where it pierces the medial intermuscula septum and enters the posterior compartment of th arm. It is accompanied by the superior ulnar collat eral vessels. At the elbow, it passes behind th medial epicondyle where it can be palpated with ; finger (Fig. 8.12). The ulnar nerve is palpated benim the medial epicondyle. Its course in forearm an hand has been discussed in Chapter 9.

Radial Nerve

At the beginning of the brachial artery, the radiE nerve lies posterior to the artery. Soon the nerv leaves the artery by entering the radial (spiral) groov on the back of the arm where it is accompanied by th profunda brachii artery (Fig. 8.12). In the lower par of the arm, the nerve appears again on the front of th arm where it lies between the brachialis (medially and the brachioradialis and extensor carpi radiali longus (laterally). Its branches will be discussed wit the back of the arm.

Fig. 8.12: Nerves related to posterior aspect of humerus.

Deltoid muscle

Axillary

Radial

Ulnar
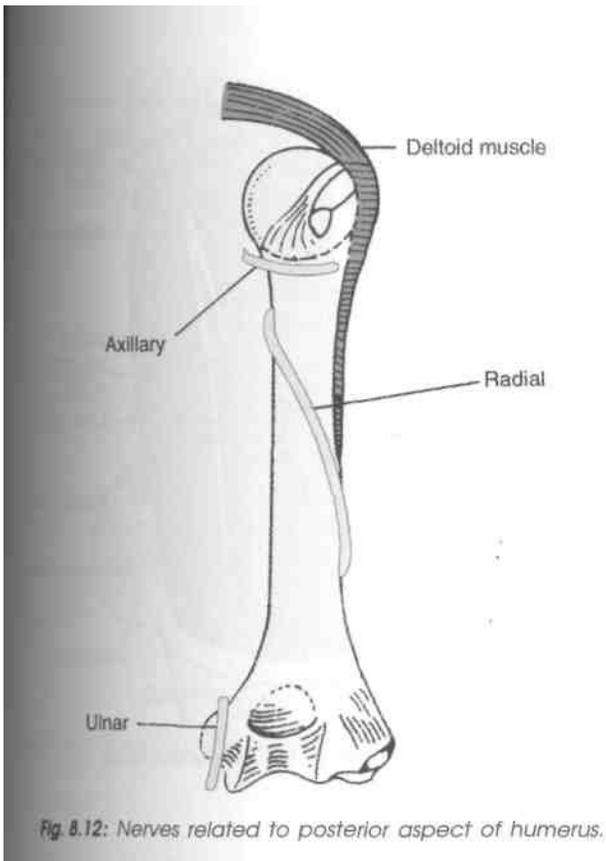
the front of two epicondyles of the humerus.

Apex — is directed downwards, and is formed by the meeting point of the lateral and medial boundaries.

Fig. 8.13: Boundaries of the left cubital fossa.

Base of cubital fossa

Brachioradialis

Cubital fossa

Pronator teres

Apex
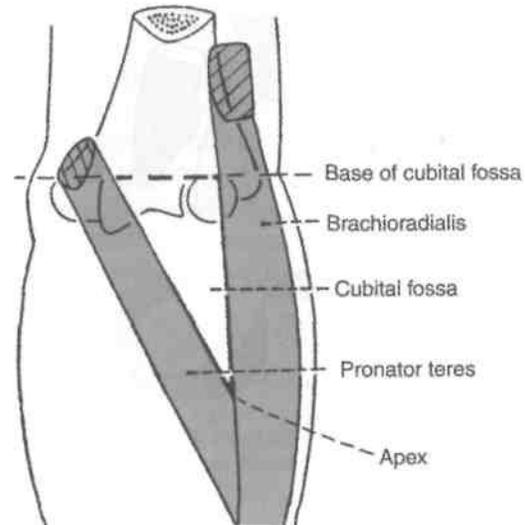
CUBITAL FOSSA

Cubital Fossa is a triangular hollow situated on the front of the elbow. (It is homologous with the popliteal fossa of the lower limb situated on the back of the knee.)

DISSECTION

Identify the structures (see text) present in the roof of a shallow cubital fossa located on the front of the elbow. Separate the lateral and medial boundaries formed respectively by the brachioradialis and pronator teres muscles. Clean the contents: (i) terminal part of brachial artery bifurcating into radial and ulnar arteries; (ii) median nerve on the medial side of brachial artery; (iii) the radial nerve on the lateral side of the brachial artery; (iv) the tendon of biceps brachii muscle between the artery and radial nerve.

Identify brachialis and supinator muscles, forming the floor of cubital fossa.

Boundaries

Laterally — medial border of the brachioradialis (Fig. 8.13).
Medially — lateral border of the pronator teres. — is directed upwards, and is represented by an imaginary line joining

Roof: The roof of the cubital fossa (Fig. 8.14) is formed by:

(a) Skin

(b) superficial fascia containing the median cubital vein, the lateral cutaneous nerve of the forearm and the medial cutaneous of the forearm

(c) deep fascia.

Fig. 8.14: Structures in the roof of the left cubital fossa.

Basilic vein

Medial cutaneous nerve of forearm

Cephalic vein

Lateral cutaneous nerve of forearm

Median cubital vein

Bicipital aponeurosis
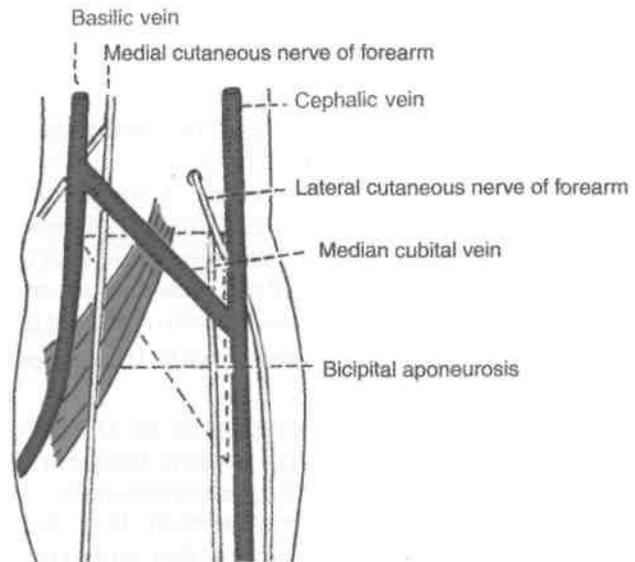
(d) bicipital aponeurosis.

Floor: It is formed by: (i) the brachialis and (ii) the
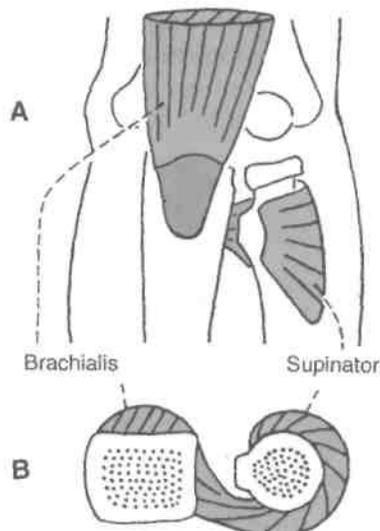
Fig. 8.15: The floor of the cubital fossa is formed by. the brachialis and supinator muscles: (A) surface view and (B) cross-sectional view.

supinator muscles (Fig. 8.15).

Contents

The fossa is actually very narrow. The contents described are seen after retracting the boundaries. From medial to the lateral side, the contents are :

1.*The median nerve.* It gives branches to flexor carpi radialis, palmaris longus, flexor digitorum superficialis and leaves the fossa by passing between the two heads of pronator teres (Fig. 9.16).

2.The termination of the brachial artery, and the beginning of the radial and ulnar arteries lie in the fossa. The radial artery is smaller and more superficial than the ulnar artery. It gives off the radial recurrent branch. The ulnar artery goes deep and runs downwards and medially, being separated from the median nerve by the deep head of the pronator teres. It gives off the anterior ulnar recurrent, the posterior ulnar recurrent, and the common interosseous branches. The common interosseous branch divides into the anterior and posterior interosseous arteries, and latter gives off the interosseous recurrent branch.

3.The tendon of the biceps, with the bicipital aponeurosis (Fig. 8.16).

4.The radial nerve (accompanied by the radial collateral artery) appears in the gap between the brachialis (medially) and the brachioradialis and extensor carpi radialis longus laterally (Fig. 8.17). While running in the intermuscular gap, radial nerve supplies the three flanking muscles, and at the level
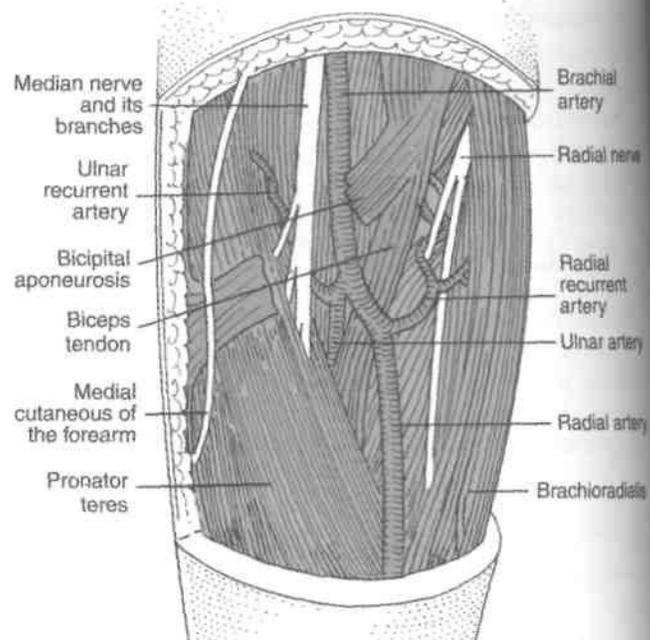
Fig. 8.16: Contents of the left cubital fossa.
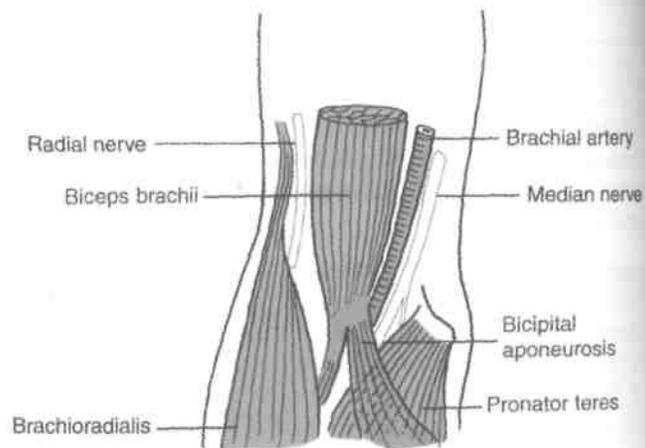
Fig. 8.17: Contents of the right cubital fossa.

of the lateral epicondyle it gives off the posterior interosseous nerve or deep branch of the radial nerve which leaves the fossa by piercing the supinator muscle (Fig. 8.18).

CLINICAL ANATOMY

The cubital region is important for the following reasons.

1. The median cubital vein is often the vein of choice for intravenous injections (*see* the superficial vein of the upper limb).

2. The blood pressure is universally recorded by auscultating the brachial artery in front of the elbow.

3. The anatomy of the cubital fossa is useful while dealing with the fracture around the elbow, like the supracondylar fracture of the humerus.
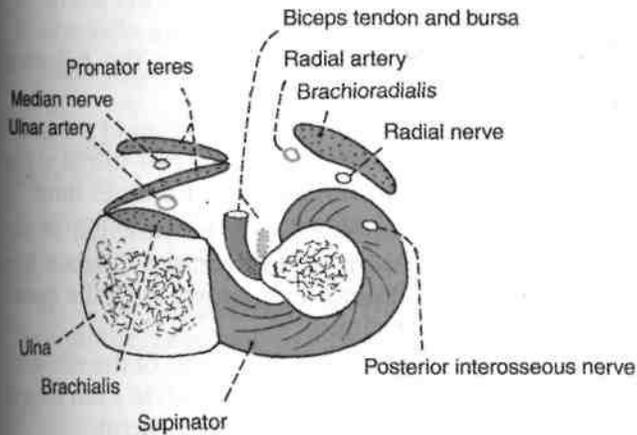
Fig. 8.18: Contents of the cubital fossa as seen in a cross-section.

THE BACK OR POSTERIOR COMPARTMENT OF THE UPPER ARM

The region contains the triceps muscle, the radial nerve and the profunda brachii artery. The nerve and artery run through the muscle. The ulnar nerve runs through the lower part of this compartment.

DISSECTION

Reflect the skin of back of arm to view the triceps brachii muscle. Define its attachments and separate the long head of the muscle from its lateral head. Radial nerve will be seen passing between the long head of triceps and medial border of the humerus. Note the continuity of radial nerve upto axilla. Carefully cut through the lateral head of triceps to expose radial nerve along with profunda brachii vessels. Note that the radial nerve lies in the radial groove, on the back of humerus, while passing between the lateral head of triceps above and its medial head below. In the lower part of arm, the radial nerve lies on the front of elbow just lateral to the brachialis, dividing into two terminal branches in the cubital fossa. The ulnar nerve (which was seen in the anterior compartment of arm till its middle) pierces the medial intermuscular septum with its *accompanying vessels, reaches* ■ the back of elbow and may easily be palpated on the back of medial epicondyle of humerus.

TRICEPS BRACHII MUSCLE

Origin

Triceps brachii muscle arises by the following three heads (Fig. 8.19).

1. The long head arises from the infraglenoid tubercle of the scapula; it is the longest of the three heads.

2. The lateral heads arises from an oblique ridge on the upper part of the posterior surface of the humerus, corresponding to the lateral lip of the radial (spiral) groove.

3. The medial head arises from a large triangular area on the posterior surface of the humerus below the radial groove, as well as from the medial and
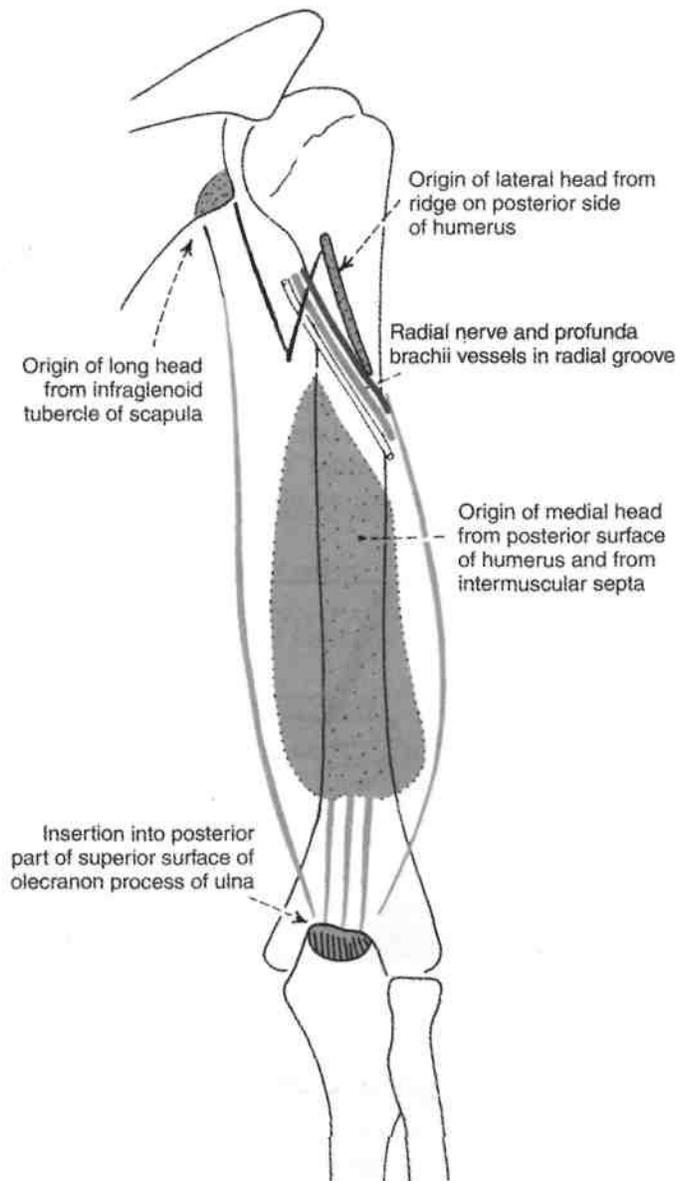
Fig. 8.19: The origin and insertion of the triceps brachii muscle.

lateral intermuscular septa. At the level of the radial groove, the medial head is medial to the lateral head.

Insertion

The long and lateral heads converge and fuse to form a superficial flattened tendon which covers the medial head and inserted into the the posterior part of the superior surface of the olecranon process. The medial head is inserted partly into the superficial tendon, and partly into the olecranon. Although the medial head is separated from the capsule of the elbow joint by a small bursa, a few of its fibres are inserted into this part of the capsule: this prevents nipping of the capsule during extension of the arm. (These fibres are referred to as the *articularis cubiti,* or as the *subanconeus.)*

Nerve Supply

Each head receives a separate branch from the the radial nerve (C7, C8). The branches arise in the axilla and in the radial groove.

Actions

The triceps is a powerful active extensor of the elbow. The long head supports the head of the humerus in the abducted position of the arm. Gravity extends the elbow passively.

Electromyography has shown that the medial head of the triceps is active in all forms of extension, and the actions of the long and lateral heads are minimal, except when acting against resistance. Triceps is tested against resistance as shown in Fig. 8.20.
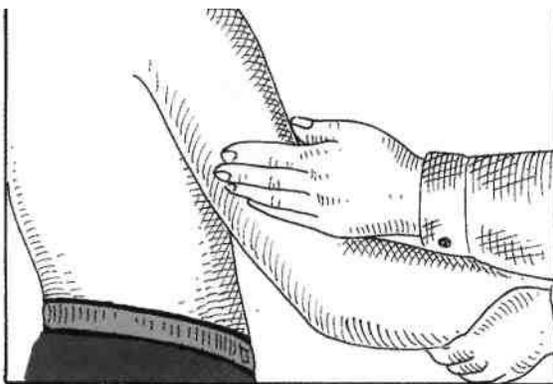
Fig. 8.20: *Testing triceps against resistance.*

CLINICAL ANATOMY

In radial nerve injuries in the arm, the triceps usually escapes paralysis because the nerves supplying it arise in the axilla.

RADIAL NERVE

Radial nerve is the largest branch of the posterior cord of the brachial plexus with a root value of C5-C8, Tl (Fig. 4.7).

Surface Marking

In the Arm: It is marked by joining the following! I points (Fig. 8.21):

(i)   The first point is at the junction of the anterior one-third and posterior two-thirds of the I lateral wall of the axilla at its lower limit, (ii)   The second point is at the junction of the upper one-third and lower two-thirds a line joining the lateral epicondyle with the inser- I tion of the deltoid, (iii)   The third point is on the front of the elbow at the level of the lateral epicondyle 1 cm lateral to the tendon of the biceps brachii. The first and second points are joined across the back of the arm to mark the oblique course of the radial nerve in the radial (spiral) groove (posterior
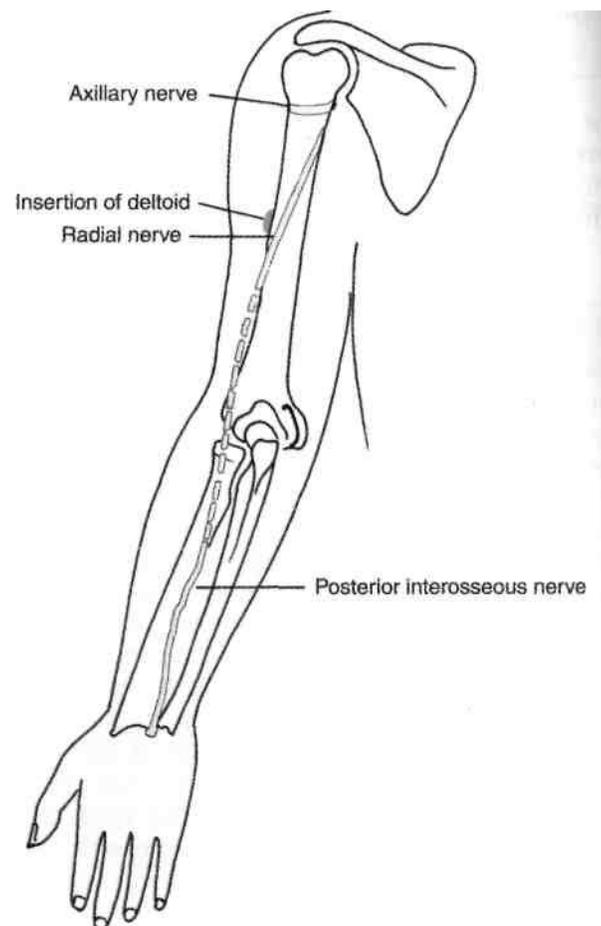
Fig. 8.21: *Surface projection of axillary, radial and posterior interosseous nerves (posterior view of limb).*

Iimpartment). The second and third points are joined i the front of the arm to mark the vertical course of le nerve in the anterior compartment.

ourse and Relations

A. In the lower part of the axilla, radial nerve passes downwards and has the following relations.

Anteriorly Third part of the axillary artery (Fig. *4.13).*

Posteriorly Subscapularis, latissimus dorsi and teres major.

Laterally Axillary nerve and coracobrachialis.

Medially Axillary vein (Fig. 4.14).

B. In the upper part of the arm, it continues behind the brachial artery, and passes postero-laterally (with the profunda brachii vessels) through the lower triangular space, below the teres major, and between the long head of the triceps and the humerus. It then enters the radial groove with the profunda vessels (Figs 7.10, 7.11).

C. In the radial groove, the nerve runs downwards and laterally between the lateral and medial heads of the triceps, in contact with the humerus (Fig. 8.22). At the lower end of the groove, 5 cm below the deltoid tuberosity, the nerve pierces the lateral intermuscular septum and passes into the anterior compartment of the arm (Fig. 8.23). The part of the nerve in the cubital fossa has been described earlier.

Branches and Distribution

Various branches of radial nerve are shown in Fig. 8.24.
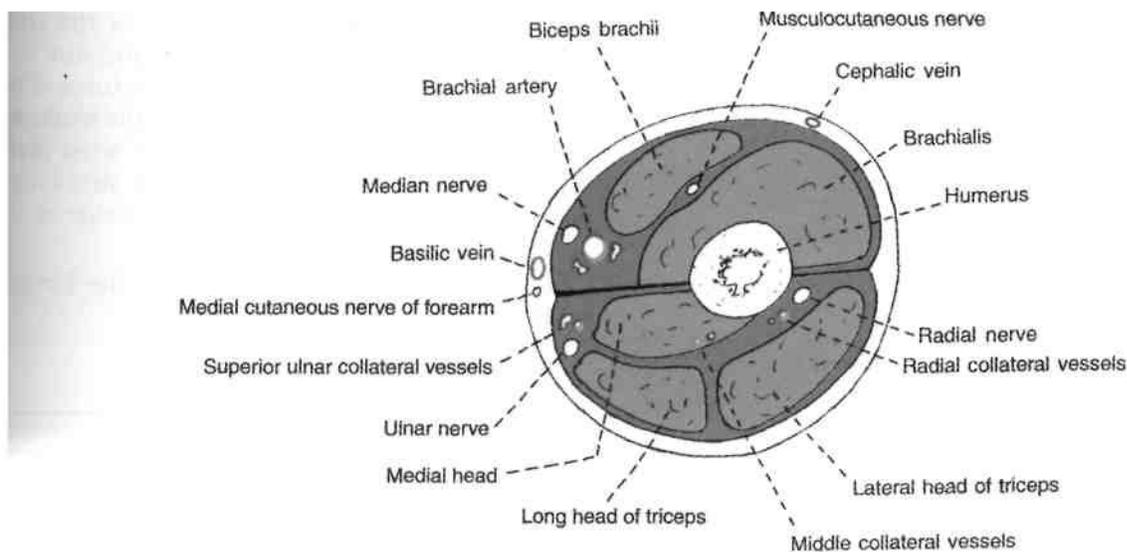
Fig. 8.22: *Transverse section through the arm a little below the insertion of the coracobrachialis and deltoid showing arrangement of three heads of the triceps, and the radial nerve in the radial groove.*
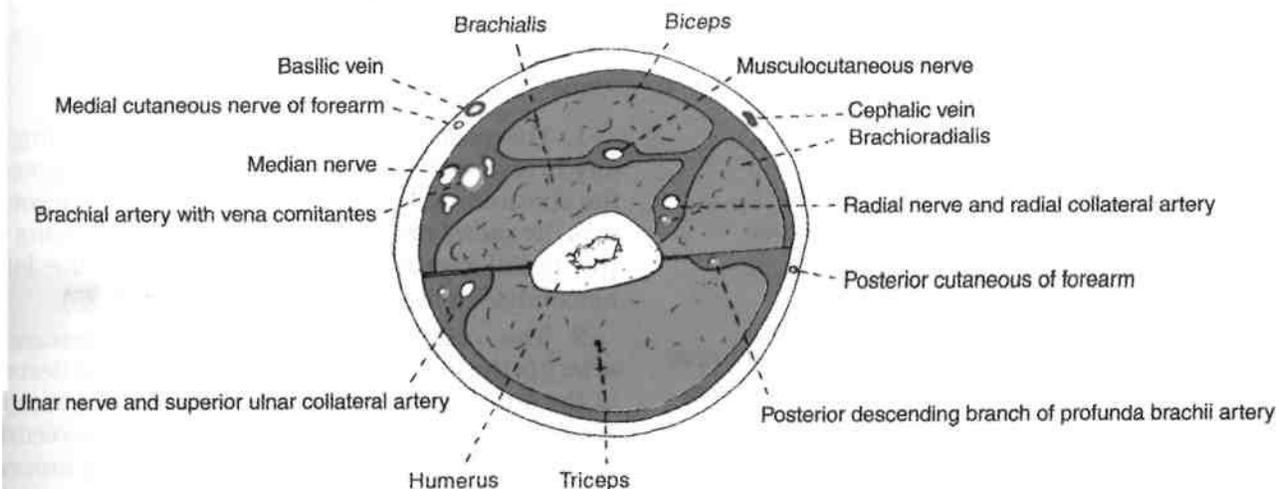
Fig. 8.23: *Transverse section through the lower third of the arm.*

Fig. 8.24: Distribution of axillary and radial nerves.

Lower part of posterior cord of brachial plexus C5, C6, C7, C8, T1)

Axillary nerve — Radial

Long head and posterior cutaneous nerve of arm

Upper lateral cutaneous nerve of arm — Medial head

Lateral head

Posterior cutaneous nerve of forearm

Medial head

Brachioradialis and extensor carpi radialis longus — Anconeus

Brachialis

Extensor carpi radialis brevis

Superficial branch

Deep branch

Muscular

(1) Before entering the spiral groove, radial nerve supplies the long and medial heads of the triceps. <^f (2) In the spiral groove, it supplies the lateral and medial heads of the triceps and the anconeus. *J*

(3) Below the radial groove, on the front of the arm, it supplies the brachialis with proprioceptive

fibres, the brachioradialis, and the extensor carpi, radialis longus.

Cutaneous Branches

(1) Above the radial groove, radial nerve gives off the posterior cutaneous nerve of the arm which supplies the skin on the back of the arm.

1(2) In the radial groove, the radial nerve gives off the lower lateral cutaneous nerves of the arm and the posterior cutaneous nerve of the forearm.J}

Articular branches: The articular branches near the elbow supply it the elbow joint.

CLINICAL ANATOMY

The radial nerve is very commonly damaged in the region of the radial (spiral) groove. The common causes of injury are: (i) intramuscular injections in the arm (triceps), (ii) sleeping in an armchair with the limb hanging by the side of the chair (Saturday night palsy), or even the pressure by a crutch (crutch paralysis), and (iii) fractures of the shaft of the humerus. This results in the weakness or loss of power of extension at the wrist (wrist drop) and sensory loss over a narrow strip on the back of forearm, and on the lateral side of the dorsum of the handA

The course of the radial nerve in the forearm and hand is described in Chapter 9.

PROFUNDA BRACHII ARTERY

Profunda brachii artery is a large branch, arising just below the teres major. It accompanies the radial nerve through the radial groove, and before piercing the lateral intermuscular septum it divides into the anterior and posterior descending branches which take part in the anastomosis around the elbow joint (Fig. 8.11).

Branches

1.The *radial collateral (anterior descending)* artery is one of the terminal branches, and represents the continuation of the profunda artery. It accompanies the radial nerve, and ends by anastomosing with the radial recurrent artery in front of the lateral epicondyle of the humerus (Figs 8.22, 8.23).

2.The *middle collateral (posterior descending)* artery is the largest terminal branch, which descends in the substance of the medial head of the triceps. It ends by anastomosing with the interosseous recurrent artery, behind the lateral epicondyle of the humerus. It usually gives a branch which accompanies the nerve to the anconeus.

3.The *deltoid (or ascending)* branch ascends between the long and lateral heads of the triceps, and anastomoses with the descending branch of the posterior circumflex humeral artery.

4.The *nutrient artery to the humerus* is often iresent. It enters the bone in the radial groove just behind the deltoid tuberosity. However, it may be

membered that the main artery to the humerus is a branch of the brachial artery.

Additional Reading

Bansal PC and Vare AM (1971). Anatomical factors in the compression of the ulnar nerve. *Journal of Anatomical Society of India,* 20: 71-75.

Kolte PM (1969). A case of unilateral coracobrachialis brevis muscle. *Journal of Anatomical Society of India,* 18: 62-63.

Singh S and Singh SP (1971). Higher division of brachial artery with other associated anomalies. *Quarterly Journal of Surgical Sciences,* 7: 36-39.

Vare AM and Bansal PC (1969). A case of anomalous brachial artery and other associated vascular anomalies in a single upper limb. *Journal ofAnatomical Society of India,* 18: 50-53.

09

The Forearm and Hand
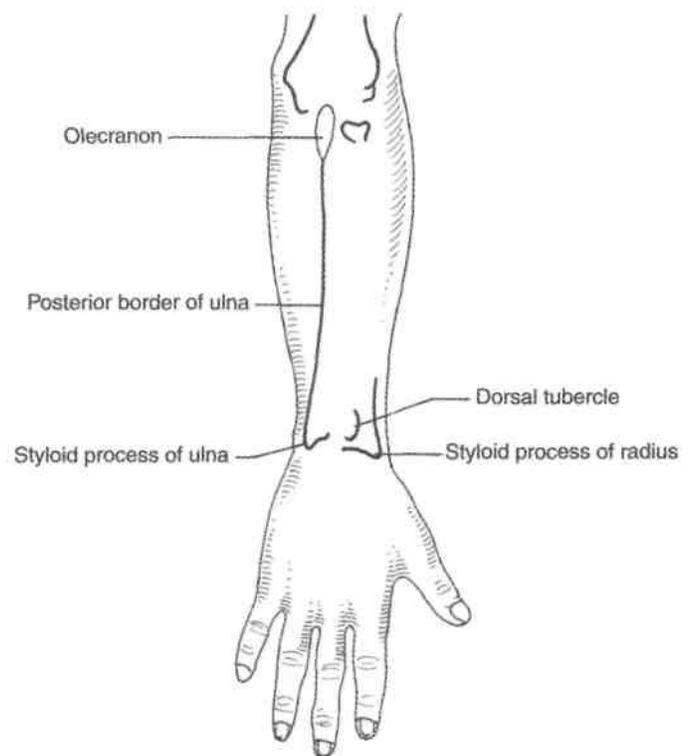
Fig. 9.1: Surface landmarks: Sides and back of forearm.

Firearm extends between the elbow and the wrist joints. Radius and ulna form its skeleton. These two bones articulate at both their ends to form superior and inferior radioulnar joints. Their shafts ', are kept at optimal distance by the interosseous membrane. Muscles accompanied by nerves and blood vessels are present both on the front and the back of the forearm. Hand is the most distal part of the upper limb, meant for carrying out diverse activities. Numerous muscles,

tendons, bursae, blood vessels and nerves are artistically placed and protected in this region.

THE FRONT OF THE FOREARM

The front of the forearm presents the following components for study.

Components

1. Eight muscles, five superficial and three deep.
2. Two arteries, radial and ulnar.
3. Three nerves, median, ulnar and radial. These structures can be better understood by reviewing the long bones of the upper limb and having an articulated hand by the side.

SURFACE LANDMARKS OF FRONT AND SIDES OF FOREARM

1. The *epicondyles* of the humerus have been examined. Note that medial epicondyle is more prominent than the lateral. The posterior surface of the medial epicondyle is crossed by the *ulnar nerve* which can be rolled under the palpating finger. Pressure on the nerve produces tingling sensations on the medial side of the hand (Fig. 8.1).
2. The *tendon of the biceps brachii* can be felt in front of the elbow. It can be made prominent by

flexing the elbow joint against resistance. Pulsations of the brachial artery can be felt just medial to the tendon.

1.The *head of the radius* can be palpated in a depression on the posterolateral aspect of the extended elbow, distal to the lateral epicondyle. Its rotation can be felt during pronation and supination of the forearm.

2.The *styloid process* of the radius project 1 cm lower than the styloid process of the ulna (Fig. 9.1). It can be felt in the upper part of the anatomical snuff box. Its tip is concealed by the tendons of the

abductor pollicis longus and the *extensorpollicis brevis,* which must be relaxed during palpation.

1. The *head of the ulna* forms a surface elevation on the medial part of the posterior surface of the wrist when the hand is pronated.

2. The *styloid process of the ulna* projects downwards from the posteromedial aspect of the lower end of the ulna. Its tip can be felt on the posteromedial aspect of the wrist, where it lies about 1 cm above the tip of the styloid process of the radius (Fig. 9.1).

3. The *pisiform bone* can be felt at the base of the hypothenar eminence (medially) where the tendon of the *flexor carpi ulnaris* terminates. It becomes visible and easily palpable at the medial end of the distal transverse crease (junction of forearm and hand) when the wrist is fully extended.

4. The *hook of the hamate* lies one finger breadth below the pisiform bone, in line with the ulnar border of the ring finger. It can be felt only on deep palpation through the hypothenar muscles.

5. The *tubercle of the scaphoid* lies beneath the lateral part of the distal transverse crease in an extended wrist. It can be felt at the base of the thenar eminence in a depression just lateral to the tendon of the flexor carpi radialis (Fig. 9.2).

1. The *tubercle (crest) of the trapeziummay be* felt on deep palpation inferolateral to the tubercle of the scaphoid.

2. The *brachioradialis* becomes prominent along the lateral border of the forearm when the elbow is flexed against resistance in the midprone position of the hand.

3. The *tendons of the flexor carpi radialis, pal-maris longus,* and *flexor carpi ulnaris* can be identified on the front of the wrist when the hand is flexed against resistance. The tendons lie in the order stated, from lateral to medial side.
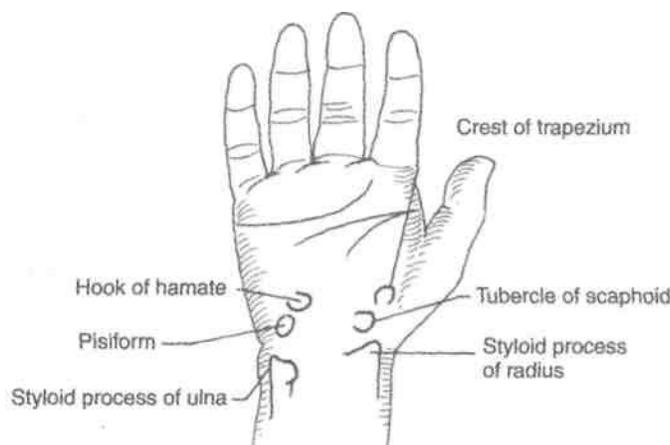
Fig. 9.2: Surface landmarks: Wrist and palm.

1. The pulsation of the *radial artery* can be felt in I front of the lower end of the radius just lateral to the! tendon of the flexor carpi radialis.

2. The pulsations of the *ulnar artery* can be felt by careful palpation just lateral to the tendon of the flexor carpi ulnaris. Here the ulnar nerve lies medial to the artery.

3. The *transverse creases* in front of the wrist are important landmarks. The proximal transverse crease lies at the level of the wrist joint, and distal crease corresponds to the proximal border of the flexor retinaculum.

4. The *median nerve* is very superficial in position at and above the wrist. It lies along the lateralj edge of the tendon of the palmaris longus at the middle of the wrist.

5. The *anatomical snuff box* is a depression I which appears on the lateral side of the wrist whenB the thumb is extended. It is bounded anteriorly byB the abductor pollicis longus and extensor pollicisB brevis, and posteriorly by the extensor pollicis longus. I Pulsations of the radial artery can be felt in the floor I of the depression against the scaphoid and trapezium. I The beginning of the cephalic vein can be seen in its I roof. The styloid process of the radius can be felt in I the upper part of the depression as already mentioned I

SUPERFICIAL MUSCLES OF THE FRONT OF THE FOREARM

The muscles of the front of the forearm may be divided into superficial and deep groups.

The skin of the forearm has already been reflected on each side. Cut through the superficial and deep fasciae to expose the superficial muscles of the forearm. Identify these five superficial muscles. These are from lateral to medial side, pronator teres getting inserted into middle of radius, flexer carpi radialis reaching till the wrist, palmaris longus continuing with palmar aponeurosis, flexor digitorum superficialis passing through the palm and most medially the flexor carpi ulnaris getting inserted into the pisiform bone (Fig. 9.3).

Deep muscles

Cut through the origin of superficial muscles of forearm at the level of medial epicondyle of humerus and reflect them distally. This will expose the three deep muscles, e.g. flexer pollicis longus, flexor digitorum profundus and pronator quadratus.
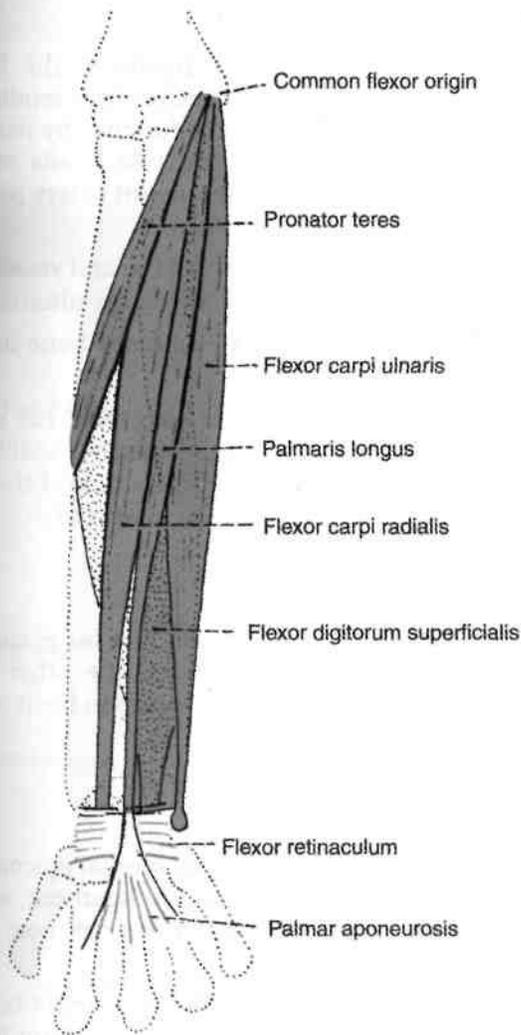
Fig. 9.3: The superficial muscles of the front of the forearm.

There are five muscles in the superficial group. These are the pronator teres, the flexor carpi radialis, the palmaris longus, the flexor carpi ulnaris, and the flexor digitorum superficialis (sublimus).

I Common Flexor Origin

All the superficial flexors of the forearm have a common origin from the front of the medial epicondyle of the humerus. This is called the common flexor origin.

Pronator Teres

Origin

1.*Humeral head* from the medial epicondyle of the humerus—common flexor origin (Fig. *9.3).*

2.*Ulnar head* or deep head from the medial margin of the coronoid process of the ulna.

insertion

Middle one-third of the lateral surface of the shaft of the radius.

Nerve Supply

VIedian nerve.

Action - fve <,u?;|tv :-;\ "

It is the main pronator of the forearm. It also flexes the elbowf)

Important Relations

The median nerve passes between the two heads of the muscle. The ulnar artery is deep to both heads.

Variations

The ulnar head may be absent. Additional slips may be derived from the biceps, the brachialis, the medial intermuscular septum, or the supracondylar process of the humerus.

Flexor Carpi Radialis

Origin

From the medial epicondyle of the humerus (common flexor origin).

Insertion

Into palmar surface of the bases of the second and third metacarpal bones.

Nerve Supply

Median nerve.

Important Relation

In the lower part of the forearm, the radial artery lies between the tendons of the brachioradialis and the flexor carpi radialis.

Variations

Proximally the muscle may have additional slips, and distally additional insertions on the flexor retinaculum, trapezium, and the 4th metacarpal bone.

Palmaris Longus

Origin

Medial epicondyle of the humerus (common flexor origin).

Insertion

Distal half of flexor retinaculum and the apex of the palmar aponeurosis.

Nerve Supply

Median nerve.

Action

Palmaris longus flexes the wrist and makes the palmar aponeurosis tense.

Additional Points

(i) At the wrist, the tendon lies over the median nerve which projects on its lateral side, (ii) The tendon enters the hand by passing superficial to the flexor retinaculum.

(iii) The palmaris longus muscle is more important morphologically than functionally. It is a degenerating muscle as it has a short belly and a long tendon. It is absent in 10% subjects.

(iv) The palmar aponeurosis represents the distal part of the tendon of the palmaris longus, another evidence of retrogression of the muscle (cf. the plantaris in the leg).

(v) Variations in size, shape and attachments are common.

Flexor Carpi Ulnaris

Origin

1. Humeral head from the medial epicondyle of the humerus (common flexor origin).

2. Ulnar head from the medial margin of the olecranon and by an aponeurosis from the posterior border of the ulna. The ulnar nerve passes between the humeral and ulnar heads.

Insertion

The insertion is primarily into the pisiform bone, but the pull of the muscle is transmitted through the pisohamate and pisometacarpal ligaments to the hook of the hamate and the base of the 5th metacarpal bone (which represent the true insertion of the muscle). The pisiform bone may, therefore, be regarded as a sesamoid bone developed within the tendon of the muscle.

Nerve Supply: Ulnar nerve.

Actions

1. Flexion of the wrist (along with the flexor carpi radialis and the palmaris longus).

2. Adduction of the wrist (along with the extensor carpi ulnaris).

3. Fixes the pisiform bone during contraction of the hypothenar muscles.

Additional Points

1. The humeral and ulnar heads of the flexM carpi ulnaris are connected together by a tendinous I arch. The ulnar nerve enters the forearm by passing I deep to this arch, between the two heads of the I muscle. The posterior ulnar recurrent artery passes I upwards through the same gap.

2. Above the wrist, the ulnar nerve and vessels lie I lateral to the tendon of the flexor carpi ulnaris.   1

3. The pisiform bone is a sesamoid bone in the tendon of this muscle.

4. Proximally, an additional slip from the coro-noid process may be present. Distally, additional) attachments to the flexor retinaculum, and the 4th j or 5th metacarpal bones may be observed.

Flexor DigitoroflfiStiperficialis (Sublimus)

[V]The Flexor digitorum superficialis is a large muscle forming a middle stratum between the other four superficial flexors and the deep flexors in front of the forearm)(Fig. 9.4).

Origin

1. Humeroulnar head from the medial epicondyl* of the humerus, the ulnar collateral ligament, and; tubercle on the medial border of the coronoid pro cess of ulna.

2. The radial head arises from the anterior borde of the radius up to the insertion of the pronator teres

3. Some fibres arise from fibrous arch passin from the ulna to the radius and connecting the tw heads. The median nerve and the ulnar artery pas deep to this arch.

Insertion

The muscle ends in four tendons, one each for th medial four digits. Opposite the proximal phalan the tendon for each digit splits into medial an lateral slips which are inserted on the correspondir sides of the middle phalanx. At the wrist the foi tendons are arranged in two pairs, the superfici; pair for the middle and ring fingers, and the deep pa for the index and little fingers. The tendons lie medi; to the palmaris longus and lateral to the ulnj vessels and nerve.

The tendons enter the hand by passing deep to tl flexor retinaculum, enclosed within a common syi ovial sheath, the ulnar bursa (Fig. 9.5).

T\%sV   \

I New&Supply: Median nerve A

Brachial artery

Median nerve

Flexor digitorum superficia

Radial artery

Ulnar artery

Median nerve

Flexor retinaculum

Middle phalanx
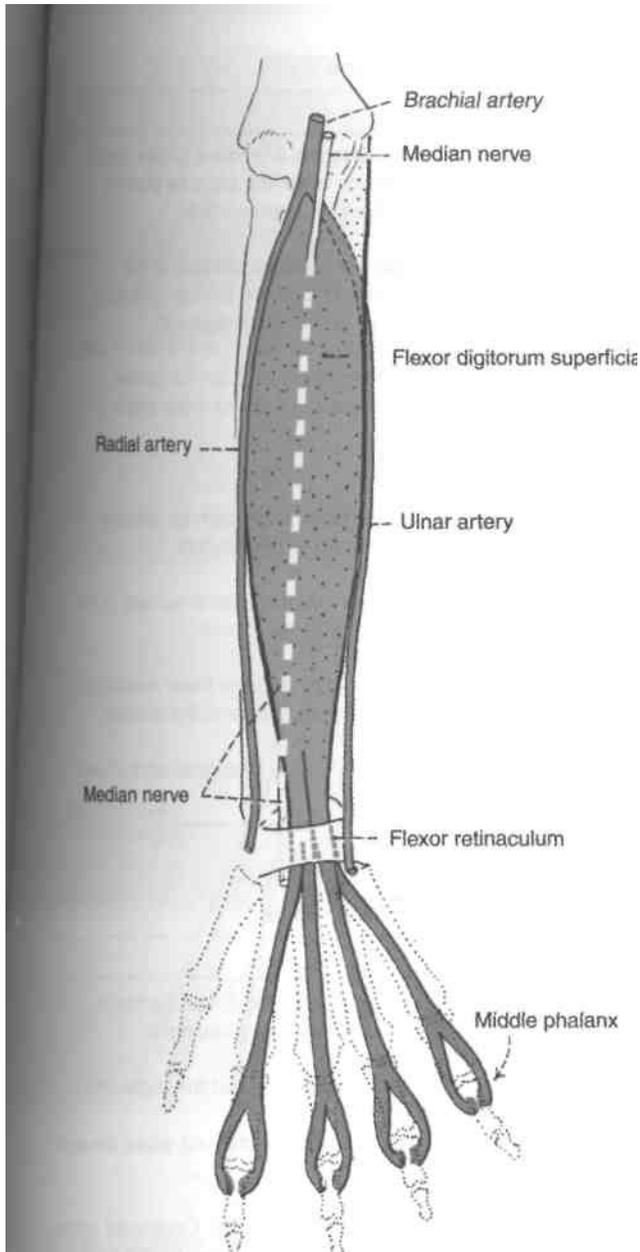
Fig. 9,4: The flexor digitorum superficialis muscle and its relationship to the median nerve and to the radial and ulnar arteries.

Palmar cutaneous branch of ulnar nerve

Volar carpal ligament

Ulnar artery and nerve

Hypothenar muscles

Palmaris longus

Palmar cutaneous branch of median nerve

Median nerve

Thenar muscles

Flexor carpi radialis

Flexor digitorum superficialis

Ulnar bursa

Flexor pollicis longus

Flexor digitorum profundus

Fig. 9.5: Transverse section through the carpus showing attachments and relations of the flexor retinaculum.

DEEP MUSCLES OF THE FRONT OF THE FOREARM

Actions

The flexor digitorum superficialis is the main flexor of the proximal interphalangeal joints. Secondarily, it may also flex the metacarpophalangeal and wrist joints.

Variations

1. The radial head may be absent.
2. A substantial sffp from trie deep strrraex? o/tfre nuscle may act on the index finger.
3. The tendon' to the little finger may be replaced >y an additional slip from the ulna, the flexor etinaculum or the palmar aponeurosis.

Deep muscles of the front of the forearm are the flexor digitorum profundus, the flexor pollicis longus and the pronator quadratus and are described in Tables 9.1 and 9.2. Following are some other points of importance about these muscles.

Additional Points about the Flexor Digitorum Profundus

1.It is the most powerful, and most bulky, muscle of the forearm. It forms the muscular elevation seen and felt on the posterior surface of the forearm medial to the subcutaneous posterior border of the ulna (Figs 9.6, 9.7).

2.The main gripping power of the hand is provided by the flexor digitorum profundus.

3.The muscle may be joined by accessory slips from the radius (action on the index finger), from the flexor digitorum superficialis, or from the flexor pollicis longus, or from the coronoid process of the ulna.

Additional Points about the Flexor Pollicis Longus

1.The anterior interosseous nerve and vessels descend on the anterior surface of the interosseous membrane between the flexor digitorum profundus and the flexor pollicis longus.

2.The tendon passes deep to the flexor retinacu- Axfir toc^«\cva*r i&s- <sppsmens pcdJivte .and the nhUijije head of the adductor pollicis, to enter the fibrous flexor sheath of the thumb (Fig. 9.8).

3.The muscle may be connected by slips with the flexor digitorum superficialis, the flexor digitorum

Table 9.1: Attachments of the deep muscles of the front of the forearm

Muscle	Origin from	Insertion
1. Flexor digitorum profundus (composite or hybrid muscle)	(i) Upper three-fourths of the anterior and medial surface of the shaft of ulna deep to the flexor retinaculum	(i) The muscle forms 4 tendons for the medial 4 digits which enter the palm by passing
	(ii) Upper three-fourths of the posterior border of uina the tendon of the flexor digitorum superficialis	(ii) Opposite the proximal phalanx of the corresponding digit the tendon perforates
	(iii) Medial surface of the olecranon and coronoid processes of ulna	(iii) Each tendon is inserted on the palmar surface of the base of the distal phalanx
	(iv) Adjoining part of the anterior surface of the interosseous membrane	
2. Flexor pollicis longus	(i) Upper three-fourths of the anterior surface of the shaft of radius	(i) The tendon enters the palm by passing deep to the flexor retinaculum
	(ii) Adjoining part of the anterior surface of the interosseous membrane	(ii) It is inserted into the palmar surface of the distal phalanx of the thumb
3. Pronator quadratus	Oblique ridge on the lower one-fourth of anterior surface of the shaft of ulna, and the area medial to it	(i) Superficial fibres into the lower one-fourth of the anterior surface and the anterior border of the radius
		(ii) Deep fibres into the triangular area above the ulnar notch

Table 9.2: Nerve supply and actions of the deep muscles of the front of the forearm

Muscle	Nerve Supply	Actions
.tjW 1. Flexor digitorum profundus 5^' ((Figs 9.6, 9.7) vKj vJ^	(i) Medial half by ulnar nerve \ (ii) Lateral half by anterior interosseous nerve (C8, T1W /	(i) Flexor of distal phalanges after the flexor digitorum superficialis has flexed the middle phalanges
		(ii) Secondarily it flexes the other joints of the digits and fingers, and the wrist (iii) It is the chief gripping muscle. It acts best when the wrist is extended
1.Flexor pollicis longus (Fig. 9.8)	Anterior interosseous nerve	(i) Flexes the distal phalanx of the thumb. Continued action may also flex the proximal joints crossed by the tendon
2.Pronator quadratus	Anterior interosseous nerve	(i) Superficial fibres pronate the forearm
		(ii) Deep fibres bind the lower ends of radius and ulna

profundus, or the pronator teres. The interosseous portion, or the whole muscle, may be absent.

' . ,_. ., ■"_■_.
Synovial Sheaths of Fexor Tendons

(1) *Common flexor synovial sheath (ulnar bursa).* The long flexor tendons of the fingers (flexor digitorum superficialis and profundus), are enclosed in a common synovial sheath while passing deep to the flexor retinaculum (carpal tunnel). The sheath has a parietal layer lining the walls of the carpal tunnel, and a visceral layer closely applied to the tendons (Fig. 9.9). From the arrangement of the sheath it appears that the synovial sac has been invaginated by the tendons from its lateral side. The synovial sheath extends upwards for 5 or 7.5 cm into the

t___» , , , „ ■, . + .. , ,,,
forearm and downwards into the palm up to the middle of the shafts of the metacarpal bones. It is important to note that the lower medial end is continuous with the digital synovial sheath of the little finger.

Infection of the ulnar bursa is usually secondary to infection of the little finger. In turn this may spread to the forearm space of Parona. It results in

Fig. 9.6: The flexor digitorum profundus and the flexor pollic longus.

Labels on Fig. 9.6:
Flexor pollicis longus
Flexor digitorum profundus
Areas of origin from bones and from interosseous membrane are shaded
Tendon of flexor pollicis longus
Tendons of flexor digitorum profundus
Terminal phalanx

Labels on Fig. 9.7:
Flexor digitorum superficialis
Median nerve
Flexor carpi ulnaris
Ulnar artery and nerve
Flexor digitorum profundus
Palmaris longus
Flexor carpi radialis
Brachioradialis
Radial artery and nerve
Extensor carpi radialis longus
Ulna
Aponeurosis attached to posterior border of ulna
Extensor compartment
Interosseous membrane
Pronator teres
Extensor carpi radialis brevis
Radius
Flexor digitorum profundus
Anterior interosseous nerve and artery

Fig. 9.7: Transverse section passing through the middle of the forearm showing arrangement of structures in the flexor (anterior) compartment.

Labels on Fig. 9.8:
Palmaris longus
Median nerve
Flexor digitorum profundus
Flexor digitorum superficialis
Pronator quadratus
Ulnar artery and nerve
Flexor carpi ulnaris
Flexor carpi radialis
Flexor pollicis longus
Radial artery
Ulna
Radius
1 to 6 : Compartments on dorsum of wrist
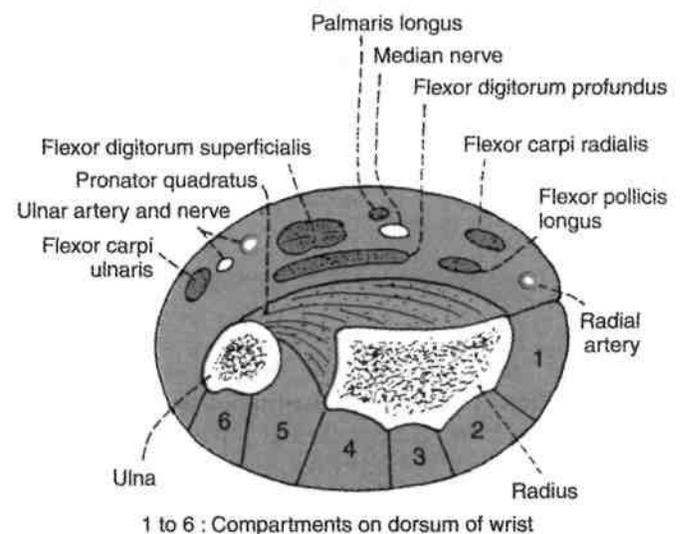
Fig. 9.8: Transverse section passing just above wrist showing arrangement of the structures in the flexor (anterior) compartment.

an hour-glass swelling called a compound palmar ganglion.

(2) *The synovial sheath of the tendon of flexor pollicis longus (radial bursa)*. This sheath is usually separate but may communicate with the common sheath behind the retinaculum. Superiorly, it is coextensive with the common sheath and inferiorly it extends up to the distal phalanx of the thumb.

(3) *The digital synovial sheaths*. The sheaths enclose the flexor tendons in the fingers and line the fibrous flexor sheaths. The digital sheath of the little finger is continuous with the ulnar bursa, and that of the thumb with the radial bursa. However, the digital sheaths of the index, middle and ring fingers are separate and independent (Fig. 9.9).

Vincula Longa and Brevia

The vincula longa and brevia are synovial folds, similar to the mesentery, which connect the tendons to the phalanges. They transmit vessels to the tendons (Fig. 9.10).

Arteries on the Front of the Forearm

The most conspicuous arteries of the forearm are the radial and ulnar arteries. However, they mainly
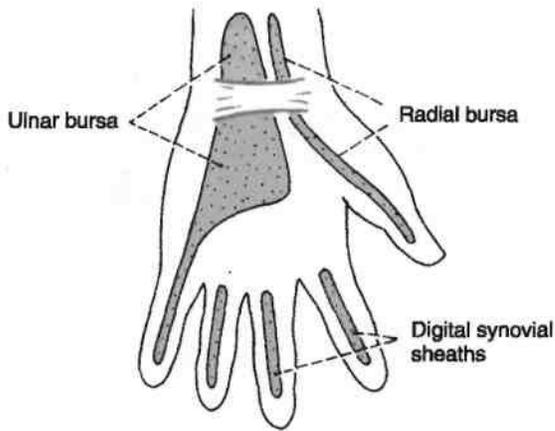
Fig. 9.9: *The synovial sheaths of the flexor tendons.*
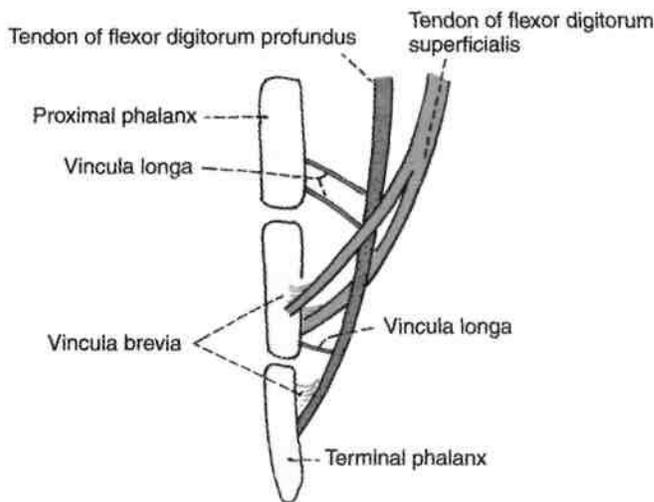
Fig. 9.10: *The flexor tendons of a finger showing the vincula longa and brevia.*

supply the hand through the deep and superficial palmar arches. The arterial supply of the forearm is chiefly derived from the common interosseous branch of the ulnar artery, which divides into anterior and posterior interosseous arteries. The posterior interosseous artery is reinforced in the upper part and replaced in the lower part by the anterior interosseous artery.

Having dissected the superficial and deep group of muscles of the forearm, identify the terminal branches of the brachial artery, e.g. ulnar and radial arteries and their branches. Radial artery follows the direction of the brachial artery. Ulnar artery passes obliquely deep to heads of pronator teres and then runs vertically till the wrist. Carefully look for common interosseous branch of ulnar artery and its anterior and posterior branches.

Radial Artery

Surface Marking

Radial artery is marked by joining the following two points (Fig. 9.11).

(i)   A point in front of the elbow at the level of the neck of the radius medial to the tendon of the biceps brachii. (ii) The second point at the wrist between the anterior border of the radius laterally and the tendon of the flexor carpi radialis medially, where the radial pulse is commonly felt. Its course is curved with a gentle convexity to the lateral side.
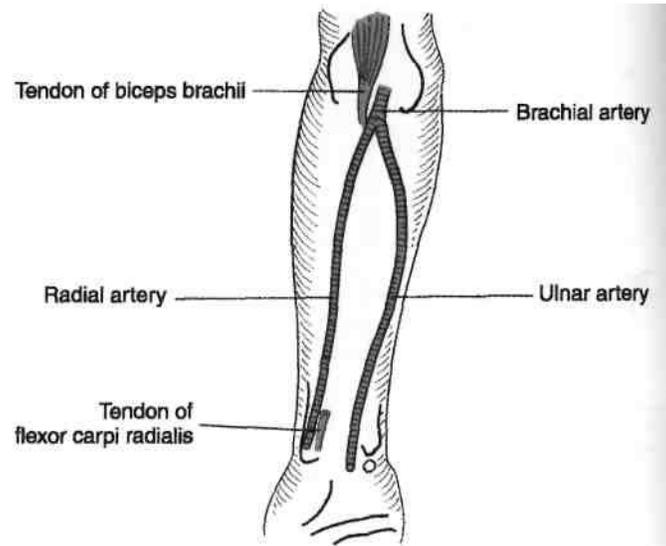
Fig. 9.11: *Arteries of front of forearm.*

Course and Relations

Radial artery is the smaller terminal branch of the brachial artery in the cubital fossa. It runs downwards to the wrist with a lateral convexity. It leaves the forearm by turning posteriorly and entering the anatomical snuff box. As compared to the ulnar artery, it is quite superficial throughout its whole course. Its distribution in the hand is described later. Its relations are as follows:

1. *An teriorly,* it is overlapped by the brachioradialis in its upper part, but in the lower half it is covered only by skin, superficial and deep fascia.

2. *Posteriorly,* the following structures form the bed of the radial artery (Fig. 9.12):

(i)   Biceps tendon
(ii)   Supinator
(iii)   Insertion of pronator teres (iv)   Radial origin of the flexor digitorum super-ficialis
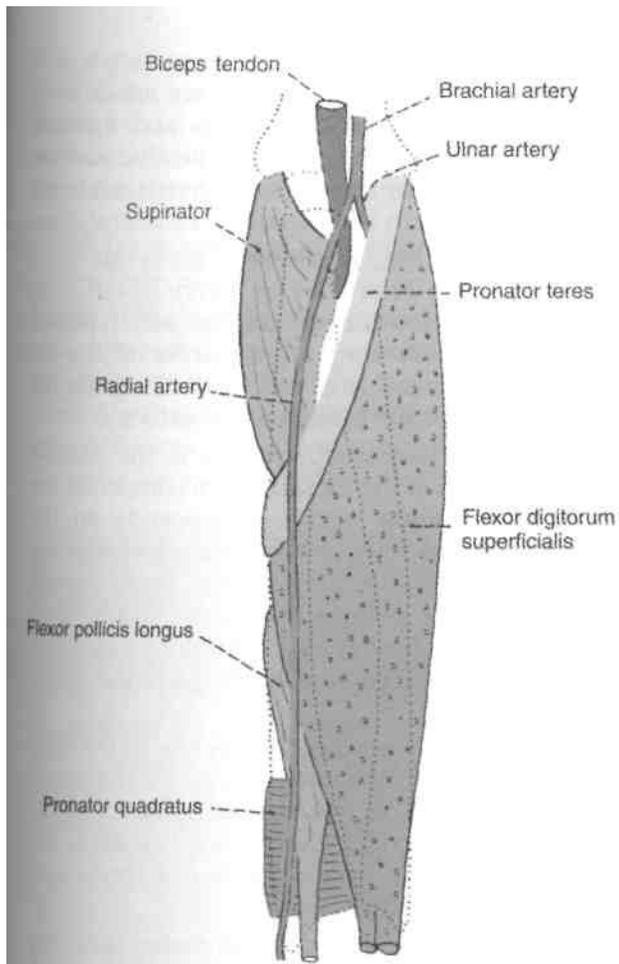
Fig. 9.12: Muscles lying deep to the radial artery.

(v) Radial origin of flexor pollicis longus (vi) Pronator quadratus (vii) Lower end of radius.

1.*Medially,* there are the pronator teres in the upper one-third and the tendon of the flexor carpi radialis in the lower two-thirds of its course.

2.*Laterally,* there are the brachioradialis in the whole extent and the radial nerve in the middle one-third.

3.The artery is accompanied by a pair of venae comitantes.

Branches in the Forearm

1.The *radial recurrent artery* arises just below the elbow, runs upwards deep to the brachioradialis, and ends by anastomosing with the radial collateral artery, in front of the lateral epicondyle of the humerus (Fig. 8.11).

2.*Muscular branches* are given to the lateral muscles of the forearm.

3.The *palmar carpal branch* arises near the lower border of the pronator quadratus, runs medially deep to the flexor tendons, and ends by anastomos-

ing with the palmar carpal branch of the ulnar artery, in front of the middle of the recurrent branch of the deep palmar arch, to form a cruciform anastomosis. The palmar carpal arch supplies bones and joints at the wrist.

4. The *superficial palmar branch* arises just before the radial artery leaves the forearm (by winding backwards). The branch passes through (occasionally over) the thenar muscles, and ends either by supplying these muscles, or by joining the terminal part of the ulnar artery to complete the superficial palmar arch.

Variations

1.*Higher origin.* In these cases, the radial artery arises more often from the axillary or upper part of the brachial artery, than from the lower part of the brachial artery.

2.*Superficial course.* In the forearm, the radial artery may lie in the superficial fascia. On turning round the wrist, it may pass superficial to the extensor tendons of the thumb.

CLINICAL ANATOMY

The radial artery is used for feeling the (arterial) pulse at the wrist. The pulsation can be felt well in this situation because of the presence of the flat radius behind the artery.

Ulnar Artery

Surface Marking

The ulnar artery (Fig. 9.11) is marked by joining the following three points.

(i) A point in front of the elbow at the level of the neck of the radius medial to the tendon of the biceps brachii.

(ii) A second point at the junction of the upper one-third and lower two-thirds of the medial border of the arm, lateral to the ulnar nerve.

(iii) The third point lateral to the pisiform bone.

Thus the course of the ulnar artery is oblique in the upper one-third, and vertical in its lower two-thirds. The ulnar nerve lies just medial to the ulnar artery in the lower two-thirds of its course. The ulnar artery continues in the palm as the superficial palmar arch.

Course and Relations

Ulnar artery is the larger terminal branch of the brachial artery, and begins in the cubital fossa (Fig. 9.13). The artery runs obliquely downwards and medially in the upper one-third of the forearm; but in the lower two-thirds of the forearm its course is vertical (Fig. 9.11). It enters the palm by passing
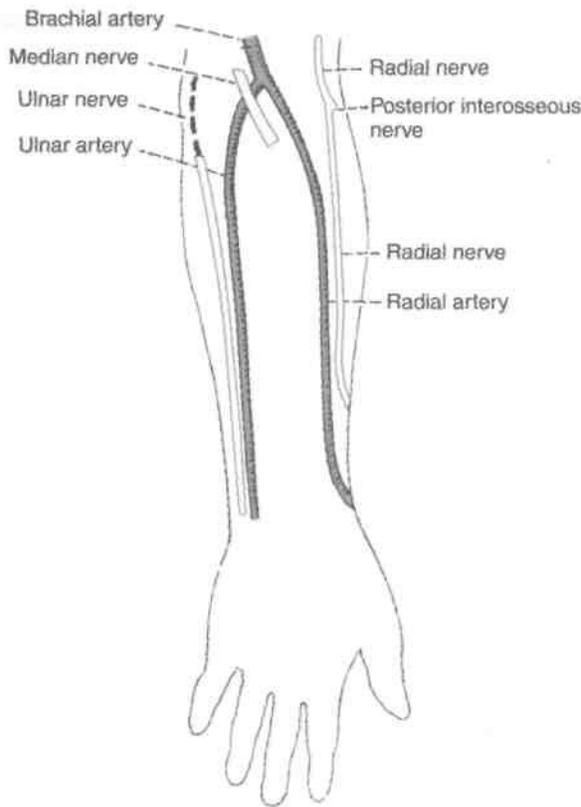
Fig. 9.13: The radial and ulnar nerves and vessels in the forearm.

superficial to the flexor retinaculum (Figs 9.4, 9.5). Its distribution in the hand is described later. Its relations are as follows.

1.*Anteriorly,* in its upper half, the artery is deep and is covered by: (i) the pronator teres (with the median nerve), (ii) the flexor carpi radialis, (iii) the palmaris longus, (iv) the flexor digitorum superficialis, and (v) the flexor carpi ulnaris. The lower half of the artery is superficial and is covered only by skin, superficial and deep fascia, and by the palmar cutaneous branch of the ulnar nerve (Figs 9.7, 9.8).

2.*Posteriorly,* the origin of the artery lies on the brachialis. In the rest of its course, the artery lies on the flexor digitorum profundus (Fig. 9.7).

3.*Medially,* it is related to the ulnar nerve, and to the flexor carpi ulnaris.

4.*Laterally,* it is related to the flexor digitorum superficialis (Fig. 9.4).

5.The artery is accompanied by two venae comitantes.

Branches

1. The *anterior and posterior ulnar recurrent arteries* anastomose around the elbow. The smaller anterior ulnar recurrent artery arises just below the elbow, runs upwards deep to the pronator teres, and ends by anastomosing with the inferior ulnar collat-

eral artery in front of the medial epicondyle. The I larger posterior ulnar recurrent artery arises lower ■ than the anterior, runs backwards and upwards I deep to the flexor digitorum superficialis, and be- I tween the heads of the flexor carpi ulnaris, and ends I by anastomosing with the two ulnar collateral arteries behind the medial epicondyle (Fig. 8.11).

2. The *common interosseous artery* (about 1 cm long) arises just below the radial tuberosity. It passes I backwards to reach the upper border of the in terosseous membrane, and end by dividing into the anterior and posterior interosseous arteries.

The anterior interosseous artery is the deepest artery on the front of the forearm. It accompanies the I anterior interosseous nerve. It descends on the   j surface of the interosseous membrane between the I flexor digitorum profundus and the flexor pollicis longus (Fig.9.7). It pierces the interosseous membrane at the upper border of the pronator quadratus to enter the extensor compartment (peroneal artery in the leg).

The artery gives muscular branches to the deep muscles of the front of the forearm, nutrient branches to the radius and ulna, reinforcing branches to the ! extensor compartment, a descending branch to the anterior carpal arch, and a median artery which accompanies the median nerve.

Near its origin, the *posterior interosseous artery* gives off the interosseous recurrent artery which runs upwards, and ends by anastomosing with middle collateral artery behind the lateral epicondyle.

1.*Muscular branches* supply the medial muscles of the forearm.

2.*Palmar and dorsal carpal* branches take part in the anastomosis round the wrist joint. The palmar carpal branch helps to form the palmar carpal arch.

The dorsal carpal branch arises just above the pisiform bone, winds backwards deep to the tendons, and ends in the dorsal carpal arch. This arch is formed medially by the dorsal carpal branch of the ulnar artery, and laterally by the dorsal carpal branch of the radial artery. Superiorly, the arch is joined by the anterior and posterior interosseous arteries. Inferiorly, the arch supplies three slender dorsal matacarpal arteries.

Variations

Higher origin and superficial course. When the origin of the ulnar artery is high the artery arises more often from the brachial artery (than from the axillary artery). In such cases, the artery passes superficial to the forearm flexors either deep or superficial to the deep fascia; and the brachial artery becomes continuous with the common interosseous artery.

Near its origin the *anterior interosseous artery* gives off the median artery which accompanies and supplies the median nerve. The median artery may arise from the common interosseous artery. Sometimes this artery is large and reaches the palm.

NERVES OF THE FRONT OF THE FOREARM

Nerves of the front of the forearm are the median, ulnar and radial nerves. The radial and ulnar nerves ran along the margins of the forearm, and are never crossed by the corresponding vessels which gradually approach them. The ulnar artery, while approaching the ulnar nerve, gets crossed by the median nerve.

DISSECTION

Median nerve is the chief nerve of the forearm. It enters the forearm by passing between two heads of pronator teres muscle. Its anterior interroseous branch is given off as it is leaving the cubital fossa. Identify median nerve stuck to the fascia on the deep surface of flexor digitorum superficialis muscle. In the distal part it lies lateral to the above mentioned muscle (Fig. 9.4). Dissect the anterior interosseous nerve as it lies on the interosseous membrane between flexor pollicis longus and flexor digitorum profundus muscles (Fig. 9.7).

Identify the ulnar nerve situated behind the medial epicondyle. Trace it vertically down till the flexor retinaculum (Fig. 9.14).

Trace the radial nerve and its two branches in the lateral part of the cubital fossa. Its deep branch is muscular and superficial branch is cutaneous (Fig. 9.14).

Median Nerve

Median nerve is the main nerve of the front of the forearm. It also supplies the muscles of thenar eminence.

Surface Marking

In the arm: Mark the brachial artery. The nerve is then marked lateral to the artery in the upper half, and medial to the artery in the lower half of the arm. The nerve crosses the artery anteriorly in the middle of the arm (Fig. 8.7).

In the forearm: It is marked by joining the following two points:

(i) A point medial to the brachial artery at the bend *of the elbow (Fig. 9.14)*. (ii) A point in front of the wrist, over the tendon of the palmaris longus (or 1 cm medial to the tendon of the flexor carpi radialis).
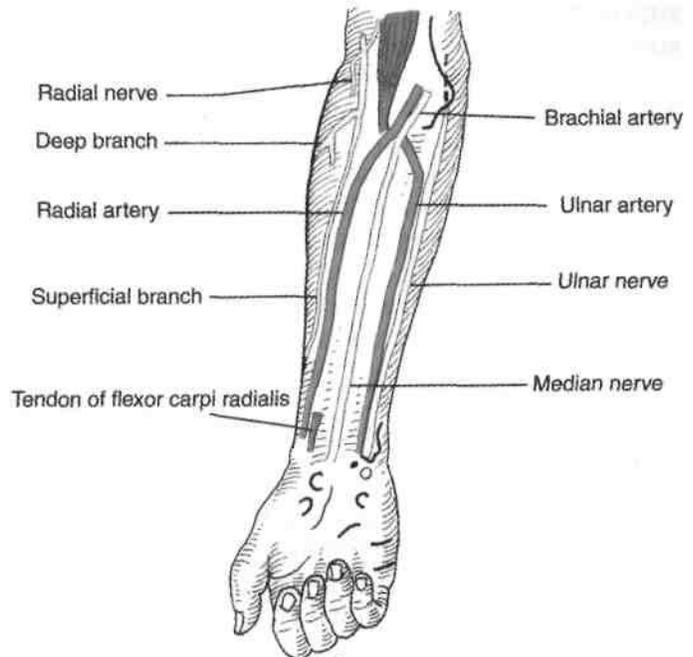
Fig. 9.14: Nerves in front of forearm.

Course and Relations

1.In the cubital fossa, median nerve lies medial to the brachial artery, behind the bicipital aponeurosis, and in front of the brachialis (Fig. 8.16).

2.The median nerve enters the forearm by passing between the two heads of the pronator teres. Here it crosses the ulnar artery from which it is separated by the deep head of the pronator teres (Figs 9.15, 8.16).

3.Along with the ulnar artery, the median nerve passes beneath the fibrous arch of the flexor digitorum
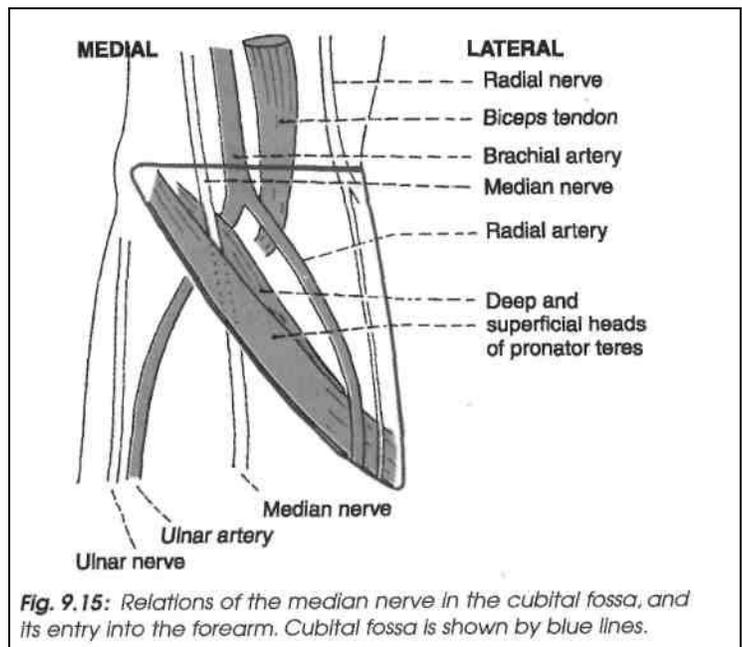
Fig. 9.15: *Relations of the median nerve in the cubital fossa, and its entry into the forearm. Cubital fossa is shown by blue lines.*

superficialis, and runs deep to this muscle on the surface of the flexor digitorum profundus. It is accompanied by the median artery, a branch of the anterior interosseous artery. About 5 cm above the flexor retinaculum (wrist), it becomes superficial and lies between the tendons of the flexor carpi radialis (laterally) and the flexor digitorum superficialis (medially). It is overlapped by the tendon of the palmaris longus (Figs 9.4, 9.5).

4. The median nerve enters the palm by passing deep to the flexor retinaculum through the carpal tunnel (Fig. 9.5).

Branches and Distribution in the Forearm

1.*Muscular branches* are given off in the cubital fossa to flexor carpi radialis, palmaris longus and flexor digitorum superficialis.

2.The *anterior interosseous branch* is given off in the upper part of the forearm. It supplies the flexor pollicis longus, the lateral half of the flexor digitorum profundus (giving rise to tendons for the index and middle fingers) and the pronator quadratus. The nerve also supplies the distal radioulnar and wrist joints (Fig. 9.16).

3.The *palmar cutaneous branch* arises a short distance above the flexor retinaculum and supplies the skin over the thenar eminence and the central part of the palm.

4.*Articular branches* are given to the elbow joint and to the proximal radioulnar joint.

5.*Vascular branches* supply the radial and ulnar arteries.

6.A *communicating branch* is given to the ulnar nerve.

<div align="center">CLINICAL ANATOMY</div>

1.The median nerve controls coarse movements of the hand, as it supplies most of the long muscles of the front of the forearm. It is, therefore, called the 'labourer's nerve'.

2.When the median nerve is injured above the level of the elbow, as might happen in supracondylar fracture of the humerus, the following features are seen.

(a)The flexor pollicis longus is paralyzed. The patient is unable to bend the terminal phalanx of the thumb when the proximal phalanx is held firmly by the clinician (to eliminate the action of the short flexors). Similarly, the terminal phalanges of the index and middle fingers can be tested.

(b)The forearm is kept in a supine position due to paralysis of the pronators.

(a)The hand is adducted due to paralysis of the flexor carpi radialis, and flexion at the wrist is weak.

(b)Flexion at the interphalangeal joints of the index and middle fingers is lost so that the index (and to a lesser extent) the middle fingers tend to remain straight while making a fist.

(c)Ape thumb deformity is present due to pairalysis of the thenar muscles.

(d)The area of sensory loss in the hand is much less than the area of distribution.

(e)Vasomotor and trophic changes: The skin on lateral three and a half digits is warm, dry and scaly. The nails get cracked easily.

/3. *Injury to the median nerve at the* wrist is , \mhch more common than at the elbow. This is due -, to the superficial position of the nerve at this site.

It produces: .^p/[1] (a) Ape thumb deformity where the thenar muscles are wasted, and the thumb is adducted and laterally rotated.

(a)Opposition of the thumb is totally lost.

(b)Paralysis of the first and second lumbricals makes the index and middle fingers lag behind in slowly making a fist. The sensory loss, vasomotor and trophic changes are similar to that seen in lesions of the nerve at the elbow.}

The distribution of the median nerve in the hand, is discribed later in this chapter.

Ulnar Nerve

Surface Marking

Ulnar nerve is marked in the arm (Fig. 9.14) by joining the following points.

(i) A point at the junction of the anterior one-third and posterior two-thirds of the lateral wall of the axilla at its lower limit, i.e. the lower border of the teres major muscle.

(ii) The second point at the middle of the medial border of the arm (Fig. 8.7).

(iii) The third point behind the base of the medial epicondyle of the humerus.

Ulnar nerve is marked in the forearm by joining the following two points.

(i) A point on the back of the base of the medial epicondyle of the humerous.

(ii) The second point lateral to the pisiform bone.

In the lower two-thirds of the forearm, the ulnar nerve lies medial to the ulnar artery.

Lateral root

Medial root

Median nerve

Tendon of biceps brachii

Elbow joint

Pronator teres

Anterior interosseous nerve

Branches to flexor carpi radialis, palmaris longus and flexor digitorum superficialis

For muscles of thenar eminence

Palmar cutaneous branch

Digital nerves
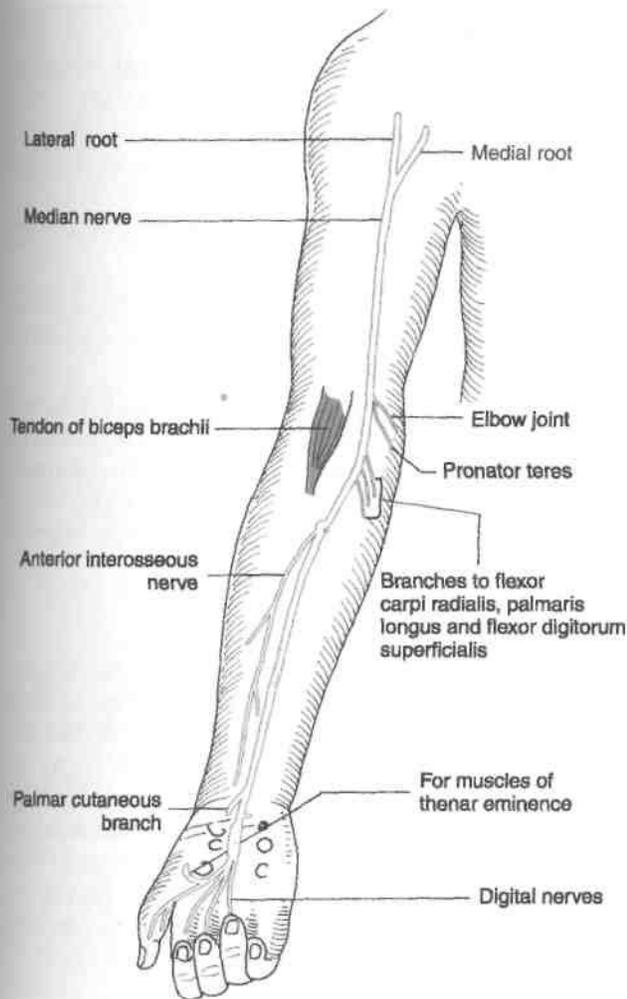
Fig. 9.16: *Distribution of median nerve.*

Course and Relations

1. At the elbow, the ulnar nerve lies behind the medial epicondyle of the humerus. It enters the forearm by passing between the two heads of the flexor carpi ulnaris (Fig. 9.13).

2. In the forearm, the ulnar nerve runs between the flexor digitorum profundus and the flexor digitorum superficialis laterally. It enters the palm by passing superficial to the flexor retinaculum lateral to the pisiform bone.

3. At the wrist, the ulnar neurovascular bundle lies between the flexor carpi ulnaris and the flexor digitorum superficialis. The bundle enters the palm by passing superficial to the flexor retinaculum, lateral to the pisiform bone (Fig. 9.5).

Branches

(i) Muscular, to the flexor carpi ulnaris and the medial half of the flexor digitorum profundus.

(ii) Palmar and dorsal cutaneous branches. The palmar cutaneous nerve arises in the middle of the forearm and supplies the skin over the hypothenar eminence.

The dorsal branch arises 7.5 cm above the wrist, winds backwards and supplies the proximal part of the ulnar *2Vo.* fingers and the adjoining area of the dorsum of the hand.

(iii) Articular branches are given off to the elbow joint.

<div align="center">

CLINICAL ANATOMY

</div>

1.The ulnar nerve is also known as the 'musician's nerve' because it controls fine movements of the fingers. Its details will be considered in the later part of this chapter.

2.The ulnar nerve is commonly injured at the elbow, behind the medial epicondyle; and at the wrist in front of the flexor retinaculum. *When the nerve is injured a t the elbowthe* flexor carpi ulnaris and the medial half of the flexor digitorum profundus are paralyzed. Due to this paralysis the medial border of the forearm becomes flattened. An attempt to produce flexion at the wrist result in abduction of the hand. The tendon of the flexor carpi ulnaris does not tighten on making a fist. Flexion of the terminal phalanges of the ring and little fingers is lost. Effects of paralysis on the hand (claw hand) will be considered later.

Radial Nerve

Surface Marking

Radial nerve is marked by joining the following three points.

(i) A point 1 cm lateral to the biceps tendon at the level of the lateral epicondyle (Fig. 9.14). (ii) The second point at the junction of the upper two-thirds and lower one-third of the lateral border of the forearm just lateral to the radial artery, (iii) The third point at the anatomical snuff box. The nerve is vertical in its course between points one and two. At the second point it inclines backwards to reach the snuff box.

The nerve is closely related to the lateral side of the radial artery only in the middle one-third of the forearm (Fig. 9.13).

Course and Relations

1. The radial nerve divides into its two terminal branches in the cubital fossa at the level of the lateral epicondyle of the humerus(Fig. 8.16). The deep ter-

minal branch (posterior interosseous) soon enters the back of the forearm by passing through the supinator muscle. The superficial terminal branch (the main continuation of the nerve) runs down in front of the forearm.

2. The superficial terminal branch of the radial nerve is closely related to the radial artery only in the middle one-third of the forearm. In the upper one-third, it is widely separated from the artery, and in the lower one-third it passes backwards under the tendon of the brachioradialis. The superficial terminal branch is purely cutaneous and is distributed to the lateral half of the dorsum of the hand, and to the proximal parts of the dorsal surfaces of the thumb, the index finger, and lateral half of the middle finger. Injury to this branch results in small area of sensory loss over the root of the thumb.

THE PALMAR ASPECT OF THE WRIST AND HAND

The human hand is designed: (i) for grasping, (ii) for precise movements, and (iii) for serving as a tactile organ.

The skin of the palm is: (i) thick for protection of underlying tissues, (ii) immobile because of its firm attachment to the underlying palmar aponeurosis, and (iii) creased. All of these characters increase the efficiency of the grip.

The skin is supplied by spinal nerves C6, C7, C8 (Fig. 6.1) through the median and ulnar nerve.

The superficial fascia of the palm is made up of dense fibrous bands which bind the skin to the deep fascia (palmar aponeurosis) and divide the subcutaneous fat into small tight compartments which serve as water-cushions during firm gripping. The fascia contains a subcutaneous muscle, the palmaris brevis, which helps in improving the grip by steadying the skin on the ulnar side of the hand. The superficial metacarpal ligament which stretches across the roots of the fingers over the digital vessels and nerves, is a part of this fascia.

The deep fascia is specialized to form: (i) the flexor retinaculum at the wrist, (ii) the palmar aponeurosis in the palm, and (iii) the fibrous flexor sheaths in the fingers. All three form a continuous structure which holds the tendons in position and thus increases the efficiency of the grip.

Flexor Retinaculum

Flexor retinaculum is a strong fibrous band which bridges the anterior concavity of the carpus and converts it into a tunnel, the *carpal tunnel.*

DISSECTION

1. A horizontal incision at the distal crease of front of the wrist has already been made.

2. Make a vertical incision from the centre of the above incision through the palm to the centre of the middle finger (Fig. 9.17).

3. Give one horizontal incision along the distal palmar crease.

4. Give an oblique incision starting 3 cm distal to incision no. 2 and extend it till the tip of the distal phalanx of the thumb.

Thus the skin of the palm gets divided into 3 areas. Reflect the skin of lateral and medial flaps on their respective sides. The skin of the intermediate flap is reflected distally towards the distal palmar crease. Further the skin of middle finger is to be reflected on either side.

Superficial fascia and deep fascia

Remove the superficial fascia to clean the underlying deep fascia. Deep fascia is modified to form the flexor retinaculum at wrist, palmar aponeurosis in the palm, and fibrous flexor sheaths in the digits (Fig. 9.18). Identify the structures on its superficial surface. Divide the flexor retinaculum between the thenar and hypothenar eminences, carefully preserving the underlying median nerve and long flexor tendons. Identify long flexor tendons enveloped in their synovial sheaths including the digital synovial sheaths.

Surface Marking

Flexor retinaculum is marked by joining the following four points:

  (i) Pisiform bone
  (ii) Tubercle of the scaphoid bone
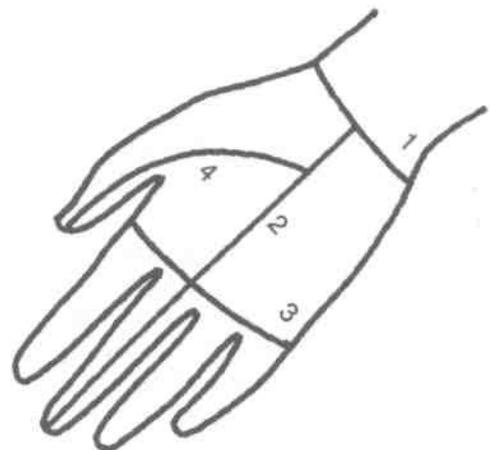
Fig. 9.17: Incisions of palm and digit.

(iii) Hook of the hamate bone

(iv) Crest of the trapezium

The upper border is obtained by joining the first and second points, and the lower border by joining the third and fourth points (Fig. 9.18). The upper border is concave upwards, and the lower border is concave downwards.

the flexor digitorum superficialis, (iii) the tendons of the flexor dogitorum profundus, (iv) the tendon of the flexor pollicis longus, (v) the ulnar bursa, and (vi) the radial bursa. The tendon of the flexor carpi radialis lies between the retinaculum and its deep slip, in the groove on the trapezium.)

Fig. 9.18: *The deep fascia of the hand forming the flexor retinaculum, palmar aponeurosis and fibrous flexor sheaths.*
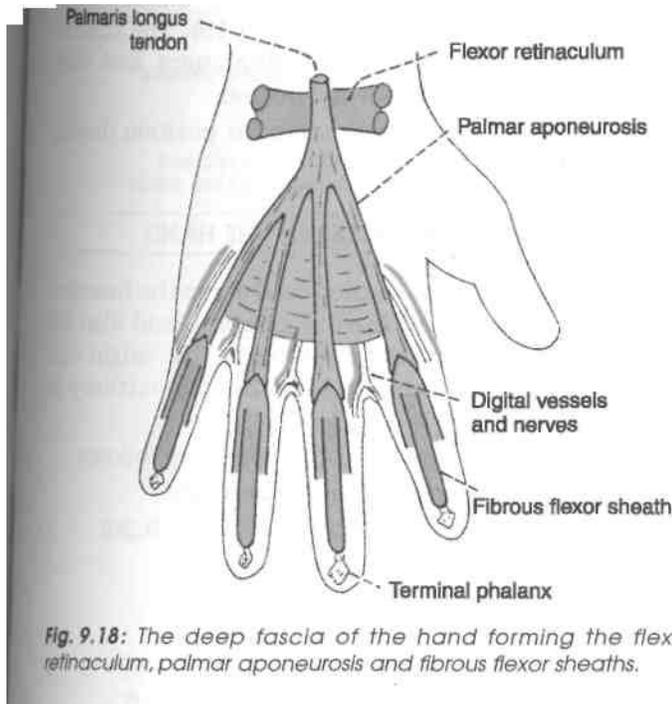
Attachments

Medially, to (i) the pisiform bone, and (ii) to the hook of the hamate. Laterally, to (i) the tubercle of the scaphoid, and (ii) the crest of the trapezium.

On either side the retinaculum has a slip: (1) the lateral *deep slip* is attached to the medial lip of the groove on the trapezium which is thus converted into a tunnel for the tendon of the flexor carpi radialis; (2) the medial *superficial slip (volar carpal ligament)* is attached to the pisiform bone. The ulnar vessels and nerves pass deep to this slip.

Relations , ₐ< /f\

The structures passing superficial to the flexor retinaculum are: (i) the tendon of the palmaris longus, (ii) the palmar cutaneous branch of the median nerve, (iii) the palmar cutaneous branch of the ulnar nerve, (iv) the ulnar vessels, and (v) the ulnar nerve. The flexor carpi ulnaris is partly inserted on the retinaculum, and the thenar and hypothenar muscles arise from it (Fig. 9.5).

/The structures passing deep to the flexor retinaculum are: (i) the median nerve, (ii) the tendons of

Carpal Tunnel Syndrome

This syndrome consists of motor, sensory, vasomotor and trophic symptoms in the hand caused by compression of the median nerve in the carpal tunnel. Examination reveals wasting of thenar eminence (ape-like hand) hypoaesthesia to light touch on the palmar aspect of lateral $2 > Vi$ digits. However, the skin over the thenar eminence is not affected as the branch of median nerve supplying it arises in the forearm.

Motor changes: Ape-like thumb deformity, loss of opposition of thumb, index and middle fingers lag behind while making the fist.

Sensory *changes:* Loss of sensations on lateral $3^x/2$ digits including the nail beds and distal phalanges on dorsum of hand.

Vasomotor changes: The skin areas with sensory loss is warmer due to arteriolar dilatation; it is also drier due to absence of sweating due to loss of sympathetic supply.

Trophic changes: Long-standing cases of paralysis lead to dry and scaly skin. The nails crack easily with atrophy of the pulp of fingers.

It usually occurs in females between the age of 40 and 70. They complain of intermittent attacks of pain in the distribution of the median nerve on one or both

sides. The attacks frequently occur at night. Pain may be referred proximally to the forearm and arm.

Palmar Aponeurosis

This term is often used for the entire deep fascia of the palm. However, it is better to restrict this term to the central part of the deep fascia of the palm which covers the superficial palmar arch, the long flexor tendons, the terminal part of the median nerve, and the superficial branch of the ulnar nerve (Fig. 9.18).

Features

Palmar aponeurosis is triangular in shape. The *apex* which is proximal blends with the flexor retinaculum and is continuous with the tendon of the palmaris longus. The base is directed distally. It divides into four slips opposite the heads of the metacarpals of

the medial four digits. Each slip divides into two parts which are continuous with the fibrous flexor sheaths. Extensions pass to the deep transverse metacarpal ligament, the capsule of the metacarpophalangeal joints and the sides of the base of the proximal phalanx. The digital vessels and nerves, and the tendons of the lumbricals emerge through the intervals between the slips. From the lateral and medial margins of the palmar aponeurosis, the lateral and medial *palmar septa* pass backwards and divide the palm into compartments.

Morphology

Phylogenetically, the palmar aponeurosis represents the degenerated tendon of the palmaris longus.

Functions

Palmar aponeurosis fixes the skin of the palm and thus improves the grip. It also protects the underlying tendons, vessels and nerves.

CLINICAL ANATOMY

Dupuytren 's Contracture: This condition is due to inflammation involving the ulnar side of the palmar aponeurosis. There is thickening and contraction of the aponeurosis. As a result the proximal phalanx and later the middle phalanx become flexed and cannot be straightened. The terminal phalanx remains unaffected. The ring finger is most commonly involved.

Fibrous Flexor Sheaths of the Fingers

The fibrous flexor sheaths are made up of the deep fascia of the fingers. The fascia is thick and arched. It is attached to the sides of the phalanges and across I the base of the distal phalanx. ProximaUy, it is I continuous with a slip of the palmar aponeurosis.

In this way, a blind osseofascial tunnel is formed which contains the long flexor tendons enclosed in I the digital synovial sheath (Fig. 9.19). The fibrous sheath is thick opposite the phalanges and thin opposite the joints to permit flexion.

The sheath holds the tendons in position during flexion of the digits.

INTRINSIC MUSCLES OF THE HAND

The intrinsic muscles of the hand serve the function of adjusting the hand during gripping and also for carrying out fine skilled movements. The origin and insertion of these muscles is within the territory of the hand.

There are 20 muscles in the hand, as follows.
1. (a) *Three muscles of thenar eminence*
   (i) Abductor pollicis brevis (Fig. 9.20). (ii) Flexor pollicis brevis. (iii) Opponens pollicis. (b) *One adductor of thumb* (i) Adductor pollicis.
2. *Fourhypothenarmuscles*
   (i) Palmaris brevis (Fig. 9.20). (ii) Abductor digiti minimi.

Palmaris longus
Origin of palmaris brevis
Pisiform bone
Origin of abductor digiti minimi
Origin of flexor digiti minimi
Origin of opponens digiti minimi
Hook of hamate
Insertion of opponens digiti minimi
Insertion of abductor digiti minimi and flexor digiti minimi

Flexor retinaculum
Tubercle of scaphoid
Origin of abductor pollicis brevis
Origin of flexor pollicis brevis
Origin of opponens pollicis
Crest of trapezium
Origin of adductor pollicis (oblique head)
Insertion of opponens pollicis
Insertion of abductor pollicis brevis and flexor pollicis brevis
Insertion of adductor pollicis and first palmar interosseous
Origin of adductor pollicis (transverse head)

Fig. 9.20: *The origin and insertion of the thenar and hypothenar muscles.*

    (iii)   Flexor digiti minimi.

   (iv)   Opponens digiti minimi. I Muscles (ii)-(iv) are muscles of hypothenar emi-Hence.

13. *Fourlumbricals.* BV *Fourpalmarinterossei.* B. *Four dorsal interossei.*

! These muscles are described below.

<div align="center">

DISSECTION

</div>

Clean the thenar and hypothenar muscles. Carefully preserve the median nerve and superficial and deep branches of ulnar nerve which supply these muscles.

   Abductor pollicis is the lateral muscle; flexor pollicis brevis is the medial one. Both these form the superficial lamina. The deeper lamina is constituted by opponens pollicis. Cut through the abductor pollicis to expose the opponens pollicis. These three muscles constitute the muscles of thenar eminence. Incise flexor pollicis brevis in its

centre *sod reftectits tivs> parts This* will reveal the tendon of flexor pollicis longus and adductor Dollicis on a deeDer rjlane. The muscles of thenar

eminence are supplied by thick recurrent branch of median nerve.

On the medial side of hand identify thin palmaris brevis muscle in the superficial fascia. It receives a twig from the superficial branch of ulnar nerve. Hypothenar eminence is comprised by abductor digiti minimi medially, flexor digiti minimi just lateral to it. Deep to both these lies opponens digiti minimi. Identify these three muscles and trace their nerve supply from deep branch of ulnar nerve.

Between the two eminences of the palm deep to palmar aponeurosis, identify the superficial palmar arch formed mainly by superficial branch of ulnar and superficial palmar branch of radial artery. Identify its common and proper digital branches. Clean, dissect and preserve the branches of the median nerve and superficial division of ulnar nerve in the palm lying between the superficial palmar arch and long flexor tendons (Fig. 9.21).

Lying on a deeper plane are the tendons of flexor digitorum superficialis muscle. Dissect the peculiar mode of its insertion in relation to that of tendon of flexor digitorum profundus.

Cut through the tendons of flexor digltorarrr superficialis 5 cm above the wrist. Divide both

ends of superficial palmar arch. Reflect them distally towards the metacarpophalangeal joints. Identify four tendons of flexor digitorum profundus diverging in the palm with four delicate muscles, the lumbricals arising from them. Dissect the nerve supply to these lumbricals. The first and second are supplied from median and third and fourth from the deep branch of ulnar nerve.

Divide the flexor digitorum profundus 5 cm above the wrist and reflect it towards the metacarpophalangeal joints. Trace one of its tendon to its insertion into the base of distal phalanx of one finger.

Abductor Pollicis Brevis

Origin

1. Tubercle of the scaphoid.
2. Crest of the trapezium.
3. Flexor retinaculum.

Insertion

I. Lateral side of the base of the proximal phalanx of the thumb.

Nerve supply: Median nerve (C8.T1), *Action:* Abduction of the thumb at the metacarpophalangeal and carpometacarpal joints. Abduction is associated with medial rotation.
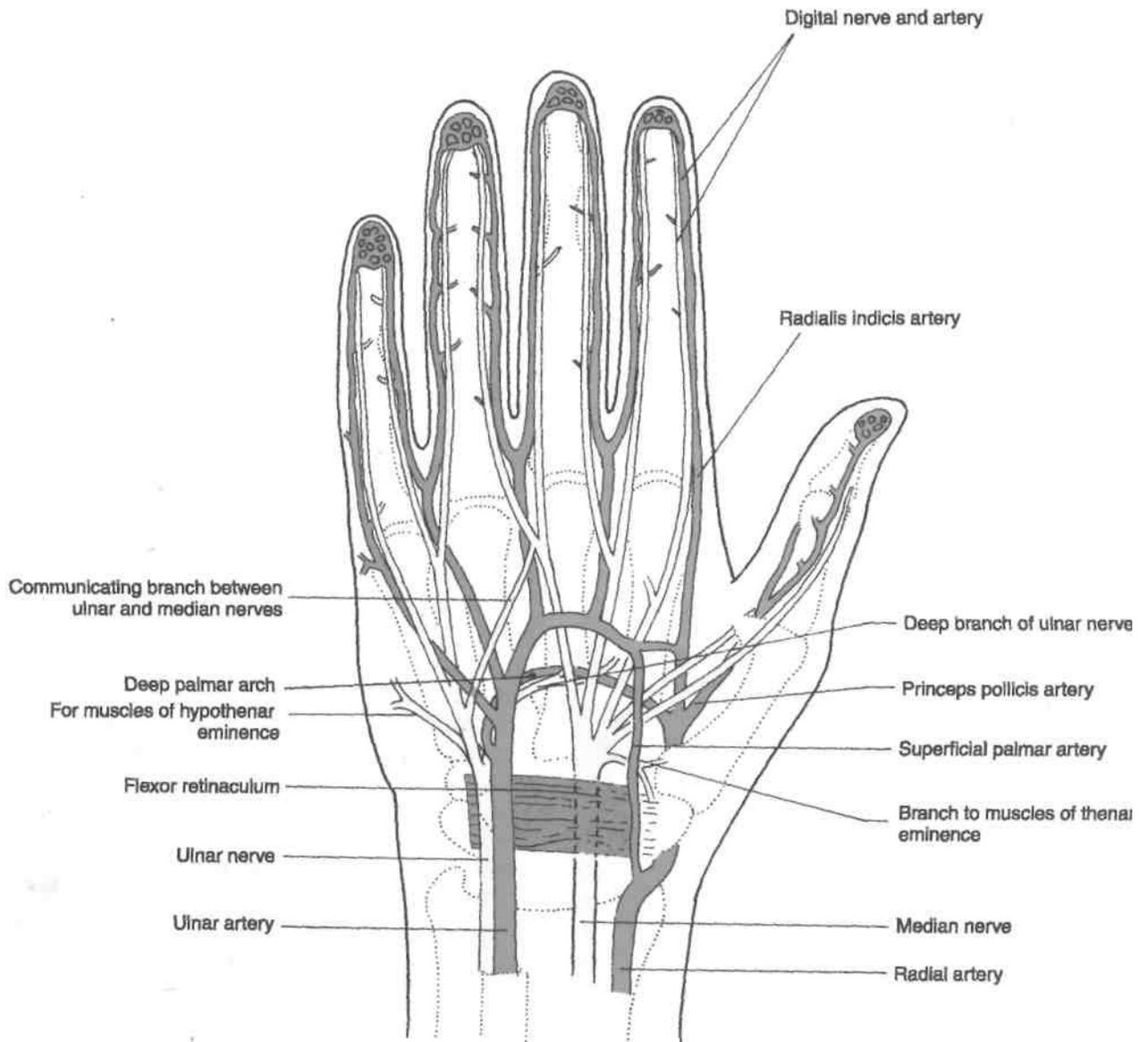
Fig. 9.21: Anterior view of palm. Palmar aponeurosis and greater part of flexor retinaculum have been removed to display sup palmar arch, deep palmar arch, ulnar nerve and median nerve.

fcexor *Pollicis Brevis*

The *superficial head* takes origin from

1. The crest of the trapezium.
2. The flexor retinaculum.

The *deep head* arises from the trapezoid and capitate bones.

Insertion: Lateral side of the base of the proximal phalanx.

Nerve Supply: It is supplied by the median nerve. The deep head may be supplied by the deep branch of the ulnar nerve. *Action:* Flexion of the thumb.

I *Opponens Pollicis*

I Origin

1. Crest of trapezium.
2. Flexor retinaculum.

Insertion: Lateral half of the palmar surface of the first metacarpal bone. *Nerve Supply:* Median nerve (C8,T1).

Action: Opposition of the thumb. This is a combination of flexion and medial rotation.

■dducforPo///c/"s

Origin

The muscle has two heads—oblique and transverse.

The oblique head arises from:

1. The capitate bone.
2. The base of the 2nd and 3rd metacarpal bones.

The transverse head arises from *the* palmar aspect of the third metacarpal bone.

Insertion: Medial side *of the base of the proximal* phalanx of the thumb.

Nerve Supply: Deep branch of ulnar nerve (C8, Tl).

Action: The muscle adducts the thumb from the flexed or abducted position. The movement is forceful in gripping.

Actions of Thenar Muscles

In studying the actions of the thenar muscles, it must be remembered that the movements of the thumb take place in planes at right angles to those of the other digits because the thumb (first metacar-

L pal) is rotated medially through 90 degrees. Flexion and extension of the thumb take place in the plane of the palm; and abduction and adduction at right angles to the plane of palm. Movement of the thumb across the palm to touch the other digits is known as

opposition. This movement is a combination of flexion and medial rotation.

Palmaris Brevis

This muscle is superficial and lies just under the skin.

Origin: From flexor retinaculum and palmar aponeurosis.
Insertion: Skin along medial border of the hand.
Nerve Supply: Ulnar nerve, superficial branch (C8, Tl).
Action: Helps in gripping by making the hypoth-enar eminence more prominent, and by wrinkling the skin over it.

Abductor Digiti Minimi

Origin: This muscle arises from the pisiform bone. The origin extends on to the tendon of the flexor carpi ulnaris (proximally) and on to the pisohamate ligament (distally).

Insertion: Ulnar side of the base of the proximal phalanx of the little finger.
Nerve Supply: Deep branch of ulnar nerve (C8, Tl).
Action: Abduction of little finger at the metacarpophalangeal joint.

Flexor Digiti Minimi

Origin

1.Hook of the hamate bone.
2.Flexor retinaculum.

Insertion: Ulnar side of the base of the proximal phalanx of the little finger.

JVerve *Supply:* Deep branch of the ulnar nerve (C8, Tl).
Action: Flexion of the little finger at the metacar-*pophalangeal joint.*

Opponens Digiti Minimi

Origin

1.Hook of the hamate.
2.Flexor retinaculum.

Insertion: Medial surface of the shaft of the fifth metacarpal bone.
Nerve Supply: Deep branch of ulnar nerve (C8, Tl).
Action: Flexor of the fifth metacarpal and rotates it laterally (as making the palm hollow).

Lumbrical Muscles

Lumbrical muscles are four small muscles that take origin from the tendons of the flexor digftorum profundus. They are numbered from lateral to medial

Origin: The *first lumbrical* arises from the radial side of the tendon for the index finger (Fig. 9.22). The *second lumbrical* arises from the radial side of the tendon for the middle finger. *The third lumbrical* arises from contiguous sides of the tendons for the middle and ring fingers. *The fourth lumbrical* arises from the contiguous sides of the tendons for the ring and little fingers.

Lumbricals

ndon of flexor digitorum profundus   **Tendon of flexor pollicis longus**

4th   3rd   2nd   1st
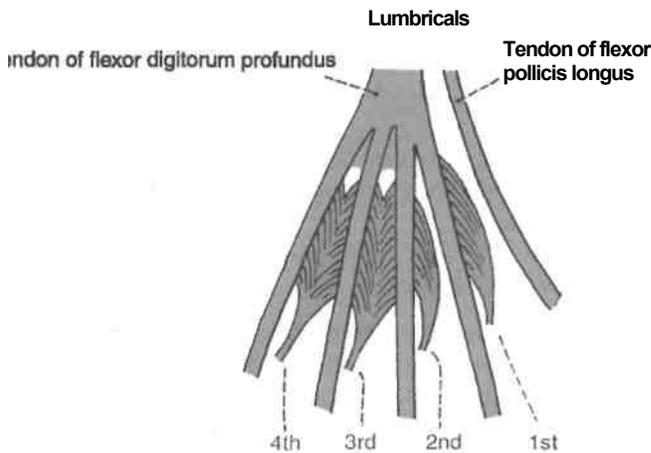
Fig. 9,22: The origin of the lumbrical muscles.

Insertion: The tendons of the first, second, third and fourth lumbricals pass backwards on the radial side of the second, third, fourth and fifth metacarpophalangeal joints respectively. They are inserted into the dorsal digital expansions of the corresponding digits.

Nerve Supply

1. The first and second lumbricals by the median nerve (C8, Tl).
2. The third and fourth lumbricals by the deep branch of the ulnar nerve (C8, Tl).

Actions: The lumbrical muscles flex the metacarpophalangeal joints, and extend the interphalangeal joints of the digit into which they are inserted.

Deep to the lateral two tendons of flexor digitorum profundus muscle, note an obliquely placed muscle extending from two origins, i.e. from the shaft of the third metacarpal bone and the bases of 2nd and 3rd metacarpal bones and adjacent carpal bones to the base of proximal phalanx of the thumb. This is adductor pollicis. Reflect the adductor pollicis muscle from its origin towards its insertion. Identify the deeply placed interossei muscles. Identify the radial artery entering the

palm between two heads of first dorsal interosseous muscle and then between two heads of adductor pollicis muscle turning medially to join the deep branch of ulnar artery to complete the deep palmar arch. Identify the deep branch of ulnar nerve lying in its concavity. Carefully preserve it, including its multiple branches. Deep branch of ulnar nerve ends by supplying the adductor pollicis muscle. It may supply deep head of flexor pollicis brevis also. Lastly, define four small palmar interossei and four relatively bigger dorsal interossei muscles (Figs 9.23, 9.24).
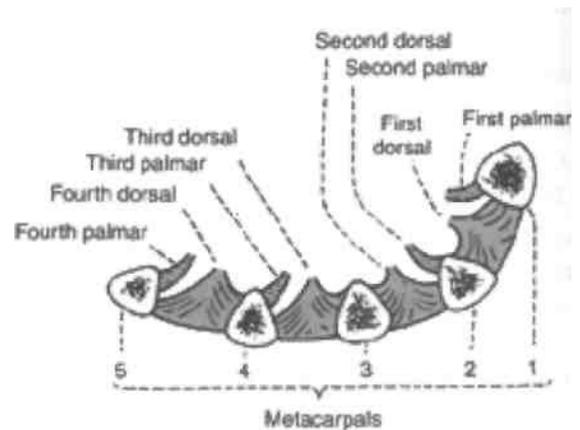
Fig. 9.23: The origin of the interossei muscles.
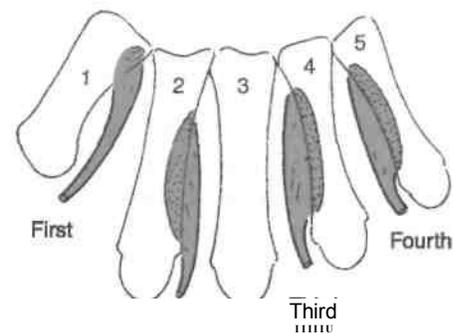
Second *Fig. 9.24: The palmar interossei.*

Palmar Interossei

Palmar interossei are four small muscles placed between the shafts of the metacarpal bones. They are numbered from lateral to medial side (Figs 9.24, 9.25).

Origin

1. *First palmar in terosseous* muscle from the medial side of the base of the first metacarpal bone.
2. *Second palmar interosseous* muscle from the medial half of the palmar aspect of the shaft of the second metacarpal bone (Fig. 9.24).
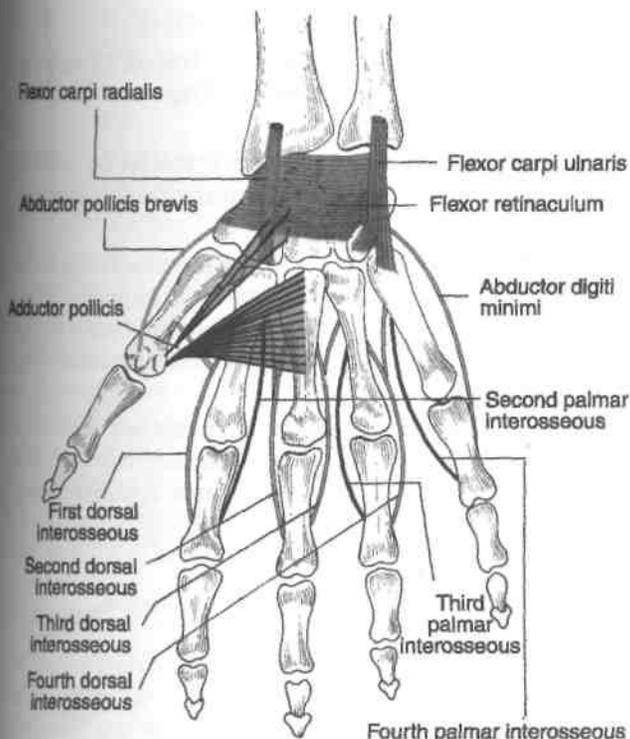
Fig. 9.25: Some muscles of the palm.

Fig. 9.26: The dorsal digital expansion of right middle finger. Note the insertions of the lumbricals and interossei into it.

3. *Third palmar interosseous* muscle from the lateral part of the palmar aspect of the shaft of the fourth metacarpal bone.

4. *Fourth palmar interosseous* from the lateral part of the palmar aspect of the shaft of the fifth metacarpal bone.

Insertion

Each muscle is inserted into the dorsal digital expansion of one digit. It may also be attached to the base of the proximal phalanx of the same digit. The digits into which individual palmar interossei are inserted are as follows.

1. First muscle: Medial side of thumb.
2. *Second* muscle: Medial side of the index finger.
3. *Third* muscle: Lateral side of the fourth digit.
*4. *Fourth* muscle: Lateral side of the fifth digit.

Note that the middle finger does not receive the insertion of any palmar interosseous muscle.

./Verve Supply

All palmar interossei are supplied by the deep branch of the ulnar nerve (C8, Tl).

Actions

All palmar interossei adduct the digit to which they are attached towards the middle finger. In addition, they flex the digit at the metacarpophalangeal joint and extend it at the interphalangeal joints.

Dorsal Interossei

Like the palmar interossei the dorsal interossei are four small muscles placed between the metacarpal bones, and are numbered from lateral to medial side (Figs 9.25, 9.26).

Origin

1. First *dorsal interosseous:* Shafts of first and second metacarpals (Fig. 9.23).
2. *Second dorsal interosseous:* Shafts of second and third metacarpals.
3. Third *dorsal interosseous:* Shafts of third and fourth metacarpals.
4. *Fourth dorsal interosseous:* Shafts of fourth and fifth metacarpals.

Insertion

Each muscle is inserted into the dorsal digital expansion of the digit; and into the base of the proximal phalanx of that digit. The digits into which individual muscles are inserted are as follows:

1. First: Lateral side of index finger.
2. *Second:* Lateral side of middle finger.
3. Third; Medial side of middle finger.
4. *Fourth:* Medial side of fourth digit.

Note that the middle linger receives one ubrsca[1] interosseous muscle on either side; and that the first and fifth digits do not receive any insertion.

Nerve Supply

All dorsal interossei are supplied by the deep branch of the ulnar nerve (C8, Tl).

Actions

All dorsal interossei cause abduction of the digits away from the line of the middle finger. This movement occurs in the plane of palm (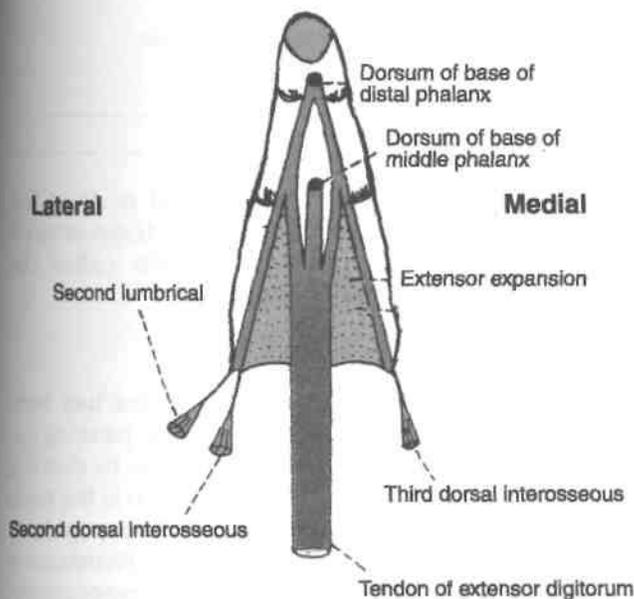Fig. 9.27) in contrast to the movement of thumb where abduction occurs at right angles to the plane of palm (Fig. 9.28). Note that movement of the middle finger to either medial or lateral side constitutes abduction. Also note that the first and fifth digits do not require dorsal interossei as they have their own abductors. In addition (like the palmar interossei), the dorsal interossei flex the metacarpophalangeal joint of the digit concerned and extend the interphalangealjoints.

2. Testing the muscles:
 (i) The opponens pollicis is tested by asking the subject to touch the fingertips with the tip of the thumb.
 (ii) The dorsal interossei are tested by asking the subject to spread out the fingers against resistance.
(iii) The palmar interossei and adductor pollicis are tested by placing a piece of paper between the fingers, between thumb and index finger and seeing how firmly it can be held (Fig. 9.29).
(iv) The lumbricals and interossei are tested by asking the subject to flex the fingers at the metacarpophalangeal joints against resistance.

Fig. 9.29: Test for palmar interossei.

Abduction ←--- | ---→ Abduction
Adduction ---→ | ←-- Adduction

Fig. 9.27: The planes of movements of the fingers.
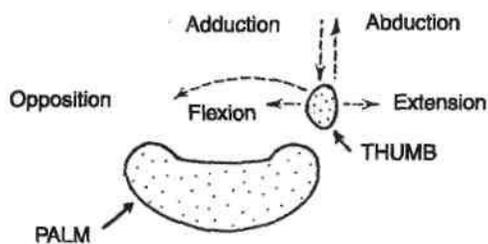
Fig. 9.28: The planes of movements of the thumb.

CLINICAL ANATOMY

1. Paralysis of the intrinsic muscles of the hand produces *claw hand* in which there is hyper-extension at the metacarpophalangeal joints, and flexion at the interphalangealjoints. (The effect is opposite to the action of the lumbricals and interossei.)

ARTERIES OF THE HAND

Arteries of the hand are the terminal parts of the ulnar and radial arteries. Branches of these arteries unite and form anastomotic channels called the superficial and deep palmar arches.

Ulnar Artery

The course of this artery in the forearm has been described earlier. It enters the palm by passing superficial to the flexor retinaculum. It ends by dividing into the superficial palmar branch, which is the main continuation of the artery, and the deep palmar branch. These branches take part in the formation of the superficial and deep palmar arches respectively.

Superficial Palmar Arch

The arch represents an important anastomosis between the ulnar and radial arteries along with the deep arch.

Surface Marking

Superficial palmar arch is formed by the direct continuation of the ulnar artery, and is marked as a curved line by joining these points:

(i) A point just lateral and distal to the pisiform bone (ii) The second point on the hook of the hamate bone

■ (iii) The third point on the distal border of the thenar eminence in line with the cleft between the index and middle fingers.

The convexity of the arch is directed towards the fingers, and its most distal point is situated at the level of the distal border of the fully extended thumb.

The superficial palmar arch is formed as the direct continuation of the ulnar artery beyond the flexor retinaculum, i.e. by the superficial palmar branch. On the lateral side the arch is completed by one of the following branches of the radial artery: (i) superficial palmar branch, (ii) the radialis indicis, (iii) the princeps pollicis (Fig. 9.30).

Relations

The superficial palmar arch lies deep to the palmaris brevis and the palmar aponeurosis. It crosses the palm over the flexor digiti minimi, the flexor tendons of the fingers, the lumbricals, and the digital branches of the median nerve.

Branches

Superficial palmar arch gives off four digital branches which supply the medial *?>Vi* fingers. The lateral three digital branches are joined by the corresponding palmar metacarpal arteries from the deep palmar arch.

The deep branch of the ulnar artery arises in front of the flexor retinaculum immediately beyond the pisiform bone. Soon it passes between the flexor and abductor digiti minimi to join and complete the deep palmar arch.

Radial Artery

Surface Marking

Radial artery is marked by joining the following three points:

(i) A point at the wrist between the anterior border of the radius and the tendon of the flexor carpi radialis

(ii) A second point just below the tip of the styloid process of the radius

(iii) The third point at the proximal end of the first intermetacarpal space
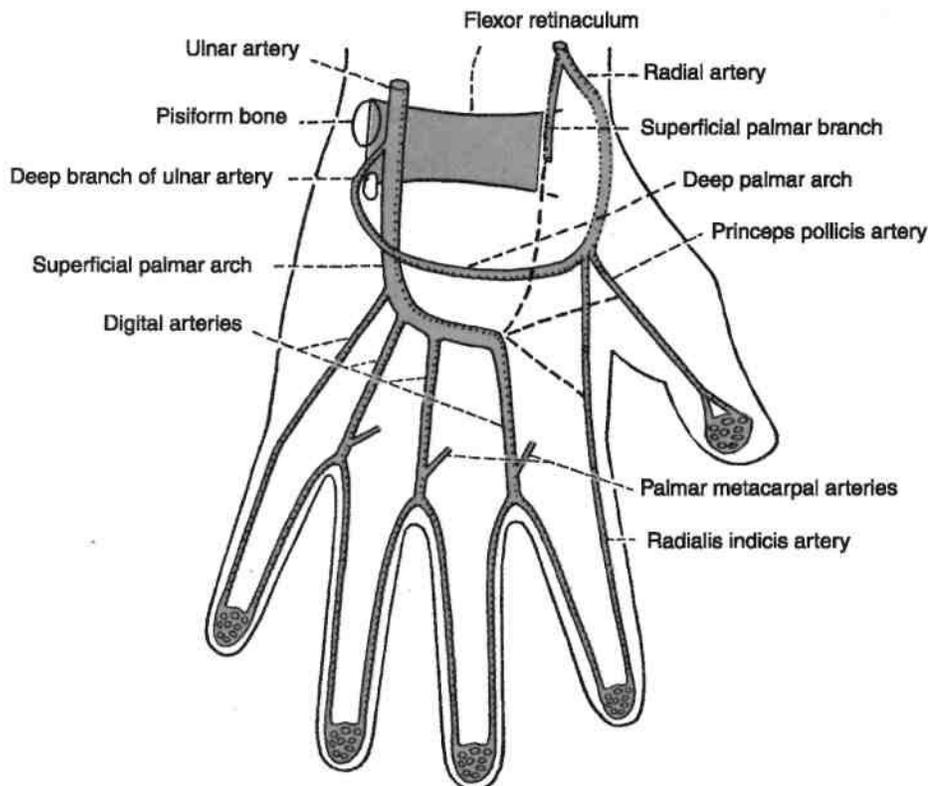
Fig. 9.30: *The superficial and deep palmar arches.*

Course and Relations

In this part of its course, the radial artery runs obliquely downwards, and backwards deep to the tendons of the abductor pollicis longus, the extensor pollicis brevis, and the extensor pollicis longus, and superficial to the lateral ligament of the wrist joint. Thus it passes through the anatomical snuff box to reach the proximal end of the first interosseous space (Fig. 9.31). Further, it passes between the two heads of the first dorsal interosseous muscle and between the two

of this muscle. Therefore, it is known as the deep palmar arch (Fig. 9.30).

Cephalic vein

Radial artery

Branch of radial nerve
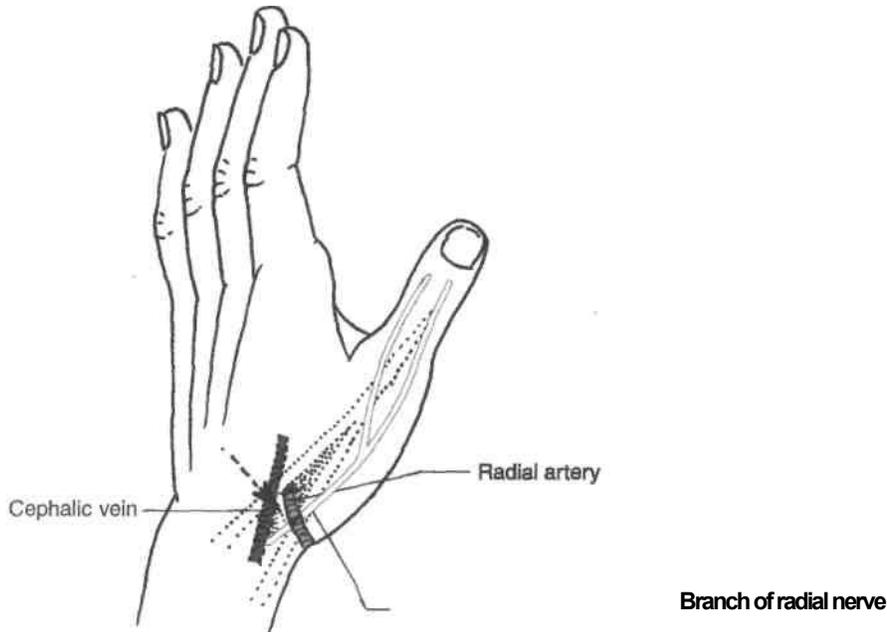
heads of adductor pollicis to form the deep palmar arch in the palm.

Fig. 9.31: Anatomical snuff box.

The course of this artery in the forearm is described earlier.

1. It leaves the forearm by winding backwards *round the wrist.*

   1. It passes through the anatomical snuff box where it lies deep to the tendons of the abductor pollicis longus, the extensor pollicis brevis and the extensor pollicis longus. It is also crossed by the digital branches of the radial nerve. The artery is superficial to the lateral ligament of the wrist joint, the scaphoid and the trapezium.

   2. It reaches the proximal end of the first interosseous space and passes between the two heads of the first dorsal interosseous muscle to reach the palm.

   3. In the palm, the radial artery runs medially. At first it lies deep to the oblique head of the adductor pollicis, and then passes between the two heads

Branches

Dorsum of hand: On the dorsum of the hand the radial artery gives off:

(1) A branch to the lateral side of the dorsum of the thumb.

(2) The *first dorsal metacarpal artery.* This artery arises just before the radial artery 'passes into the interval between the two heads of the first dorsal interosseous muscle. It at once divides into two branches for the adjacent sides of the thumb and the index finger.

Palm: In the palm (deep to the oblique head of the adductor pollicis), the radial artery gives off:

(1) The *princeps pollicis* arteiywhich divides at the base of the proximal phalanx into two branches for the palmar surface of the thumb.

(2) The *radialis indicis artery* descends between the first dorsal interosseous muscle and the transverse head of the adductor pollicis. It supplies the lateral side of the index finger. At the distal border of the transverse head of the adductor pollicis it anastomoses with the princeps pollicis artery, and gives a communicating branch to the superficial palmar arch.

The radialis indicis artery may arise from the princeps pollicis. Sometimes the princeps pollicis and the radialis indicis arteries arise by a common trunk called the first palmar metacarpal artery.

Deep Palmar Arch

Surface Marking

Deep palmar arch is formed as the direct continuation of the radial artery. It has a slight convexity towards the fingers. It is marked by a more or less horizontal line, 4 cm long, just distal to *the hook* of *the hamate bone.*

The deep palmar arch lies 1.2 cm proximal to the superficial palmar arch across the metacarpals, immediately distal to their bases. The deep branch of ulnar nerve lies in its concavity (Fig. 9.20).

This arterial arch provides a second channel connecting the radial and ulnar arteries in the palm (the first one being the superficial palmar arch already considered). It is situated deep to the long flexor tendons.

Formation

The deep palmar arch is formed mainly by the terminal part of the radial artery, and is completed medially at the base of the fifth metacarpal bone by the deep palmar branch of the ulnar artery.

The arch lies on the proximal parts of the shafts of the metacarpals, and on the interossei; under cover of the oblique head of the adductor pollicis, the flexor tendons of the fingers, and the lumbricals. The deep branch of the ulnar nerve lies within the concavity of the arch.

Branches

1.From its convexity, i.e. from its distal side, the arch gives off three *palmar metacarpal arteries,* which run distally in the 2nd, 3rd and 4th spaces, supply the medial four metacarpals, and terminate at the finger clefts by joining the common digital branches of the superficial palmar arch (Fig. 9.30).

2.Dorsally, the arch gives off three (proximal) *perforating arteries* which pass through the medial three interosseous spaces to anastomose with the dorsal metacarpal arteries. The digital perforating arteries connect the palmar digital branches of the superficial palmar arch with the dorsal metacarpal arteries.

3. *Recurrent branch* arises from the concavity of the arch and pass proximally to supply the carpal bones and joints, and end in the palmar carpal arch.

NERVES OF THE HAND   ~

Ulnar Nerve

Ulnar nerve is the main nerve of the hand (like the lateral plantar nerve in the foot).

Course and Relations

1.The ulnar nerve enters the palm by passing superficial to the flexor retinaculum where it lies between the pisiform bone and the ulnar vessels. Here the nerve divides into its superficial and deep terminal branches (Figs 9.32, 9.33).

2.The superficial terminal branch supplies the palmaris brevis and divides into two digital branches for the medial 1/4 fingers (Fig. 9.34).

3.The deep terminal branch accompanies the deep branch of the ulnar artery. It passes backwards between the abductor and flexor digiti minimi, and
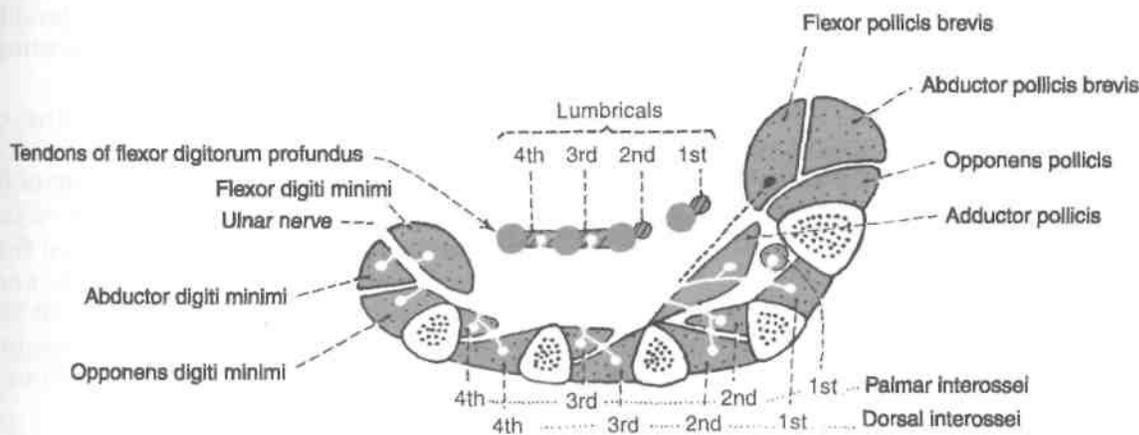
Fig. 9.32: Distribution of the deep branch of the ulnar nerve.
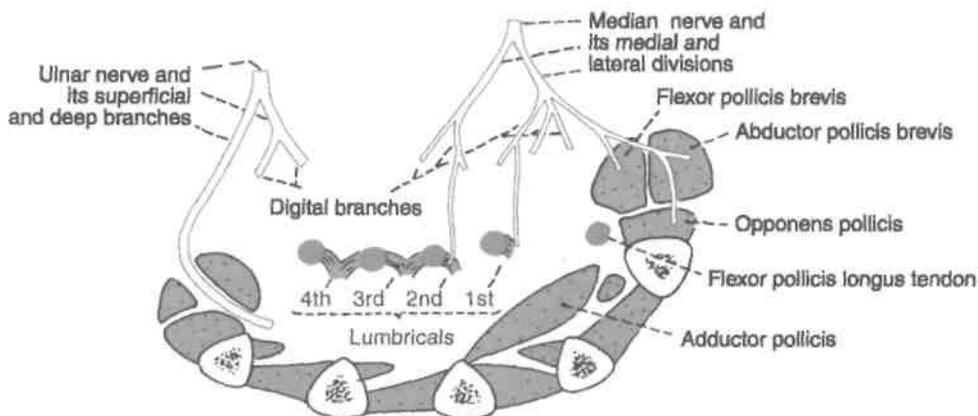
Fig. 9.33: Distribution of the median nerve in the hand. The main divisions of the ulnar nerve are also shown.
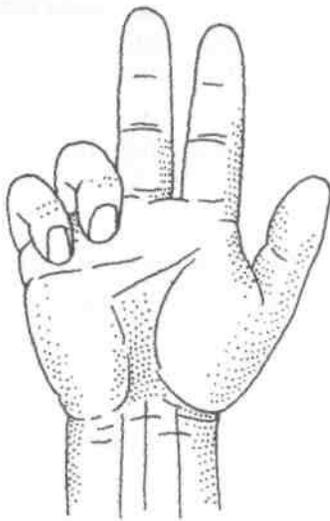
Fig. 9.34: Position of fingers in an ulnar 'claw-hand'.

then between the opponens digiti minimi and the fifth metacarpal bone, lying on the hook of the hamate. Finally, it turns laterally within the concavity of the deep palmar arch. It ends by supplying the adductor pollicis muscle (Fig. 9.33).

Branches

From Superficial Terminal Branch

1.Muscular branch: to palmaris brevis.

2.Cutaneous branches: two palmar digital nerves supply the medial one and a half fingers with their nail beds. The medial branch supplies the medial side of the little finger. The lateral branch is a common palmar digital nerve. It divides into two proper palmar digital nerves for the adjoining sides of the ring and little fingers. The common palmar digital nerve communicates with the median nerve.

From Deep Terminal Branch

1.Muscular branches: (a) at its origin the deepy branch supplies three muscles of hypothenar emi- > nence, (b) as the nerve crosses the palm. It supplies the medial two lumbricals and eight interossei, (c) the deep branch terminates by supplying the adductor pollicis, and occasionally the deep head of the flexor pollicis brevis.

2.An articular branch supplies the wrist joint.

CLINICAL ANATOMY

1.The ulnar nerve is often called the 'musician's nerve' because it controls fine movements of the fingers through its extensive motor distribution to the short muscles of the hand.

2.The ulnar nerve is most commonly injured at two sites: behind the medial epicondyle of the

humerus, and at the wrist. At both sites, it is quite superficial and vulnerable to injury. An ulnar .••nerve lesion at the wrist produces 'ulnar claw-hand', involving mainly the ring and little fingers. True claw-hand, involving all the fingers is produced by a combined lesion of the ulnar and median nerve.

Ulnar claw-hand is characterized by the following signs.

(a)Hyperextension at the metacarpophalangeal joints and flexion at the interphalangeal joints, involving the ring and little fingers—more than the index and middle fingers (Fig. 9.34). The little finger is held in abduction by extensor muscles. The intermetacarpal spaces are hollowed out due to wasting of the interosseous muscles. Claw-hand deformity is more obvious in wrist lesions as the profundus muscle is spared: this causes marked flexion of the terminal phalanges (action of paradox).

(b)Sensory loss is confined to the medial one-third of the palm and the medial one and a half fingers including their nail beds (Fig. 9.35).

(c)*Vasomotor changes:* The skin areas with sensory loss is warmer due to arteriolar dilatation; it is also drier due to absence of sweating due to loss of sympathetic supply.

(d)*Trophic changes:* Long-standing cases of paralysis lead to dry and scaly skin. The nails crack easily with atrophy of the pulp of fingers.

(e)The patient is unable to spread out the fingers due to paralysis of the dorsal interossei. The power of adduction of the thumb, and flexion of the ring and little fingers are lost. It should be noted that median nerve lesions are more disabling. In contrast, ulnar nerve lesions leave a relatively efficient hand.

^ (Claw-hand can be produced by a number of lesions, including Klumpke's paralysis, lesion of the medial cord of the brachial plexus, lesion of the ulnar nerve, a combined lesion of the ulnar and median nerves. A similar deformity can also result from a late and severe Volkmann's ischaemic contracture, the end result of a neglected suppurative tenosynovitis of the ulnar bursa (Fig. 9.36). Ulnar nerve injury at the wrist can be excluded by Froment's sign, or the book test which tests the adductor pollicis muscle. When the patient is asked to grasp a book firmly between the thumb and other fingers of both the hands, the terminal phalanx of the thumb on the paralysed side becomes flexed at the interphalangeal joint (by the flexor pollicis Jongus which is supplied by the median nerve).)
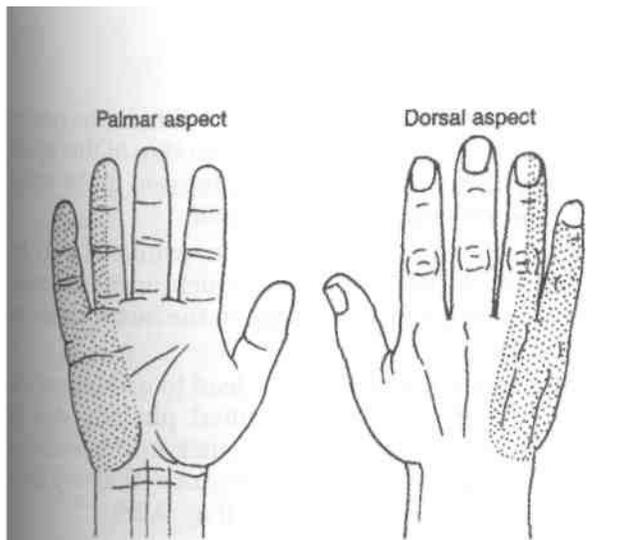
Fig. 9.35: *Area of sensory loss following division of the ulnar nerve.*

Fig. 9.36: *Complete claw-hand.*

^Bpn Nerve

The median nerve is important because of its role in controlling the movements of the thumb which are :rucial in the mechanism of gripping by the hand.

Course and Relations

1.The median nerve enters the palm by passing deep to the flexor retinaculum, where it lies in front)f the ulnar bursa enclosing the flexor tendons, in the narrow space of the carpal tunnel. Immediately below the retinaculum the nerve divides into lateral and medial divisions (Fig. 2.31).

2.The lateral division gives off a muscular branch to the thenar muscles, and three digital branches for be lateral one and half digits including the thumb.

The muscular branch curls upwards round the istal border of the retinaculum and supplies the lenar muscles. Out of the three digital branches, two supply the thumb and one the lateral side of the index finger. The digital branch to the index finger also supplies the first lumbrical (Fig. 9.33).

I The medial division divides into two common ligital branches for the second and third interdigital fts, supplying the adjoining sides of the index, middle and ring fingers. The lateral common digital ranch also supplies the second lumbrical.

Distribution

In the hand, the median nerve supplies:

(a)Five muscles, namely the abductor pollicis brevis, the flexor pollicis brevis, the opponens pollicis and the first and second lumbrical muscles.

(b)Palmar skin over the lateral three and a half digits with their nail beds.

CLINICAL ANATOMY

1. *Median nerve injury at the wrist.* This is a common occurrence and is characterized by the following signs.

(a)The median nerve controls coarse movements of the hand and is the nerve of grasp. In all injuries of this nerve, at whatever level, the patient is unable to pick up a pin with the thumb and index finger. In fact, inability to oppose the thumb is the chief disability of median nerve lesions at the wrist.

(b)*Ape-like hand.* Paralysis of the short muscles of the thumb, and the unopposed action of the extensor pollicis longus produces an ape-like hand. The thenar eminence is wasted and flattened. The thumb is adducted and laterally rotated so that the first metacarpal lies in the same plane as the other metacarpals.

(c)*Pen test for abductor pollicis brevis.* Lay the hand flat on a table with the palm directed up-wards. The patient is unable to touch with his thumb a pen held in front of the palm.

(d)Sensory loss corresponds to distribution of the median nerve in the hand.

As already mentioned, median nerve lesions are more disabling than ulnar nerve lesions. This is largely due to the inability to oppose the thumb, so that the gripping action of the hand is totally lost.

1.*Carpal tunnel syndrome.* Involvement of the median nerve in carpal tunnel syndrome has been described earlier with flexor retinaculum.

2.If both median and ulnar nerves are paralysed, the result is complete claw-hand (Fig. 9.36).

Radial Nerve

The part of the radial nerve seen in the hand is a continuation of the superficial terminal branch. It reaches the dorsum of the hand (after winding round the lateral side of the radius) and divides into 4 or 5 dorsal digital branches which supply the skin of the digits as follows (Fig. 9.37).

1st: Lateral side of thumb

2nd: medial side of thumb
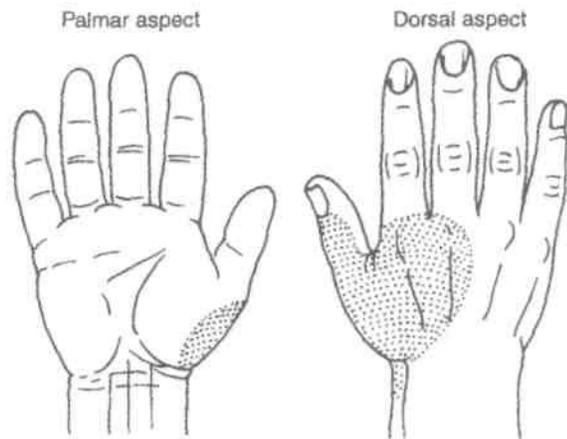
Fig. 9.37: *Area of sensory loss following division of the radial nerve above the elbow.*

oru: laxeiai siue *ui* muex linger

4th: contiguous sides of index and middle fingers

5th: when present it supplies the contiguous sides of the middle and ring fingers

Note that skin over the dorsum of the distal phalanges, and part of the middle phalanges, is supplied by the median nerve (not radial). Sensory loss corresponds to the distribution of the nerve.

THE SPACES OF THE HAND

Spaces of the Hand

Having learnt the anatomy of the whole hand, the clinically significant spaces of the hand need to be understood and their boundaries to be identified from the following text.

The arrangement of fasciae and the fascial septa in the hand is such that many spaces are formed. These spaces are of surgical importance because they may become infected and distended with pus. The important spaces are as follows:

A. *Palmar Spaces*
   1. Pulp space of the fingers
   2. Midpalmar space
   3. Thenar space
B. *Dorsal Spaces*
   1. Dorsal subcutaneous space
   2. Dorsal subaponeurotic space
C. The *Forearm Space ofParona.*

Pulp Space of the Fingers

The tips of the fingers and thumb contain subcutaneous fat arranged in tight compartments formed by

fibrous septa which pass from the skin to the periosteum of the terminal phalanx. Infection of this space is known as whitlow. The rising tension in the space gives rise to severe throbbing pain.

Infections in the pulp space (whitlow) can be drained by a lateral incision which opens all compartments and avoids damage to the tactile tissue in front of the finger.

If neglected, a whitlow may lead to necrosis of the distal four-fifths of the terminal phalanx due to occlusion of the vessels by the tension. The proximal one-fifth (epiphysis) escapes because its artery does not traverse the fibrous septa (Fig. 9.38).

Fig. 9.38: The digital pulp space.

Midpalmar Space

Midpalmar space is triangular space situated under the inner half of the hollow of the palm. Proximally, it extends up to the distal margin of the flexor retinaculum and communicates with the forearm space (Table 9.3). Distally, it extends up to the distal palmar crease and communicates with the fascial sheaths of the 3rd and 4th (occasionally 2nd) lurn-brical muscles (lumbrical canals) (Fig. 9.39).

The space is bounded:

(a) Anteriorly by the palmar aponeurosis and the flexor tendons of the 3rd, 4th and 5th fingers:

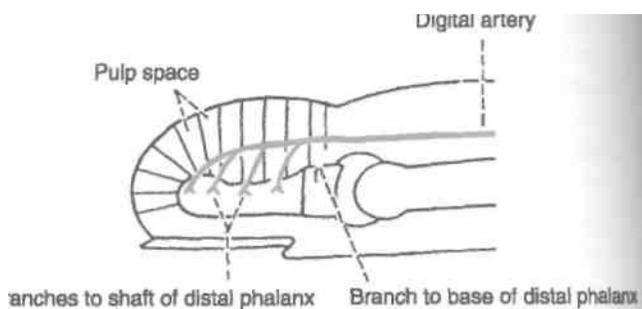(i) the 2nd, 3rd and 4th lumbrical muscles; (ii) the superficial palmar arch; and (iii)   the digital nerves and vessels of the medial three and a half fingers.

(a)Posteriorly, by the 3rd, 4th and 5th metacarpals. The fascia, covering the interossei of the 3rd and 4th spaces.

(b)Medially, by the medial palmar septum; and

(c)Laterally, by the intermediate palmar septum.

After the advent of antibiotics and advanced surgical techniques, the incidence of infection of the midpalmar space has been markedly reduced. Sometimes, however, infection of the space may result from tenosynovitis of the middle and ring fingers, or

Table 9.3: Midpalmar and thenar spaces

Features	Midpalmar space
	Thenar space
1.Shape	Triangular
Triangular	
2.Situation	Under the inner half of the
hollow of the palm	Under the outer half of the
hollow of the palm	
3.Extent:	
Proximal	Distal margin of the flexor
retinaculum	Distal margin of the flexor
retinaculum	
Distal	Distal palmar crease
	Proximal transverse
palmar crease	
4. Communications:	
Proximal	Forearm space
	Fascial sheath of the first
lumbrical;	
Distal	Fascial sheaths of the 3rd
and 4th	occasionally 2nd
	lumbricals; occasionally
	2nd
5. Boundaries:	
Anterior	(i) Flexor tendons of 3rd,
4th and 5th	(i) Short muscles of
thumb	
	fingers
	(ii) Flexor tendons of the index finger
	(ii) 2nd, 3rd and 4th lumbricals
	(iii) First lumbrical
	(iii) Palmar aponeurosis
	(iv) Palmar aponeurosis
Posterior	Fascia covering interossei
and metacarpals	Transverse head of
adductor pollicis	
Lateral	Intermediate palmar
septum	(i) Tendon of flexor
pollicis longus	
with radial bursa	
(ii) Lateral palmar septum	
Medial	Medial
palmar septum	
Intermediate palmar septum	
6. Drainage	Incision in either the 3rd or
4th web space	Incision in the first web,
posteriorly	

Digital nerv[e]
Palmar aponeurosis
Superficial palmar arch
Tendons of flexor digitorum superficialis
Tendons of flexor digitorum profundus
Hypothenar muscles
Dorsal subaponeurotic space
Dorsal subcutane[ous]

Fig. 9.39: Cross-section of th[e]

from a web infection which has spread proximally through the lumbrical canals. When this happens the normal concavity of the palm is obliterated, and the swelling extends to the dorsum of the hand. The palm. Proximally, space can be drained by an incision in either the 3rd or 4th web depending on where the pus points.

Thenar Space

Thenar space is a triangular space situated under the outer half of the hollow of the palm. Proximally, it extends up to the distal margin of the flexor retinaculum, and communicates with the forearm

space. Distally, it extends up to the proximal transverse palmar crease and communicates with the subcutaneous web of the thumb, through the fascial sheath of the first lumbrical muscle. It may also communicate with the second lumbrical canal.

It is bounded

(a) Anteriorly by the palmar aponeurosis covering: (i) the tendon of the flexor pollicis longus with its synovial sheath; (ii) the flexor tendons of the index finger; (iii) the first lumbrical muscle; and (iv) the palmar digital vessels and nerves of the thumb and lateral side of the index finger.

(b) Posteriorly, by the fascia covering the transverse head of the adductor pollicis and the first dorsal interosseous muscle (Fig. 9.40);
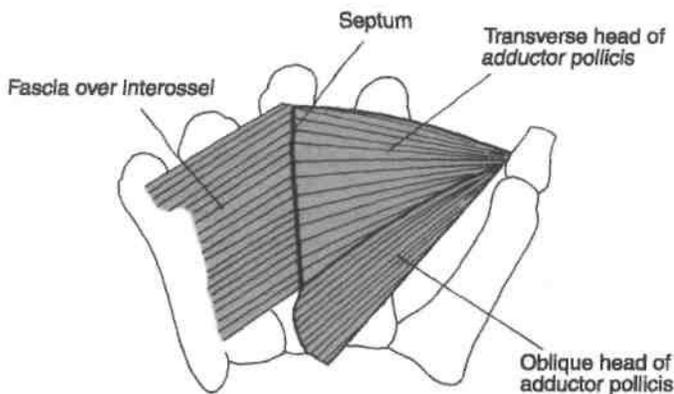

Fig. 9.40: *Floor of thenar space (right side) and midpalmar space (left side).*

(c) Medially, by the intermediate palmar septum; and

(d) Laterally, by the lateral palmar septum.

The thenar space may be infected by spread of any infection in the thumb or index finger. This results in marked *swelling of the web* of the thumb and thenar region. The thumb is held in an abducted position. The space can be drained by an incision in the first web posteriorly, or where the pus points.

Dorsal Spaces

The *dorsal subcutaneous space* lies immediately deep to the loose skin of the dorsum of the hand. The *dorsal subtendinous space* lies between the metacarpal bones and the extensor tendons which are united to one another by a thin aponeurosis.

Infection of the dorsal spaces is uncommon. However, sweffingof *the* dorsum is very common and can be produced by almost every infection of the hand, especially in midpalmar space infections. Some-

times the dorsal spaces are infected after injury over J the knuckles. In subcutaneous infections, the pus points through the skin, and can be drained at the] pointing site. In subtendinous infections, the pus I *points either at the webs or at the borders* of the l *hand, and can be drained accordingly.*

Forearm Space of Parona

Foream space of Parona is a rectangular space I situated deep in the lower part of the forearm just I above the wrist. It lies in front of the pronator I quadratus, and deep to the long flexor tendons. I Superiorly, the space extends up to the oblique! origin of the flexor digitorum superficialis. Interiorly, it extends up to the flexor retinaculum, and communicates with the midpalmar space; and possibly also with the thenar space. The proximal part of the flexor synovial sheaths protrudes into the forearm space. I

The *forearm space may be infected through* infections in the related synovial sheaths, especially of the ulnar bursa. Pus points at the margins of the distal part of the forearm where it may be drained.

|_____SYNOVIAL SHEATHS_____J

Many of the tendons entering the hand are surrounded by synovial sheaths. The extent of these sheaths is of surgical importance as they can be infected (Fig. 9.9).

Digital Synovial Sheaths

The synovial sheaths of the 2nd, 3rd and 4th digits are independent and terminate proximally at the levels of the heads of the metacarpals. The synovial sheath of the little finger is continuous proximally with the ulnar bursa, and that of the thumb with the radial bursa. Therefore, infections of the little finger and thumb are more dangerous because they can spread in to the palm and even up *to 2.5* cm above *the wrist. In about 50%* cases, the radial and ulnar bursae communicate with each other behind the flexor retinaculum.

Infections of the digital synovial sheaths are drained through two transverse incisions, one in the crease of the distal interphalangeal joint and the other in the distal palmar crease. This opens the sheath at either end.

Ulnar Bursa

Infection of this bursa is usually secondary to *the* infection of the JitiJe *finger, and this in turn* may spread to the forearm space of the Parona. It results in an hour-glass swelling (so called because there is one swelling in the palm and another in the distal

part of the forearm, the two being joined by a constriction in the region of the flexor retinaculum).

The ulnar bursa is approached by an incision along the lateral margin of the hypothenar eminence.

Radial Bursa

Infection of the thumb may spread to the radial bursa and then to the ulnar bursa if these two communicate. It can be drained by an incision along the medial margin of the thenar eminence. The incision should be restricted proximally to avoid injury to the branch of the median nerve to the thenar muscles.

CLINICAL ANATOMY

Surgical Incisions of the Hand

Incisions in the hand should be planned carefully to avoid contractures. In general, the incision should be transverse, parallel with the creases of the wrist, hand or fingers. They should never be at right angles to the creases. When necessary the transverse incision can be enlarged by a longitudinal extension at each end in opposite directions (Figs 9.41, 9.42).

A longitudinal incision in the fingers, palm, or wrist must be at the sides where the skin is least subjected to movements. Here the skin is thin and pliable and heals well in time.

Optimum Position of the Hand

When the hand requires prolonged immobilization, this must be done with the hand in optimum position to avoid any permanent joint stiffness. The optimum position is one in which the ligaments are at their maximum length. If the joints are immobilized for 3-6 weeks in any other position, the ligaments shorten and may never regain their normal length. In optimum position of the hand the wrist is dorsiflexed by 15 to 20 degrees, the metacarpophalangeal joints are flexed by 90 degrees, the interphalangeal joints are flexed by 5 degrees and the thumb is held in opposition.

THE BACK OF THE FOREARM AND HAND

This section deals mainly with the extensor retinaculum of the wrist, muscles of the back of the forearm, the deep terminal branch of the radial nerve, and the posterior interosseous artery.
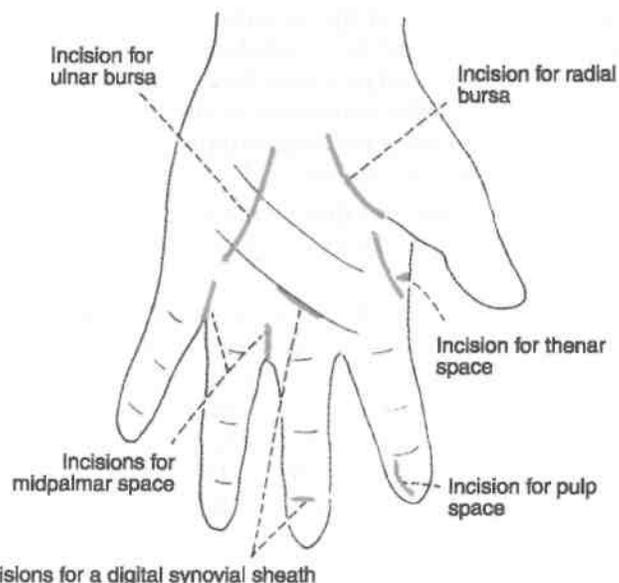
Fig. 9.41: *The surgical incisions of the hand.*
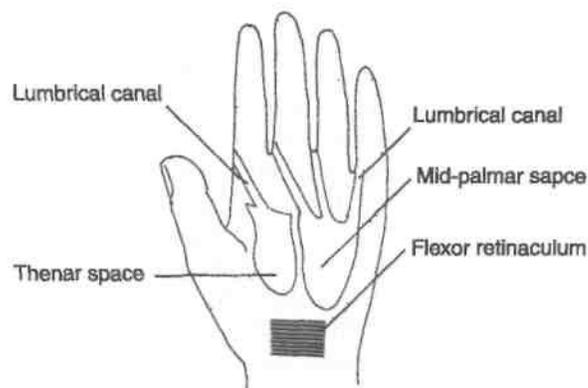
Fig. 9.42: *The fascial spaces of the palm. Lumbrical canals are between the digits.*

SURFACE LANDMARKS

1.The *olecranon process* of the ulna is the most prominent bony point on the back of a flexed elbow (Fig. 9.1). Normally, it forms a straight horizontal line with the two epicondyles of the humerus when the elbow is extended, and an equilateral triangle when the elbow is flexed to a right angle. The relative position of the three bony points is' disturbed when the elbow is dislocated.

2.The *head of the radius* can be palpated in a depression on the posterolateral aspect of an extended elbow just below the lateral epicondyle of the humerus. Its rotation can be felt during pronation and supination of the forearm.

3.The *posterior border of the ulna* is subcutaneous in its entire length. It can be felt in a longitudinal

groove on the back of the forearm when the elbow is flexed and the hand is supinated. The border ends distally in the styloid process of the ulna. It separates the flexors from the extensors of the forearm. Being superficial, it allows the entire length of the ulna to be examined for fractures.

1. The *head of the ulna* forms a surface elevation on the posteromedial aspect of the wrist in a pronated forearm.

2. The *styloid processes of the radius and ulna are* important landmarks of the wrist. The styloid process of the radius can be felt in the upper part of the anatomical snuff box. It projects down 1 cm lower than the styloid process of the ulna. The latter descends from the posteromedial aspect of the ulnar head. The relative position of the two styloid processes is disturbed in fractures at the wrist, and is a clue to the proper realignment of fractured bones.

3. The *dorsal tubercle of the radius* (Lister's tubercle) can be palpated on the dorsal surface of the lower end of the radius in line with the cleft between the index and middle fingers. It is grooved on its medial side by the tendon of the extensor pollicis longus.

(~7. The *anatomical snuff box* is a triangular depression on the lateral side of the wrist. It is seen best when the thumb is extended. It is bounded anteriorly by tendons of the abductor pollicis longus and extensor pollicis brevis, and posteriorly by the tendon of the extensor pollicis longus. It is limited above by the styloid process of the radius. The floor of the snuff box is formed by the scaphoid and the trapezium, and is crossed by the radial artery.) 8. The heads of the metacarpals form the knuckles.

/   EXTENSOR RETINACULUM   /

The deep fascia on the back of the wrist is thickened to form the extensor retinaculum which holds the extensor tendons in place. It is an oblique band, directed downwards and medially. It is about 2 cm broad vertically (Fig. 9.43J.

Make the incision in the centre of dorsum of hand. Reflect the skin of dorsum of hand till the respective borders. Reflect the skin of dorsum of middle finger on each side. Look for nerves on the back of forearm and hand. These are superficial branch of radial nerve and dorsal branch of ulnar nerve.

The dorsal venous network is the most prominent component of the superficial fascia of dor-

and basilic veins by tying a tourniquet on tt forearm and exercising the closed fist on oneseli

The deep fascia at the back of wrist is thickene to form extensor retinaculum. Define its margin and attachments. Identify the structures travers ing its six compartments.

Clear the deep fascia over the back of forearm, Define the attachment of triceps brachii muscle on the olecranon process of ulna. Define the attachments of the seven superficial muscles of the back of the forearm.

Separate the anterolateral muscles, i.e. brachioradialis, extensor carpi radialis longus and brevis from the extensor digitorum lying in the centre and extensor digit! minimi and extensor carpi ulnaris situated on the medial aspect of the wrist. Anconeus is situated on the posterolateral aspect of the elbow joint. Dissect all these muscles and trace their nerve supply.

Attachments

Laterally, to the lower part of the *anterior* border of J the radius. Medially, to: (i) the styloid process of the I ulna, (iij the triquetral, and (iifj the pisiform bones. I

Surface Marking

Extensor retinaculum is an oblique band directed] downwards and medially, and is about 2 cm broad (vertically). Laterally, it is attached to the lower salient part of the anterior border of the radius, and medially to the medial side of the carpus (pisiform and triquetral bones] and to the styloid process of the ulna.
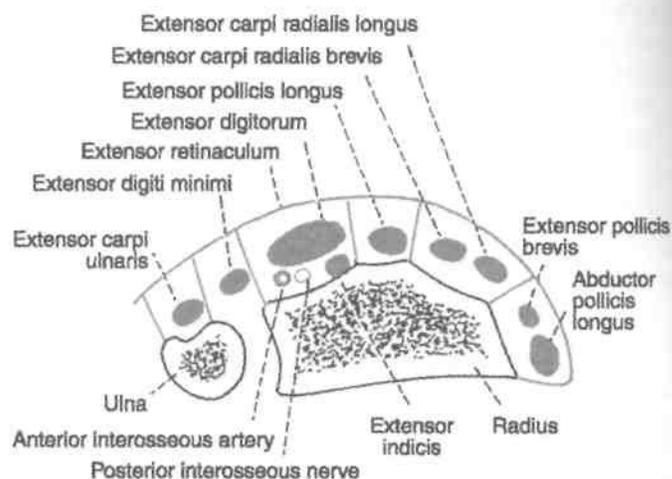

Fig. 9.43: *Transverse section passing just above the wrist showing structures passing deep to the extensor retinaculum.*

be retinaculum sends down septa which are at-ached to the longitudinal ridges on the posterior urface of the lower end of radius. In this way, 6 iteofascial compartments are formed on the back of le wrist. The structures passing through each ompartment, from lateral to the medial side, are listed below.

Table 9.4: **Structures in various compartments under extensor retinaculum**

Compartment	Structure
1	(i) Abductor pollicis longus
	(ii) Extensor pollicis brevis
II	(i) Extensor carpi radialis longus
	(ii) Extensor carpi radialis brevis
III	(i) Extensor pollicis longus
IV	(i) Extensor digitorum
	(H) *Extensor indicts*
	(iii) Posterior interosseous nerve
	(iv) Anterior interosseous artery
y	(i) Extensor digiti minimi
VI	(i) Extensor carpi ulnaris

Each compartment is lined by a synovial sheath, »hich is reflected on to the contained tendons.

SUPERFICIAL MUSCLES OF THE BACK OF THE FOREARM

fhere are seven superficial muscles (Fig. 9.44) on he back of the forearm:

1. Anconeus
2. Brachioradialis
3. Extensor carpi radialis longus
4. Extensor carpi radialis brevis
5. Extensor digitorum
6. Extensor digiti minimi
7. Extensor carpi ulnaris.

All the seven muscles cross the elbow joint. Most if them take origin (entirely or in part) from the tip oJ he lateral epicondyle of the humerus.

This is the *common extensor origin.*

Sommon **Extensor Origin**

toconeus

)rigin: Posterior aspect of lateral epicondyle of the lumerus.

vsertion 1. Lateral aspect of olecranon process of ulna.

2. Upper one-fourth of the posterior surface of ulna.

Nerve Supply: Radial nerve (C7, C8, Tl). The nerve travels through the substance of the medial head of the triceps.

Action: Weak extensor of the elbow.

Brachioradialis

Origin

1.Upper two-thirds of lateral supracondylar ridge of humerus (Fig. 9.44).

2.Lateral intermuscular septum.

Insertion: Lateral side of radius just above the styloid process.

Nerve Supply: Radial nerve (C5, C6, C7).

aih'^*Actions:* Flexor of forearm, especially in the mid-prone position. *It* supinates the fully pronated forearm; and pronates the fully supinated forearm to bring it to the midprone position."}

Some Important Relations
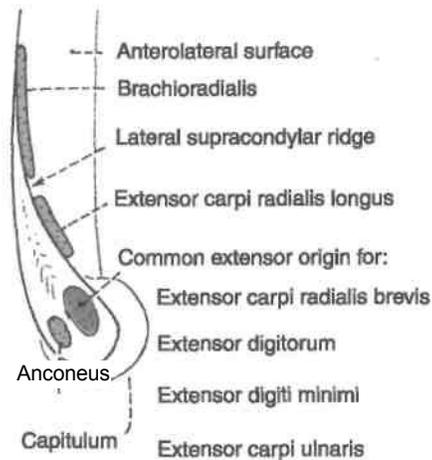
Fig. 9.44: *Right humerus, lower end, seen from the lateral side, to show the origins of the seven superficial muscles of the forearm.*

1.The upper fleshy part of the muscle forms the lateral boundary of the cubital fossa. Here the radial nerve is deep to the muscle (between it and the brachialis).

2.Near its insertion its tendon is crossed by the tendons of the abductor pollicis longus and the extensor pollicis brevis.

3.At the wrist the radial artery is medial to the tendon (between it and the tendon of the flexor carpi radialis).

Extensor Carpi Radialis Longus

Origin

1. Lower one-third of the lateral supracondylar ridge of the humerus (Fig. 9.44).
2. Some fibres arises from the common extensor origin.
3. Some fibres from the lateral intermuscular septum.

Insertion: Dorsum of base of the second metacarpal bone.

Nerve Supply: Radial nerve (C6, C7).

Actions

1. Extension of wrist (along with the extensor carpi ulnaris).
2. Abduction of the wrist (along with the flexor carpi radialis).
3. Assists movements of the digits by fixing the wrist.

Also see extensor carpi radialis brevis, below.

Extensor Carpi Radialis Brevis

Origin

1. Common extensor origin (Fig. 9.44).
2. Radial collateral ligament of elbow. *Insertion:*
   Dorsal aspect of bases of second and

third metacarpal bones.

Aferve *Supply:* Posterior interosseous nerve (C7, C8).

Actions: Same as those of extensor carpi radialis longus described above.

The extensor carpi radialis longus and brevis act as synergists with the flexors of the fingers when the fist is clenched, and stabilize the wrist. They act more often as synergists than as prime movers. The brevis is a better prime mover in pure wrist extension, and the longus is a better synergist in grasping or clenching

The tendons of these two muscles pass through the same compartment of the extensor retinaculum, and have a common synovial sheath.

Extensor Digitorum

Origin: Common extensor origin (Fig. 9.44).

Insertion: The muscle ends in a tendon which splits into four parts, one for each digit other than the thumb. Over the proximal phalanx the tendon for each digit divides into three slips—one intermediate and two collateral. The intermediate slip is inserted into the dorsal aspect of the base of the middle phalanx. The collateral slips reunite to be inserted into the dorsal aspect *of* the base *of the* distal phalanx. Also see dorsal digital expansion.

Nerve Supply: Posterior interosseous nerve (C7, I C8).
  Actions: Extension of interphalangeal, metacarpophalangeal and wrist joints.

Additional Points

1. The extensor digitorum and extensor indicis I pass through the same compartment of the extensor I retinaculum, and have a common synovial sheath. |
2. The four tendons of the extensor digitorum I emerge from under cover of the extensor retinaculum and fan out over the dorsum of the hand. The tendon to the index finger is joined on its medial side by the tendon of the extensor indicis, and the tendon to the little finger is joined on its medial side by the I two tendons of the extensor digiti minimi.
3. On the dorsum of the hand adjacent tendons are variably connected together by three inter- I tendinous connections directed obliquely downwards and laterally. The medial connection is strong; the | lateral connection is weakest and may be absent.

The four tendons and three intertendinous connections are embedded in deep fascia, and together form the roof of the subtendinous (subaponeurotic) space on the dorsum of the hand.

Dorsal Digital Expansion

The dorsal digital expansion (or extensor expansion) is a small triangular aponeurosis (related to each tendon of the extensor digitorum) covering the dorsum of the proximal phalanx. Its base, which is proximal, covers the metacarpophalangeal joint. The main tendon of the extensor digitorum occupies the central part of the extension, and is separated from the MP joint by a bursa.

The posterolateral corners of the extensor expansion are joined by tendons of the interossei and of lumbrical muscles. The corners are attached to the deep transverse metacarpal ligament. The points of attachment of the interossei (proximal) and lumbrical (distal) are often called 'wing tendons'.

Near the proximal interphalangeal joint the extensor tendon divides into a central slip and two collateral slips. The central slip is joined by some fibres from the margins of the expansion, crosses the proximal interphalangeal joint, and is inserted on the dorsum of the base of the middle phalanx. The two collateral slips are joined by the remaining thick margin of the extensor expansion. They then join each other and are inserted on the dorsum of the base of the distal phalanx.

At the metacarpophalangeal and interphalangeal joints the extensor expansion forms the dorsal part of the fibrous capsule of the joints.

The retinacular ligaments (link ligaments) extend I from the side of the proximal phalanx, and from its ■ibrous flexor sheath, to the margins of the extensor I expansion to reach the base of the distal phalanx.

Wtxtensor Digit! Minimi

I *Origin:* Common extensor origin (Fig. 9.44).

Insertion: The tendon joins the tendon of the extensor digitorum for the fifth digit. It is inserted ■through the dorsal digital expansion, into the dorsal ■aspect of the base of the middle phalanx, and the ■base of the distal phalanx.

JVerve Supply: Posterior interosseous nerve (C7, I C8).

Action: Extension of the little finger at the inter-■phalangeal and metacarpophalangeal joints. It can I help in extending the wrist joint.

I *Additional Points*

1.Extensor digiti minimi is usually fused with the ■extensor digitorum.

2.The tendon passes through a separate com-I partment of the extensor retinaculum, behind the ■radioulnar joint. On the dorsum of the hand the I tendon divides into two parts which (with the tendon I of the extensor digitorum) join the extensor expansion of the little finger.

I *Extensor Carpi Ulnaris*

1.Common extensor origin (Fig. 9.44).

2.Posterior border of the ulna (by an aponeurosis common to it and to the flexor carpi ulnaris and the I flexor digitorum profundus).

Insertion: Medial side of the base of the fifth I metacarpal bone.

Nerve supply: Posterior interosseous nerve (C7, I **C8**).

■Actions

1.Extension of wrist along with the extensor I carpi radialis longus and brevis.

2.Adduction of the hand along with the flexor I carpi ulnaris.

3.Fixes the wrist during forceful movements of I the hand.

The tendon passes through a separate compart-■ment of the extensor retinaculum, in the groove between the head and styloid process of the ulna.

I *Muscles* **Inserted into Dorsal Digital Expansions of**

Index Finger: First dorsal interosseous, second I palmar interosseous, first lumbrical, extensor I digitorum slip, and extensor indicis.

Middle Finger: Second and third dorsal interossei, second lumbrical, extensor *digitorum slip.*

Ring Finger: Fourth dorsal interosseous, third palmar interosseous, third lumbrical and extensor digitorum slip.

Little Finger: Fourth palmar interosseous, fourth lumbrical, extensor digitorum slip and extensor digiti minimi.

[DEEP MUSCLES OF THE BACK OF THE FOREARM [

These are as follows (Fig. 9.45).

1.Supinator.

2.Abductor pollicis longus.

3.Extensor pollicis brevis.

4.Extensor pollicis longus.

5.Extensor indicis.

In contrast to the superficial muscles, none of the deep muscles cross the elbow joint. They arise from the radius, the ulna and the interosseous membrane.

Separate extensor carpi radials brevis from extensor digitorum and identify deeply placed supinator muscle.

Just distal to supinator is abductor pollicis longus. Other three muscles extensor pollicis longus, extensor pollicis brevis and extensor indicis are present distal to abductor pollicis longus. Identify them all.

Supinator

Origin

1.Lateral epicondyle of humerus.

2.Radial collateral ligament of the elbow joint.

3.Annular ligament.

4.Supinator crest of the ulna, and the posterior part of the triangular area in front of it (Fig. 9.45).

Insertion: Upper one-third of the lateral surface of the radius.

Nerve Supply: Posterior interosseous nerve (C6, C7).

Action: Supination of the forearm.

Note: The muscles have two layers, superficial and deep. The posterior interosseous nerve runs downwards between these layers.

Abductor Pollicis Longus

Origin: Upper parts of the posterior surfaces of the ulna and the radius, and from the interosseous membrane (Figs 9.45, 9.46).
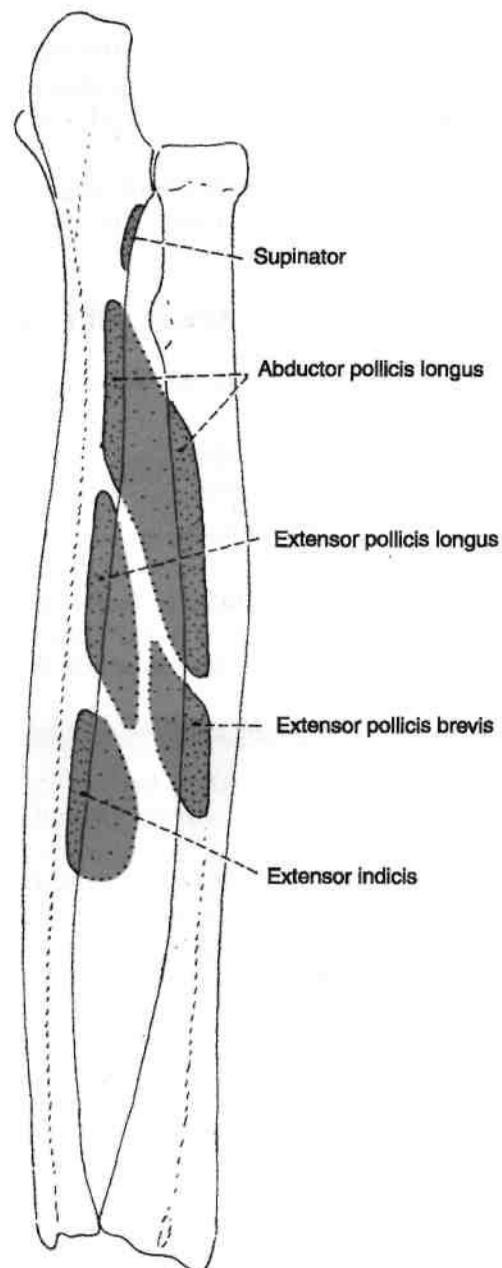
Fig. 9.45: The origin of the five deep muscles of the back of the forearm from the posterior aspects of the radius and ulna.

Insertion: The tendon usually splits into two parts: one part is attached to the lateral side of the base of the first metacarpal, and the other part is attached to the trapezium. Further fasciculi may become continuous with the opponens pollicis, or with the abductor pollicis brevis.

Nerve Supply: Posterior interosseous nerve (C7, C8).

Action: Abduction and *extension of the thumb at* the carpometacarpal joint.
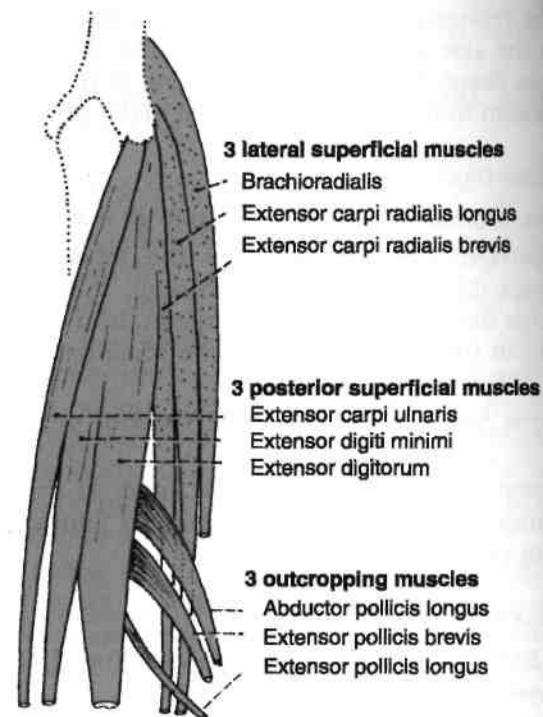
See note under extensor pollicis brevis.

Fig. 9.46: Arrangement of the muscles on the back of the forearm.

Extensor Pollicis Longus

Origin: Posterior   surface of the ulna (below the origin of the abductor pollicis longus); and from the I interosseous membrane (Figs 9.45, 9.46).

Insertion: Base of distal phalanx of the thumb (dorsal aspect).

Nerve Supply: Posterior interosseous nerve (C7, C8).

Action: Extension at all joints of the thumb.

Note: The tendon of the extensor pollicis longus crosses the tendons of the extensor carpi radialis longus and brevis to reach the thumb.

The muscle may be absent, or completely fused with the abductor pollicis longus.

Extensor Pollicis Brevis

Origin: Posterior surface of the radius below the origin of the abductor pollicis longus; and from the interosseous membrane (Fig. 9.46).

Insertion: Dorsal surface of the base of the proximal phalanx of the thumb.

Nerve Supply: Posterior interosseous nerve (C7, C8).

Action: Extends the proximal phalanx and metacarpal of the thumb.

Note: The abductor pollicis longus and the extensor pollicis brevis are deep to the superficial extensors in

I the upper part of the forearm. They become superficig by emerging between the extensor carpi radiali
I brevis and the extensor digitorum. They then cros: the tendons of the extensor carpi radialis longus anc mevis to reach their insertion.

■tfensor *Indicis*

Origin: Posterior surface of the ulna below the origii of the extensor pollicis longus, and from the in Iterosseous membrane.

Insertion: The tendon joins the ulnar side of th tendon of the extensor digitorum for the index finger

Nerve Supply: Posterior interosseous nerve (C7 C8).

Action: Extension of the index finger. It helps tc extend the wrist.

Variations

The muscle may send slips to the extensor tendons of other digits. Rarely its tendon may be interrupted, on the dorsum of the hand by an additional muscle belly called the *extensor indicis brevis manus.*

CLINICAL ANATOMY

Paralysis of the extensor muscles of the forearm produces wrist *drop.* This is usually due to injury to the radial nerve above the level of the origin of the posterior interosseous nerve, for example in the axilla and arm.

Wrist drop is quite disabling because the patient cannot grip any object firmly in the hand without the synergistic action of the extensors (Fig. 9.47).

Fig. 9.47: Wrist drop resulting from radial nerve palsy.

DEEP TERMINAL BRANCH OF RADIAL NERVE OR POSTERIOR INTEROSSEOUS NERVE

It is the chief nerve of the back of the forearm. It is a branch of the radial nerve given off in the cubital fossa, at the level of the lateral epicondyle of the humerus.

Surface Marking

Posterior interosseous nerve is marked by joining the following three points (Fig. 9.48).

(a)A point 1 cm lateral to the biceps tendon at the level of the lateral epicondyle.

(b)The second point; at the junction *of* the upper one-third and lower two-thirds of a line joining the middle of the posterior aspect of the head of the radius to the dorsal tubercle at the lower end of the radius (Lister's tubercle).

(c)The third point on the back of the wrist 1 cm medial to the dorsal tubercle.

Deep terminal branches of radial nerve and posterior interosseous artery:

Identify the posterior interosseous nerve at the distal border of exposed supinator muscle. Trace its branches to the various muscles. Look for the radial nerve in the lower lateral part of front of arm between the brachioradialis, extensor carpi radialis longus laterally and brachialis muscle medially. Trace the two divisions of this nerve in the lateral part of the cubital fossa. The deep branch (posterior interosseous nerve) traverses between the two planes of supinator muscle and reaches the back of the forearm where it is already identified.

The nerve runs amongst the muscles of the back of the forearm, and ends at the level of the wrist in a pseudoganglion.

This nerve is accompanied by posterior interosseous artery distal to the supinator muscle. This artery is supplemented by anterior interosseous artery in lower one-fourth of the forearm.

Course and Relations

1. Posterior interosseous nerve leaves the cubital fossa and enters the back of the forearm by passing between the two planes of fibres of the supinator. Within the muscle it winds backwards round the lateral side of the radius (Fig. 9.48, 9.49).
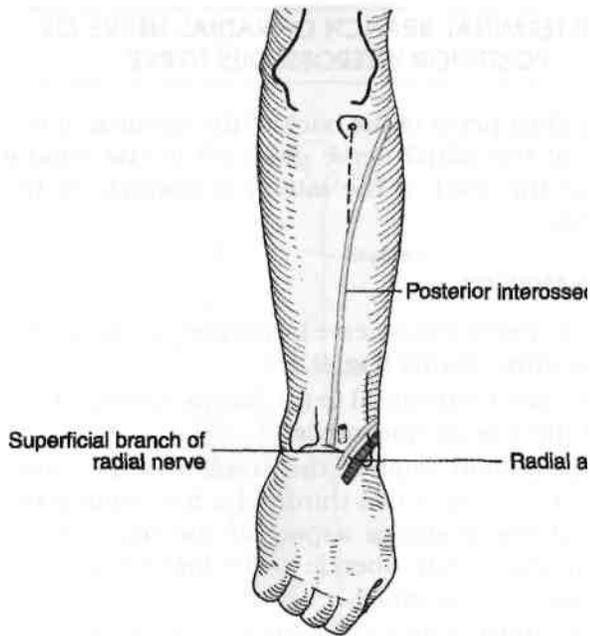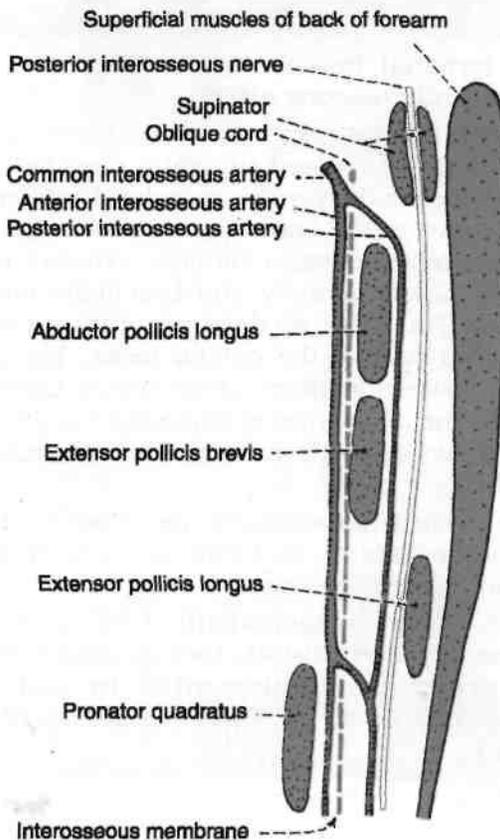
Fig. 9.48: Nerves in back of forearm.

Fig. 9.49: Course and relations of the posterior interosse͟
and the interosseous arteries.

2. It emerges from the supinator on the bac͟
forearm. Here it lies between the superficial an͟
muscles. At the lower border of the extensor ͟

brevis, it passes deep to the extensor pollicis longus. It then runs on the posterior surface of the interosseous membrane up to the wrist where it enlarges into a pseudoganglion and ends by supplying the wrist and intercarpal joints.

Branches and Distribution

Posterior interosseous nerve gives muscular and articular branches (Fig. 9.50).

(A) Muscular Branches

(a) Before piercing the supinator, branches are given to the extensor carpi radialis brevis and to the supinator.

(b) While passing through the supinator another branch is given to the supinator.

(c) After emerging from the supinator, the nerve gives three short branches to: (i) the extensor digitorum, (ii) the extensor digiti minimi, and (iii) the extensor carpi ulnaris.

It also gives two long branches, (i) a lateral branch supplies the abductor pollicis longus and the extensor pollicis brevis. (ii) a medial branch supplies the extensor pollicis longus and the extensor indicis.
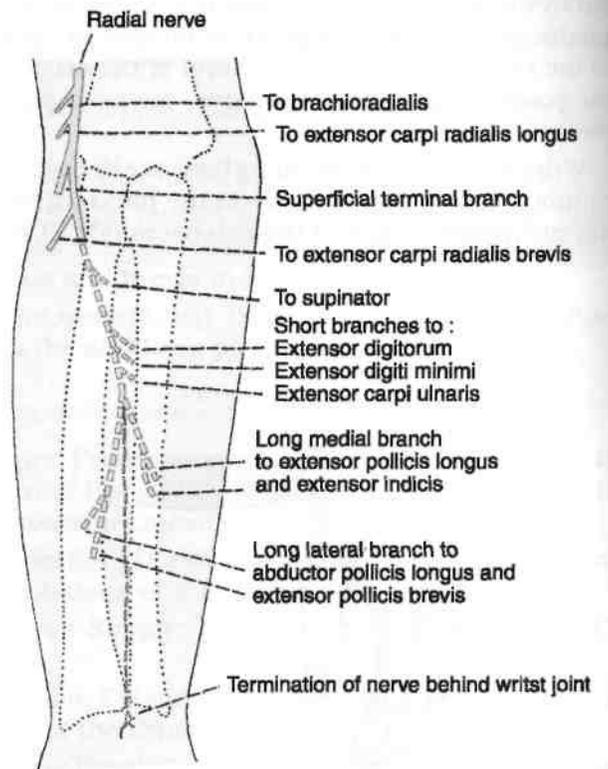

Fig. 9.50: Branches of the posterior interosseous nerve.

B *Articular Branches*

Articular branches are given to: (i) the wrist joint, (ii) [the distal radioulnar joint, and (iii) some intercarpal I and intermetacarpal joints.

I *(Q Sensory Branches*

Sensory branches are given to the interosseous membrane, the radius and the ulna.

THE POSTERIOR INTEROSSEOUS ARTERY

1.It is the smaller terminal branch of the common interosseous artery in the cubital fossa.

2.It enters the back of the forearm by passing between the oblique cord and the upper margin of the interosseous membrane (Fig. 9.49).

3.It appears on the back of the forearm in the interval between the supinator and the abductor pollicis longus and thereafter accompanies the posterior interosseous nerve. At the lower border of the extensor indicis, the artery becomes markedly reduced and ends by anastomosing with the anterior interosseous artery which reaches the posterior compartment by piercing the interosseous membrane at the upper border of the pronator quadratus. Thus in its lower one-fourth the back of the forearm is supplied by the anterior interosseous artery.

4. The posterior interosseous artery gives off an interosseous recurrent branch which runs upwards and takes part in the anastomosis on the back of the lateral epicondyle of the humerus.

10
The Joints of the Upper Limb

Joints are sites where two or more bones or cartilages articulate. Free movements occur at the synovial joints. Shoulder joint is the most freely mobile joint. Shoulder joints get excessive mobility at the cost of its own stability, since both are not feasible to the same degree. The carrying angle in relation to elbow joint is to facilitate carrying objects like buckets without hitting the pelvis.

Supination and pronation are basic movements for the survival of human being. During pronation the food is picked and by supination it is put at the right place-the mouth. While 'giving', one pronates, while 'getting' one supinates.

The first carpometacarpal joint allows movements of opposition of thumb with the fingers for picking up or holding things. Thumb is the most important digit. Remember Muni Dronacharya asked Eklavya to give his right thumb as *Guru-Dakshina,* so that he [is not able to outsmart Arjuna in archery.

THE SHOULDER GIRDLE

e shoulder girdle connects the upper limb to the axial skeleton. It consists of the clavicle and the scapula. Anteriorly, the clavicle reaches the sternum and articulates with it at the sternoclavicular joint. The clavicle and the scapula are united to each other at the acromioclavicular joint. The scapula is not connected to the axial skeleton directly, but is attached to it through muscles. The clavicle and the scapula have been studied. The joints of the shoulder girdle are described below.

Sternoclavicular Joint

The sternoclavicular joint is a synovial joint. It is a compound joint as there are three elements taking part in it; namely the medial end of the clavicle, the

Remove the subclavius muscle from first rib at its attachment with its costal cartilage. Identify the costoclavicular ligament.

Define the sternoclavicular joint and clean the anterior and superior surfaces of the capsule of this joint. Cut carefully through the joint to expose the intra-articular disc positioned between the clavicle and the sternum. The fibrocartilaginous disc divides the joint cavity into a superomedial and an inferolateral compartments.

clavicular notch of the manubrium sterni, and the upper surface of the first costal cartilage. It is a complex joint as its cavity is subdivided into two parts by an intra-articular disc (Fig. 10.1).

The *articular surface* of the clavicle is covered with fibrocartilage (as the clavicle is a membrane bone). The surface is convex from above downwards and slightly concave from front to back. The sternal surface is smaller than the clavicular surface. It has a reciprocal convexity and concavity. Because of the concavo-convex shape of the articular surfaces, the joint can be classified as a saddle joint.

The *capsular ligament* is attached laterally to the margins of the clavicular articular surface; and medially to the margins of the articular areas on the sternum and on the first costal cartilage. It is strong anteriorly and posteriorly where it constitutes the anterior and posterior sternoclavicular ligaments.

However, the main bond of union at this joint is the *articular disc.* The disc is attached laterally to the clavicle on a rough area above and posterior to the articular area for the sternum. Interiorly, the disc is attached to the sternum and to the first costal cartilage at their junction. Anteriorly and posteriorly the disc fuses with the capsule.
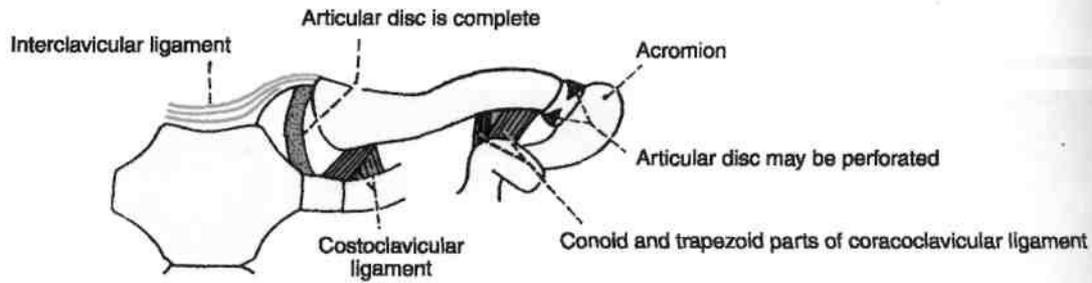
Fig. 10.1: The sternoclavicular and acromioclavicular joints.

There are two other ligaments associated with this joint. The *interclavicular ligament* passes between the sternal ends of the right and left clavicles, some of its fibres being attached to the upper border of the manubrium sterni. The *costoclavicular ligament* is attached above to the rough area on the inferior aspect of the medial end of the clavicle.

Interiorly, it is attached to the first costal cartilage and to the first rib. It consists of anterior and posterior laminae.

Blood Supply: Internal thoracic and suprascapular arteries

Nerve Supply: Medial supraclavicular nerve.

Movements: See movements of shoulder girdle, below.

Acromioclavicular Joint

The acromioclavicular joint is a plane synovial joint. It is formed by articulation of small facets present: (i) at the lateral end of the clavicle, and (ii) on the medial margin of the acromion process of the scapula. The facets are covered with fibrocartilage. The cavity of the joint is occasionally subdivided by an articular disc which may have perforation in it.

_____

DISSECTION

Remove the muscles attached to the lateral end of clavicle and acromial process of scapula. Define the articular capsule surrounding the joint. Cut through the capsule to identify the intra-articular disc. Look for the strong coracoclavicular ligament.

The bones are held together by a fibrous capsule and by the articular disc. However, the main bond of union between the scapula and the clavicle is the coracoclavicular ligament described below (Fig. 10.1).

Blood Supply: Suprascapular and acromial arteries.
Nerve Supply: Lateral supraclavicular nerve.
Movements: See movements of shoulder girdle.

Coracoclavicular Ligament

The ligament consists of two parts—conoid and trapezoid. The trapezoid part is attached, below to the upper surface of the coracoid process; and above to the trapezoid line on the inferior surface of the lateral part of the clavicle. The conoid part is attached, below to the root of the coracoid process just lateral to scapular notch. It is attached above to the inferior surface of the clavicle on the conoid tubercle!

Movements of the Shoulder Girdle

Movements at the two joints of the girdle are always associated with the movements of the scapula (Fig. 10.2a). The movements of the scapula may or may not be associated with the movements of the shoulder joint. The various movements are described below.

1. *Elevation* of scapula (as in shrugging the shoulders). The movement is brought about by the upper fibres of trapezius and by the levator scapulae. It is associated with the elevation of the lateral end and depression of the medial end of the clavicle. The clavicle moves round an anteroposterior axis formed by costoclavicular ligament (Fig 10.2b).

2. *Depression* of the scapula (drooping of the shoulder). It is brought about by gravity, and actively by the lower fibres of the serratus anterior and by the pectoralis minor. It is associated with the depression of the lateral end *and* elevation of the medial end of the clavicle (Fig 10.2c)

3. *Protraction* of the scapula (as in pushing and punching movements). It is brought about by the serratus anterior and by the pectoralis minor. It is associated with forward movements of the lateral end *and* backward movement of the medial end, of the clavicle (Fig 10.2d)

4. *Retraction* of the scapula (squaring the shoulders). It is brought about by the rhomboideus and by the middle fibres of the trapezius. It is associated with backward movement of the lateral end and forward movement of the medial end of the clavicle (Fig. 10.2e).

5. *Forward rotation of the* scapula round the chest wall takes place during overhead abduction of the arm. The scapula rotates round the coracoclavicular ligaments. The movement is brought about by the upper fibres of the trapezius and the lower fibres of the serratus anterior. This movement is associated with rotation of the clavicle around its long axis (Fig. 10.2f).
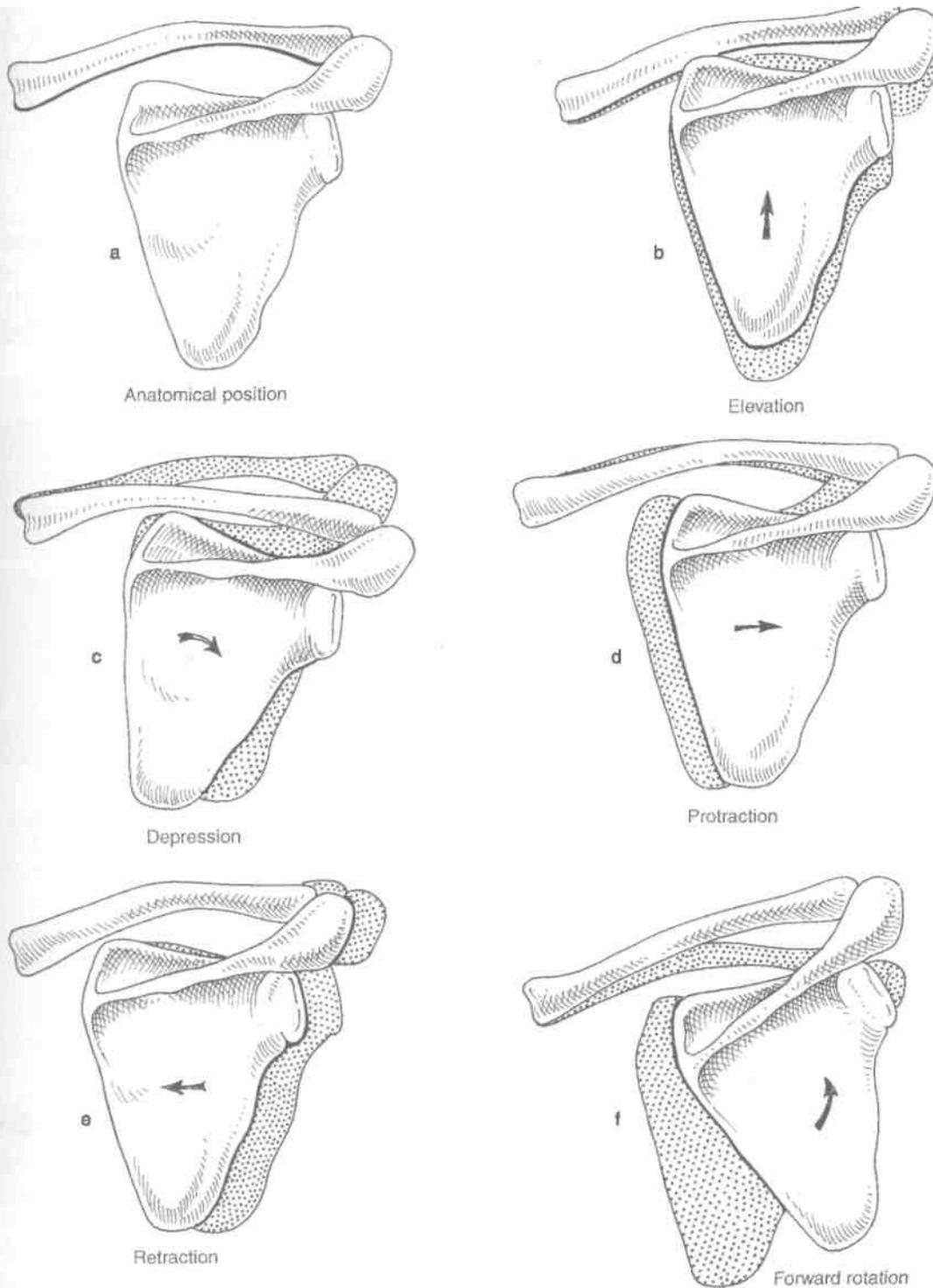

Fig. 10.2: Movements of the right shoulder girdle. Figure (a) shows the anatomical position. The dotted scapulae in figures (b-f) are also in anatomical position. The overlying scapulae show their respective movement.

6. *Backward rotation* of the scapula occurs under the influence of gravity, although it can be brought about actively by the levator scapulae and the rhom-boideus.

This is associated with rotation of the clavicle in a direction opposite to that during forward rotation.

CLINICAL ANATOMY

1.The clavicle may be dislocated at either of its ends. At the medial end, it is usually dislocated forwards. Backward dislocation is rare as it is prevented by the costoclavicular ligament.

2.The main bond of union between the clavicle and the manubrium is the articular disc. Apart from its attachment to the joint capsule the disc is also attached above to the medial end of the clavicle, and below to the manubrium. This prevents the sternal end of the clavicle from tilting upwards when the weight of the arm depresses the acromial end.

3.The clavicle dislocates upwards at the acromioclavicular joint, because the clavicle overrides the acromion.

4.The weight of the limb is transmitted from the scapula to the clavicle through the coraco-clavicular ligament, and from the clavicle to the sternum through the sternoclavicular joint. Some of the weight also passes to the first rib by the costoclavicular ligament. The clavicle usually fractures between these two ligaments.

Ligaments of the Scapula

Figure 10.3 shows details of the ligaments of scapula. The *coracoacromial ligament* (see Fig. 7.8). It is a triangular ligament, the apex of which is attached to the tip of the acromion, and the base to the lateral border of the coracoid process.

The acromion, the coracoacromial ligament and the coracoid process, together form the *coracoacromial arch,* which is known as the secondary socket for the head of the humerus. It adds to the stability of the joint and protects the head of the humerus.

The *superior transverse scapular or suprascapular ligament*. It converts the scapular notch into a foramen. The suprascapular nerve passes below the ligament, and the suprascapular artery above the ligament (Fig. 10.3).

The *inferiortransverse scapular (spinoglenoid) ligamen t.* It is a weak band which bridges the spinoglenoid notch. The suprascapular nerve and vessels pass beneath the arch to enter the infraspinous fossa.
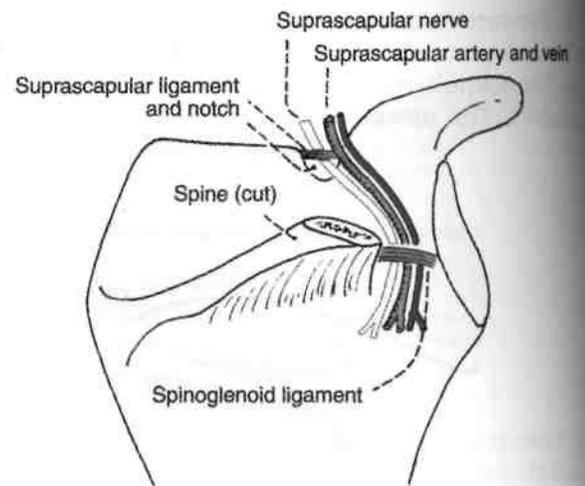

Fig. 10.3: *The suprascapular and spinoglenoid ligaments.*

THE SHOULDER JOINT   ^M

Surface Marking

The anterior margin of the glenoid cavity corresponds' to the lower half of the shoulder joint. It is marked by a line 3 cm long drawn downwards from a point just lateral to the tip of the coracoid process. The line is slightly concave laterally.

Having studied all the muscles at the upper end of the scapula it is wise to open and peep into the most mobile shoulder joint.

Identify the muscles attached to the greater and lesser tubercles of humerus. Deep to the acromion look for the subacromial bursa.

Identify coracoid process, acromion process and triangular coracoacromial arch binding these two bones together. Trace the supraspinatus muscle from supraspinous fossa of scapula to the greater tubercle of humerus. On its way it is intimately fused to the capsule of the shoulder joint. In the same way, tendons of infraspinatus and teres minor also fuse with the posterior part of the capsule. Inferiorly trace the tendon of long head of triceps brachii from the infraglenoid tubercle of scapula.

Cut through the subscapularis muscle at the neck of scapula. It also gets fused with the anterior part of capsule of the shoulder joint as it passes tc the lesser tubercle of humerus.

Type

The shoulder joint is a synovial joint of the ball an socket variety.

I Articular *Surface*

lejoint is formed by articulation of the scapula and :head of the humerus. Therefore, it is also known B the glenohumeral articulation. Structurally, it is a weak joint because the glenoid cavity is too small and shallow to hold the head of the lumerus in place. (The head is four times the size of he glenoid cavity.) However, this arrangement perls great mobility. Stability of the joint is maintained by the following factors.

1. The coracoacromial arch or secondary socket for the head of the humerus (Fig. 7.8).

2. The musculotendinous cuff of the shoulder ■ **(Fig. 7.7).**

3. The glenoidal labrum helps in deepening the glenoid fossa. Stability is also provided by the muscles attaching the humerus to the pectoral girdle, the nghead of the biceps, the long head of the triceps, and atmospheric pressure.

/faring studied the structures related to shoulder joint, the capsule of the joint is to be opened. A vertical incision is given in the posterior part of the capsule of the shoulder joint. The arm is rotated medially and laterally. This helps in head of humerus getting separated from the shallow glenoid cavity. Inside the capsule the shining tendon of long head of biceps brachii is visible as it traverses the intertubercular sulcus to reach the supragle-noid tubercle of scapula. This tendon also gets continuous with the labrum glenoidale attached to the rim of glenoid cavity.

I Ligaments of the Joint

As the articular capsule is opened, the three gleno-humeral ligaments are noticeable on the anterior part of the capsule. Define the articular surfaces, ligaments, bursae related to this important joint.

1. *The capsular ligament:* It is very loose and permits free movements. It is least supported inferi-orly where dislocations are common. Such a disloca-i tion may damage the closely related axillary nerve (Fig. 7.10).

Medially, the capsule is attached to the scapula beyond the supraglenoid tubercle and the margins of the labrum. Laterally, it is attached to the anatomical neck of the humerus with the following excep-tions. Interiorly, the attachment extends down to the surgical neck. Superiorly, it is deficient for passage of the tendon of the long head of the biceps brachii. The joint cavity communicates with the subscapular

bursa, with the synovial sheath for the tendon of the long head of the biceps brachii, and often with the infraspinatus bursa. Anteriorly, the capsule is reinforced by supplemental bands called the superior, middle and inferior glenohumeral ligaments. The capsule is lined with synovial membrane. An extension of this membrane forms a tubular sheath for the tendon of the long head of the biceps brachii.

1. *The coracohumeral ligament:* It extends from the root of the coracoid process to the neck of the humerus opposite the greater tubercle. It gives strength to the capsule.

2. *Transverse humeral ligament:* It bridges the upper part of the bicipital groove of the humerus (between the greater and lesser tubercles). The tendon of the long head of the biceps brachii passes deep to the ligament.

3. The *glenoidal labrum:* It is a fibrocartilaginous rim which covers the margins of the glenoid cavity, thus increasing the depth of the cavity.

Bursae Related to the Shoulder Joint

1. The subacromial (subdeltoid) bursa (Figs 7.8, 7.9).

2. The subscapularis bursa, communicates with the joint cavity.

1. The infraspinatus bursa, may communicate with the joint cavity.

2. *Several other bursae related to* the coracobra-chialis, teres major, long head of the triceps, latissi-mus dorsi, and the coracoid process are present.

Relations

Superiorly. Coracoacromial arch, subacromial bursa, supraspinatus and deltoid (Fig. 10.4).

Inferiorly. Long head of the triceps brachii. *Anteriorly.* Subscapularis, coracobrachialis, short head of biceps and deltoid.

Pos teriorly. Infraspinatus, teres minor and deltoid.
Within the joint: Tendon of the long head of the *biceps brachii.*

Blood Supply

1. Anterior circumflex humeral vessels,
2. Posterior circumflex humeral vessels,
3. Suprascapular vessels, and
4. Subscapular vessels.

Nerve Supply

1. Axillary nerve,
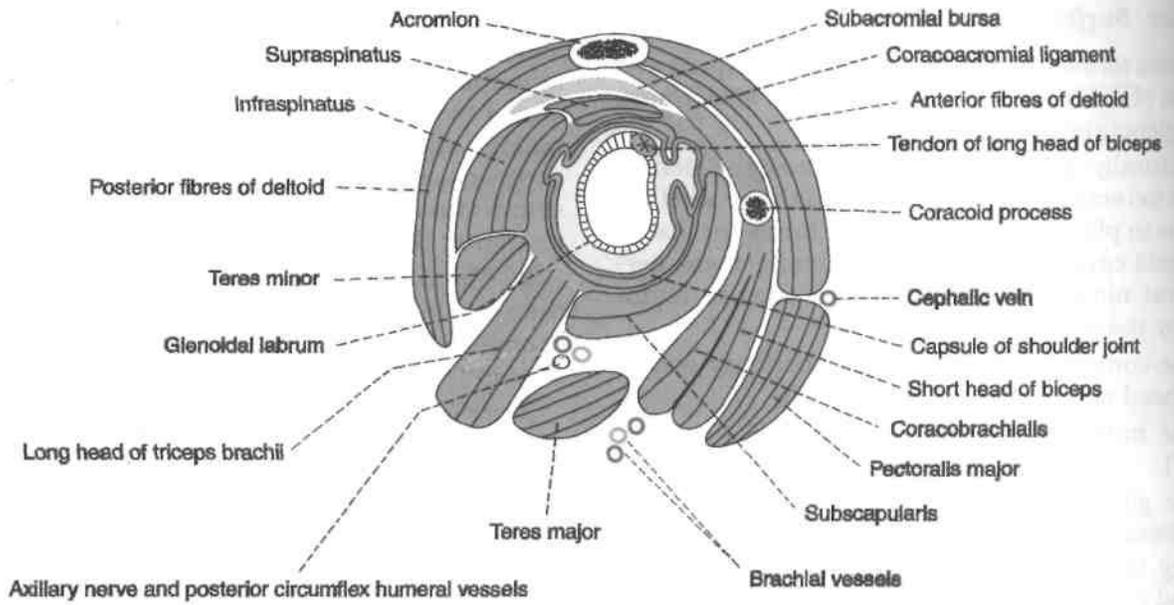2. Musculocutaneous nerve, and
3. Suprascapular nerve.

Fig. 10.4: Schematic sagittal section showing relations of the shoulder joint.
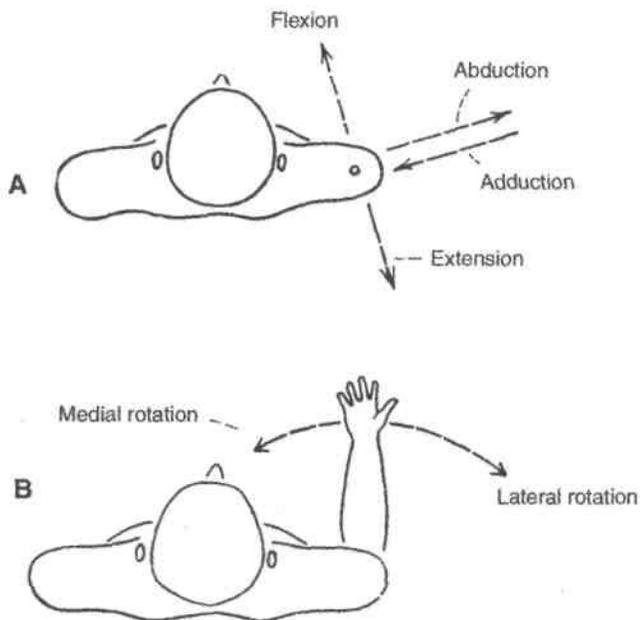

Fig. 10.5: Planes of movements of the shoulder joint.

MOVEMENTS AT THE SHOULDER JOINT

The shoulder joint enjoys great freedom of mobility at the cost of stability. There is no other joint in the body which is more mobile than the shoulder. This wide range of mobility is due to laxity of its fibrous capsule, and the large size of the head of the humerus as compared with the shallow glenoid cavity. The range of movements is further increased by concurrent movements of the shoulder girdle (Figs 10.5, 10.6).

Movements of the shoulder joint are considered in I relation to the scapula rather than in relation to the sagittal and coronal planes. When the arm is by the side (in the resting position) the glenoid cavity faces 1 almost equally forwards and laterally; and the head I of the humerus faces medially and backwards. Keep-1 ing these directions in mind, the movements are I analyzed as follows.

1.*Flexion and extension.* During flexion the arm I moves forwards and medially, and during extension I the arm moves backwards and laterally. Thus flexion I and extension take place in a plane parallel to the surface of the glenoid cavity (Figs 10.6.1, 10.6.2).

2.*Abduction and adduction* take place at right angles to the plane of flexion and extension, i.e. approximately midway between the sagittal and coronal planes. In abduction, the arm moves I anterolateral^ away from the trunk. This movement j is in the same plane as that of the body of the scapula (Figs 10.6.3, 10.6.4).

3.*Medial and lateral rotation are* best demonstrated with a midflexed elbow. In this position, the hand is moved medially in medial rotation, and laterally in lateral rotation of the shoulder joint (Figs 10.6.5, 10.6.6).

4.*Circumduction* is a combination of different movements as a result of which the hand moves along a circle.

The range of any movement depends on the availability of an area of free articular surface on the head of the humerus. It may be noted that the articular area on the head of the humerus is four times larger than that on the glenoid cavity.

fig. 10.6: *Movements of the shoulder joint: 1. Flexion; 2. Extension; 3. Abduction; 4. Adduction; 5. Medial rotation; 6. Lateral rotation.*

Muscles Producing Movements

1. *Flexion* is brought about:

   (a)Mainly by the clavicular part of the pectoralis major, the anterior fibres of the deltoid, and the coracobrachialis (Table 10.1).

   (b)Is assisted by the coracobrachialis and short head of the biceps.

2. *Extension*

   (a) In the resting position, extension is brought about by the posterior fibres of the deltoid, the teres major, and latissimus dossi.

   (bj A fully flexed arm is brought back to the plane of the body by the sternocostal part of the pectoralis major (against resistance).

   (3. *Abduction* of the arm is brought about by the supraspinatus, the deltoid, the serratus anterior, and the upper and lower fibres of the trapezius. The abduction is initiated by supraspinatus and is taken over by the deltoid which exerts an upward pull on the head of the humerus. This is counteracted by a downward pull produced by the subscapularis, the infraspinatus and the teres minor (thus avoiding upward displacement of the head of the humerus). Thus the deltoid and these three muscles constitute a 'couple' which permits true abduction in the plane

of the body of the scapula. The serratus anterior and the trapezius increase the range of the abduction considerably up to 180 degrees by rotating the! scapula so that the glenoid cavity faces upwards!)

1.*Adduction* is brought about: (a) mainly by the pectoralis major and the latissimus dorsi; and (b) is assisted by the teres major, the coracobrachialis, the I short head of the biceps brachii, and the long head of the triceps brachii.

2.*Medial rotation* is produced by the pectoralis I major, the anterior fibres of the deltoid, the latissimus dorsi, and the teres major. When the arm is by the side the movement is also assisted by the sub- I scapularis.

3.Lateral rotation is produced by the posterior fibres of the deltoid, the infraspinatus, and the teres minor.

Analysis of Abduction at the Shoulder

Abduction at the shoulder occurs through 180 degrees. The movement takes place partly at the shoulder joint and partly at the shoulder girdle (forward rotation of scapula round the chest wall). The humerus and scapula move in the ratio of 2: 1 throughout abduction. For every 15 degrees of elevation, 10 degrees occur at the shoulder joint and

Table 10.1: Muscles bringing about movements at the shoulder joint

Movements	Main muscles	Accessory muscles
1. Flexion	(i) Clavicular head of the pectoralis major (ii) Anterior fibres of deltoid	(i) Coracobrachialis (ii) Short head of biceps
2. Extension	(i) Posterior fibres of deltoid (ii) Latissimus dorsi	(i) Teres major (ii) Long head of triceps (iii) Sternocostal head of the pectoralis major
3. Adduction	(i) Pectoralis major (ii) Latissimus dorsi (iii) Short head of biceps (iv) Long head of triceps	(i) Teres major (ii) Coracobrachialis
4. Abduction	(i) Deltoid (ii) Supraspinatus (iii) Serratus anterior (iv) Upper and lower fibres of trapezius	
5. Medial rotation	(i) Pectoralis major (ii) Anterior fibres of deltoid (iii) Latissimus dorsi (iv) Teres major	(i) Subscapularis
6. Lateral rotation	(i) Posterior fibres of deltoid (ii) Infraspinatus (iii) Teres minor	

5 degrees are due to movement of the scapula. Rotation of the scapula is facilitated by movements at the sternoclavicular and acromioclavicular joints.

The articular surface of the head of the humerus permits abduction of the arm only up to 90 degrees. At the limit of this movement there is lateral rotation of the humerus and the head of the bone comes to lie deep to the coracoacromial arch.

Abduction is initiated by the supraspinatus, but the deltoid is the main abductor. The scapula is rotated by combined action of the trapezius and serratus anterior.

CLINICAL ANATOMY

1.*Dislocation.* The shoulder joint is more prone to dislocation than any other joint. This is due to laxity of the capsule and the disproportionate area of the articular surfaces. Dislocation usually occurs when the arm is abducted. In this position, the head of the humerus presses against the lower unsupported part of the capsular ligament. Thus almost always the dislocation is primarily subglenoid, but later it may become subcoracoid, subclavicular, or subspinous. Dislocation endangers the axillary nerve which is closely related to the lower part of the joint capsule.

2.*Optimum attitude.* In order to avoid ankylosis, many diseases of the shoulder joint are treated in an optimum position of the joint. In this position, the arm is abducted by 45-90 degrees.

3.*Shoulder tip pain.* Irritation of the diaphragm from any surrounding pathology causes referred pain in the shoulder. This is so because the phrenic nerve (supplying the diaphragm) and the supraclavicular nerves (supplying the skin over the shoulder) both arise from spinal segments C3, C4.

4.The shoulder joint is most commonly approached (surgically) from the front. However, for aspiration the needle may be introduced either anteriorly through the deltopectoral triangle (closer to the deltoid), or laterally just below the acromion.

5.*Frozen shoulder.* This is a common occurrence. Pathologically, the two layers of the synovial membrane become adherent to each other. Clinically, the patient (usually 40-60 years of age) complains of progressively increasing pain in the shoulder, stiffness in the joint and restriction of all movements. The surrounding muscles show disuse atrophy. The disease is self-limiting and the patient may recover spontaneously in about two years.

6. Shoulder joint disease can be excluded if the patient can raise both his arms above the head and bring the two palms together.

Continuous pain throughout abduction indicates some kind of arthritis: pain between 60-120 degrees of abduction suggests supraspinatus tendinitis, or subacromial bursitis; and abduction limited to 40-50 degree suggests tear of the supraspinatus tendon.

THE ELBOW JOINT

The elbow joint is a synovial joint between the lower end of humerus and the upper ends of radius and ulna bones.

DISSECTION

Cut through the muscles arising from the lateral and medial epicondyles of humerus and reflect them distally if not already done. Also cut through biceps brachii, brachialis and triceps brachii 3 cm proximal to the elbowj oint and reflect them distally. Remove all the muscles fused with the fibrous capsule of the elbow joint and define its attachments.

Define the articular surfaces, ligaments and relations of the joint.

Surface Marking

The joint line is situated 2 cm below the line joining the two epicondyles, and slopes downwards and medially. This slope is responsible for the carrying angle.

Type: This is a synovial joint of the hinge variety.

Articular Surfaces

Upper: The capitulum and trochlea of the humerus.

Lower: (i) Upper surface of the head of the radius articulates with the capitulum, (ii) trochlear notch of the ulna articulates with the trochlea of the humerus (Fig. 10.7).

The elbow joint is continuous with the superior radioulnar joint. The humeroradial, the humeroulnar and the superior radioulnar joints are together known as cubital articulations.

Ligaments

1. Capsular ligament. *Superiorly,* it is attached to the lower end of the humerus in such a way that the

Elbow joint
Capitulum of humerus articulates with upper surface of head of radius

Trochlea of humerus articulates with trochlear notch of ulna

Superior radioulnar joint
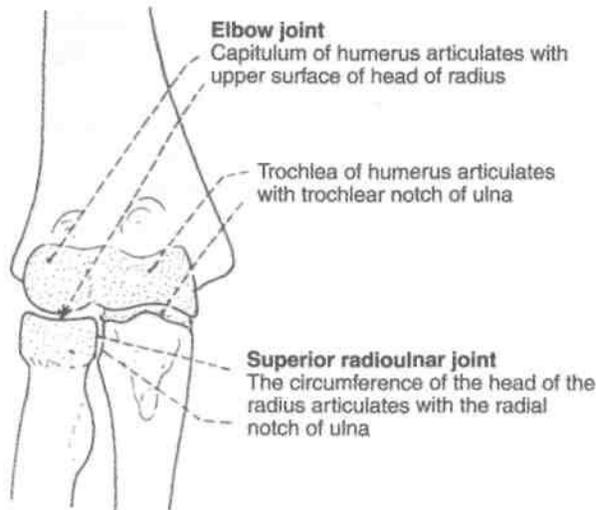The circumference of the head of the radius articulates with the radial notch of ulna

Fig. 10.7: The cubital articulations, including the elbow and superior radioulnar joints.

capitulum, the trochlea, the radial fossa, the coro-noid fossa and the olecranon fossa are intracapsular. *Inferomedially,* it is attached to the margin of the trochlear notch of the ulna except laterally; *inferolaterally,* it is attached to the annular ligament of the superior radioulnar joint. The synovial membrane lines the capsule and the fossae, named above.

1. The *anterior* ligament and

2. The *posterior* ligament are thickening of the capsule.

3. The *ulnar collateral ligament* is triangular in shape (Fig. 10.8). Its apex is attached to the medial epicondyle of the humerus, and its base to the ulna. The ligament has thick anterior and posterior bands: these are attached below to the coronoid process and the olecranon respectively. Their lower ends are
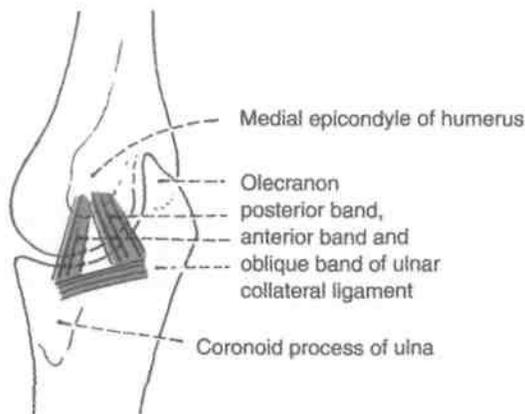

Medial epicondyle of humerus

Olecranon
posterior band,
anterior band and
oblique band of ulnar collateral ligament

Coronoid process of ulna

Fig. 10.8: The ulnar collateral ligament of the elbow joint.

joined to each other by an oblique band which gives attachment to the thinner intermediate fibres of the ligament. The ligament is crossed by the ulnar nerve and gives origin to the flexor digitorum superficialis. It is closely related to the flexor carpi ulnaris and the triceps brachii.

5. The *radial collateral or lateral ligament.* It is a fan-shaped band extending from the lateral epicondyle to the annular ligament. It gives origin to the supinator and to the extensor carpi radialis brevis (Fig. 10.9).
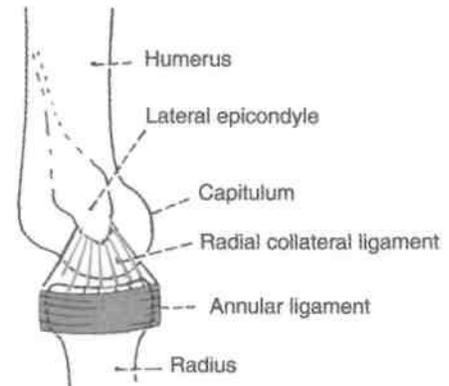

Humerus

Lateral epicondyle

Capitulum

Radial collateral ligament

Annular ligament

Radius

Fig. 10.9: The radial collateral ligament of the elbow joint.

Relations of Elbow Joint

Anteriorly: Brachialis, median nerve, brachial artery and tendon of biceps (Fig. 9.15).

Posteriorly: Triceps and anconeus.

Medially: Ulnar nerve, flexor carpi ulnaris and common flexors.

Laterally: Supinator, extensor carpi radialis brevis and other common extensors.

Blood Supply

From anastomosis around the elbow joint.

Nerve Supply

The joint receives branches from the following nerves: (i) ulnar nerve, (ii) median nerve, (iii) radial nerve, and (iv) musculocutaneous nerve through its branch to the brachialis.

Movements

1. Flexion is brought about by: (i) the brachialis, (ii) the biceps, and (iii) the brachioradialis.

2. Extension is produced by: (i) the triceps, and (ii) the anconeus.

The transverse axis of the elbow joint is directed medially and downwards. Because of this the extended forearm is not in straight line with the arm, but makes an angle of about 163 degrees with it. This is known as the carrying angle. The factors responsible for production of the carrying angle are as follows.

(a)The medial flange of the trochlea is 6 mm deeper than the lateral flange.

(b)The superior articular surface of the coronoid process of the ulna is placed oblique to the long axis of the bone.

The carrying angle disappears in full flexion of the elbow, and also during pronation of the forearm. The forearm comes into line with the arm in the midprone position, and this is the position in which the hand lis mostly used. This arrangement of gradually increasing carrying angle during extension of the elbow increases the precision with which the hand (and objects held in it) can be controlled.

CLINICAL ANATOMY

1.*Distension* of the elbow joint by an effusion occurs posteriorly because here the capsule is weak and the covering deep fascia is thin. Aspiration is done posteriorly on any side of the olecranon.

2.*Dislocation* of the elbow is usually posterior, and is often associated with fracture of the coronoid process. The triangular relationship between the olecranon and the two humeral epicondyles is lost.

1.*Subluxation* of the head of the radius (pulled elbow) occurs in children when the forearm is suddenly pulled in pronation. The head of the radius slips out from the annular ligament.

2.*Tennis elbow*. Abrupt pronation may lead to pain and tenderness over the lateral epicondyle. This is possibly due to: (i) sprain of radial collateral ligament, and (ii) tearing of fibres of the extensor carpi radialis brevis.

3.*Miner's (or student's elbow)* is characterized by effusion into the bursa over the subcutaneous posterior surface of the olecranon process.

4.*Optimum position* of the elbow. If only elbow is to be fixed it is flexed at right angle. If both elbows need fixation the right elbow is fixed in a position of flexion at an angle slightly less than 90 degrees, and the left elbow at an angle slightly more than 90 degrees. In this position, the right hand can be brought to the mouth and the left hand can be used for cutting up food. It can also reach the trouser pocket.

THE RADIOULNAR JOINTS

rhe radius and the ulna are joined to each other al ;he superior and inferior radioulnar joints. These are iescribed in Table 10.2. The radius and ulna are alsc connected by the interosseous membrane which constitutes middle radioulnar joint (Fig. 10.10).

Remove all the muscles covering the adjacent sides of radius, ulna and the intervening interosseous membrane. This will expose the superior and inferior radioulnar joints including the interosseous membrane.

Cut through the annular ligament to see the superior radioulnar joint. Clean and define the interosseous membrane. Lastly cut through the capsule of inferior radioulnar joint to locate the intra-articular fibrocartilaginous disc of the joint. Learn the movements of supination and pronation on dry bones and on yourself.
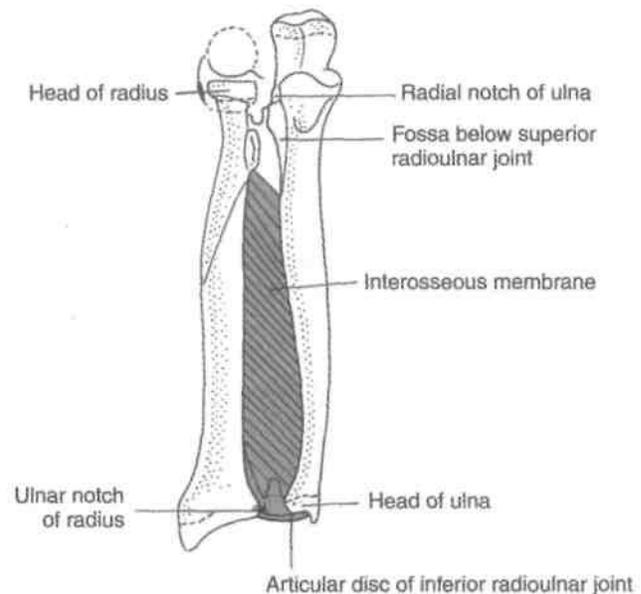

Fig. 10.10: Radioulnar joints.

Additional Features of Radioulnar Joints

1. Annular Ligament

Annular ligament is a strong band that encircles the head of the radius, and retains it in contact with the radial notch of the ulna (Fig. 10.9). It forms four-fifths of the osseofibrous ring within which the head of the radius rotates. The ligament is attached to the

150pege.2: The Radioulnar Joints (Fig. 10.10)

Features	Superior radioulnar joint	Inferior radioulnar joint
Type	Pivot type of synovial joint.	Pivot type of synovial joint.
Articular surfaces	1. Circumference of head of radius. 2. Osseofibrous ring, formed by the radial notch of the ulna and the annular ligament.	1. Head of ulna 2. Ulnar notch of radius
Ligaments	1. The annular ligament. It forms four-fifths of the ring within which the head of the radius rotates. It is attached to the margins of the radial notch of the ulna, and is continuous with the capsule of the elbow joint above. 2. The quadrate ligament, extends from the neck of the radius to the lower margin of the radial notch of the ulna.	1. The capsule surrounds the joint. The upper l part is weak, is evaginated by the synovial ' membrane to form a recess (recessus sacciformis) in front of the interosseous membrane. 2. The apex of articular disc is attached to the base of the styloid process of the ulna, and the base to the lower margin of the ulnar] notch of the radius.
Blood supply	Anastomosis round the lateral side of the elbow joint.	Anterior and posterior interosseous arteries.
Nerve supply	Musculocutaneous, median, and radial nerves.	Anterior and posterior interosseous nerves.
Movements	Supination and pronation	Supination and pronation

anterior and posterior margins of the radial notch of the ulna. The upper border of the ligament is continuous with the fibrous capsule of the elbow joint (except posteriorly where the capsule passes deep to the annular ligament to be attached to the posterior and inferior margins of the radial notch). From the lower border of the annular ligament, some fibres pass over the synovial membrane to be loosely attached to the neck of the radius.

A thin fibrous layer, often termed the *quadrate ligament,* covers the synovial membrane and closes the joint cavity from below, between the radius and the ulna.

The superficial surface of the annular ligament blends with the radial collateral ligament of the elbow, gives origin to the supinator muscle, and is related to the anconeus and to the interosseous recurrent artery. The inner surface of the upper part of the ligament is covered with cartilage, and in its lower part it is lined with synovial membrane.

2. Articular Disc of Inferior Radioulnar Joint

The disc shows age changes. With advancing age the disc undergoes progressive degeneration characterized by reduced cellularity, loss of elastic fibres, mucoid degeneration of ground substance, exposure of collagen fibres, fibrillation, thinning, and ultimately perforation. Perforation occurs only after the second decade of life.

Interosseous Membrane

The interosseous membrane connects the shafts of I the radius and ulna. It is attached to the interosseous I borders of these bones. The fibres of the membrane I run downwards and medially from the radius to ulna I (Fig. 10.10). The two bones are also connected by the I oblique cord which extends from the tuberosity of I the radius to the tuberosity of the ulna. The direction ∎ of its fibres is opposite to that in the interosseous ∎ membrane.

(a) Superiorly, the interosseous membrane be-gins 2-3 cm below the radial tuberosity. Between the I oblique cord and the interosseous membrane there I is a gap for passage of the posterior interosseous vessels to the back of the forearm.

(b) Interiorly, a little above its lower margin, there is an aperture for the passage of the anterior interos-seous vessels to the back of the forearm.

(c) The anterior surface is related to the flexor pollicis longus, the flexor digitorum profundus, the pronator quadratus, and to the anterior interosseous vessels and nerve (Fig. 2.27).

(d) The posterior surface (Fig. 9.45) is related to the supinator, the abductor pollicis longus, the extensor pollicis brevis, the extensor pollicis longus, the extensor indicis, the anterior interosseous artery and the posterior interosseous nerve.

The interosseous membrane performs the following functions.

1.It binds the radius and ulna to each other.

2.It provides attachments to many muscles.

3.It transmits forces (including weight) applied to the radius (through the hand) to the ulna. This transmission is necessary as radius is the main bone taking part in the wrist joint, while the ulna is the main bone taking part in the elbow joint.

Supination and Pronation

Supination and pronation are rotatory movements of the forearm (and hand) around a vertical axis. In a semiflexed elbow, the palm is turned upwards in supination, and downwards in pronation (kings pronate, beggars supinate). The movements are permitted at the superior and inferior radioulnar joints.

The vertical axis of movement of the radius passes through the centre of the head of the radius above, and through the ulnar attachment of the articular disc below. However, this axis is not stationary because the lower end of the ulna is not fixed: it moves backwards and laterally during pronation, and forwards and medially during, supination. As a result of this movement, the axis (defined above) is displaced laterally in pronation, and medially in supination. For the same reason, the axis of pronation and supination passes between the radius and ulna at both joints when there is marked ulnai movement; and through the centre of the head o the radius and the ulnar styloid process when ul nar movement is minimal. Inferiorly, the axis ma} pass through any digit depending on the degree o medial or lateral displacement of the lower end o the ulna.

Supination is more powerful than pronation be cause it is an antigravity movement. Supinatior movements are responsible for all screwing move ments of the hand, e.g. as in tightening nuts anc bolts. Morphologically, pronation and supination were evolved for picking up food and taking it to the mouth.

Pronation is brought about chiefly by the pronator quadratus. It is aided by the pronator teres when the movement is rapid and against resistance. Gravity also helps (Fig. 10.11).

Supinatiorjisbroughtaboutbythesupinatormuscle and the biceps brachii. Slow supination, with elbow extended, is done by the supinator. Rapid supination with the elbow flexed, and when performed against resistance, is done mainiy by the biceps (Fig, 10.12).
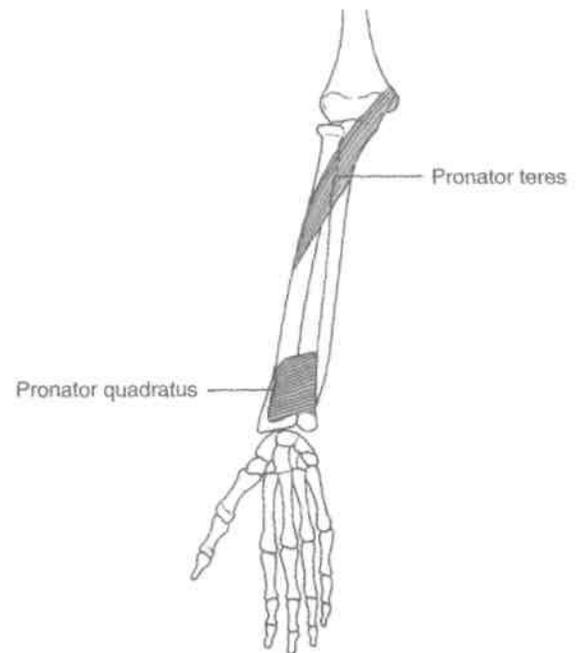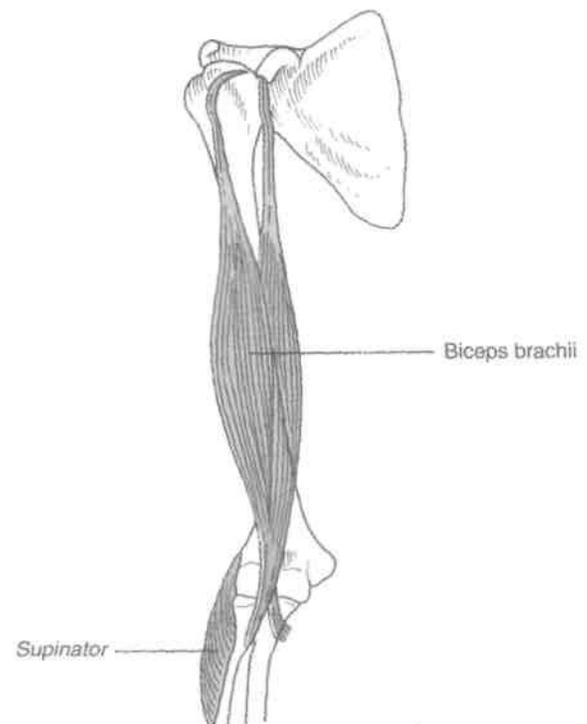

Fig. 10.11: The pronators.

Fig. 10.12: The supinators.

WRIST (RADIOCARPAL) JOINT

Type

Wrist joint is a synovial joint of the ellipsoid variety between lower end of radius and three lateral bones of proximal row of carpus.

Cut through the thenar and hypothenar muscles from their origins and reflect them distally. Separate the flexor and extensor retinacula of the wrist from the bones. Cut through flexor and extensor tendons *(if not* already done] *and reflect them*

distally,

Define the capsular attachments and ligaments and relations of the wrist joint.

Surface Marking

The joint line is obtained by joining the styloid processes of the radius and ulna. It is convex upwards. The joint neither communicates with the inferior radioulnar joint nor with the intercarpal joints.

Articular Surfaces

Upper

1. Inferior surface of the lower end of the radius (Fig. 2.24)
2. Articular disc of the inferior radioulnar joint (Fig. 10.13).

Lower

1. Scaphoid
2. Lunate
3. Triquetral bones.

Ligaments

1. The *articular capsule* surrounds the joint. It is attached above to the lower ends of the radius and
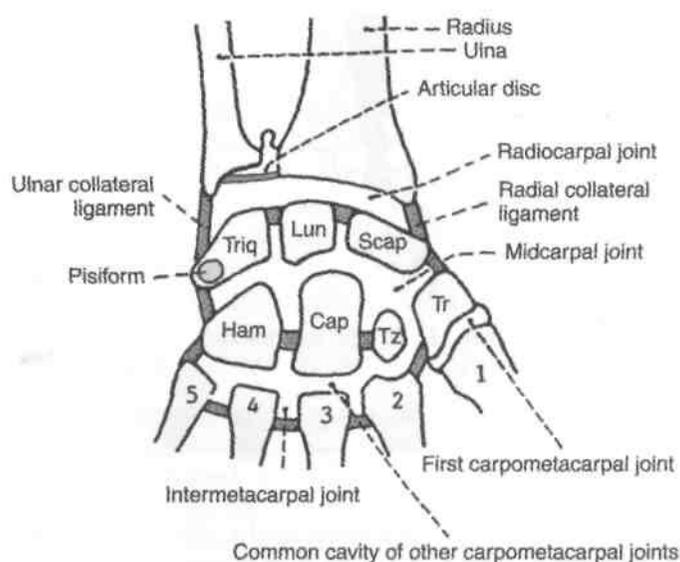
Fig. 10.13: *The joints in the region of the wrist.*

ulna, and below to the proximal row of carpal bon A protrusion of synovial membrane, called t prestyloid recess, lies in front of the styloid proa of the ulna and in front of the articular disc. It bounded inferiorly by a small meniscus project inwards from the ulnar collateral *ligament betwe the styloid process and the triquetral bone. U*

fibrous capsule is strengthened by the followinj ligaments.

2. On the palmar aspect there are two palmai carpal ligaments.

The *palmar radiocarpal ligament* is a broad band. It begins above from the anterior margin of the lower! end of the radius and its styloid process, runs downwards and medially, and is attached below to the anterior surfaces of the scaphoid, the lunate and triquetral bones.

The *palmar ulnocarpal ligament* is a rounded fasciculus. It begins above from the base of the styloid process of the ulna and the anterior margin of the articular disc, runs downwards and laterally, and is attached to the lunate and triquetral bones.

Both the palmar carpal ligaments are considered to be intracapsular.

1. On the dorsal aspect of the joint there is one *dorsal radiocarpal ligament.* It is weaker than the palmar ligaments. It begins above from the posterior margin of the lower end of the radius, runs downwards and medially, and is attached below to the dorsal surfaces of the scaphoid, lunate and triquetral bones.

2. *The radial collateral ligament* extends from the tip of the styloid process of the radius to the lateral side of the scaphoid bone. It is related to the radial artery (Fig. 10.13).

3. The *ulnar collateral ligament* extends from the tip of the styloid process of the ulna to the triquetral and pisiform bones.

Both the collateral ligaments are poorly developed.

Relations

Anterior. Long flexor tendons with their synovial sheaths, and median nerve.

Posterior. Extensor tendons of the wrist and fingers with their synovial sheaths.

Lateral. Radial artery.

Blood Supply

Anterior and posterior carpal arches.

Nerve Supply

Anterior and posterior interosseous nerves.

^Hements

Movements at the wrist are usually associated with the movements at the midcarpal joint. The active movements are described.

1. *Flexion:* It takes place more at the midcarpal than at the wrist joint. The main flexors are: (i) the I flexor carpi radialis, (ii) the flexor carpi ulnaris, and (111) the palmaris longus. The movement is assisted by the long flexors of the fingers and thumb (Fig. 10.14), and the abductor pollicis longus.
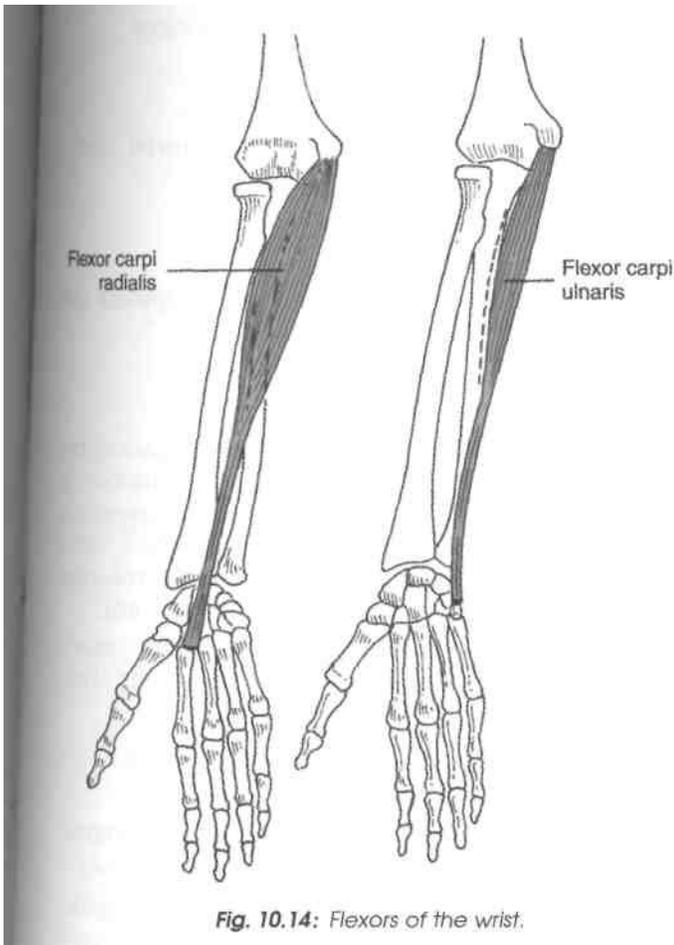

Fig. 10.14: *Flexors of the wrist.*

1.*Extension:* It takes place mainly at the wrist joint. The main extensors are: (i) the extensor carpi radialis longus, (ii) the extensor carpi radialis brevis, and (iii) the extensor carpi ulnaris. It is assisted by the extensors of the fingers and thumb (Fig. 10.15).

2.*Abduction:* It occurs mainly at the midcarpal joint. The main abductors are: (i) the flexor carpi radialis, (ii) the extensor carpi radialis longus and brevis, and (iii) the abductor pollicis longus and the extensor pollicis brevis.

3.*Adduction:* It occurs mainly at the wrist joint. The main adductors are: (i) the flexor carpi ulnaris, and (ii) the extensor carpi ulnaris.
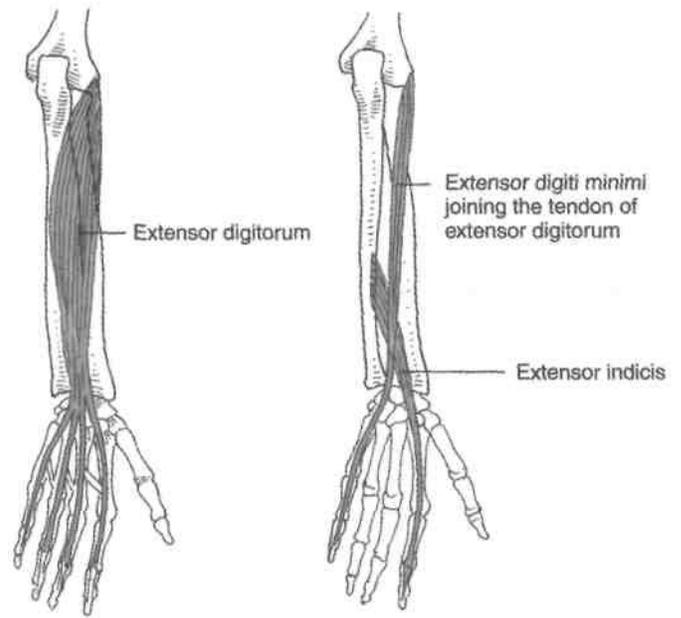

Fig. 10.15: *1. Extensor digitorum; 2. Extensor indicis; 3. Extensor digiti minimi.*

5. *Circumduction.* The range of flexion is more than that of extension. Similarly the range of adduction is greater than abduction (due to the longer styloid process of the radius).

CLINICAL ANATOMY

1.The wrist joint is commonly involved in rheumatoid arthritis, in which collagen tissue is mostly affected.

2.The back of the wrist is the common site for a ganglion. It is a cystic swelling resulting from mucoid degeneration of synovial sheaths around the tendons.

3.The wrist joint can be aspirated from the posterior surface between the tendons of the extensor pollicis longus and the extensor indicis.

4.The joint is immobilized in optimum position of 30 degree dorsiflexion (extension).

JOINTS OF THE HAND

INTERCARPAL, CARPOMETACARPAL AND INTERMETACARPAL JOINTS

There are three joint cavities among the intercarpal, carpometacarpal and intermetacarpal joints, which are: (1) pisotriquetral, (2) first carpometacarpal, and (3) a common cavity for the rest of the joints. The

common cavity may be described as the *midcarpal* (transverse intercarpal) joint between the proximal and distal rows of the carpus, which communicates with intercarpal joints superiorly, and with intercarpal, carpometacarpal and intermetacarpal joints in-feriorly (Fig. 10.13).

The midcarpal joint permits movements between the two rows of the carpus as already described with the wrist joint.

DISSECTION

Intercarpal, carpometacarpal and intermetacarpal joints:

Out of these the most important joint with a separate joint cavity is the first carpometacarpal joint. This is the joint of the thumb and a wide variety of functionally useful movements take place here. Identify the distal surface of trapezium and base of first metacarpal bone. Define the metacarpophalangeal and interphalangeal joints.

For their dissection remove all the muscles and tendons from the anterior and posterior aspects of any two metacarpophalangeal joint. Define the articular capsule and ligaments. Do the same for proximal and distal interphalangeal joints of one of the fingers and define the ligaments.

FIRST CARPOMETACARPAL JOINT ~

First carpometacarpal joint is only carpometacarpal joint which has a separate joint cavity. Movements at this joint are, therefore; much more free than at any other corresponding joint.

Type

Saddle variety of synovial joint (because the articular surfaces are concavo-convex).

Articular Surfaces

(i) The distal surface of the trapezium (ii) The proximal surface of the base of the first

metacarpal bone. The concavo-convex nature of the articular surfaces permits a wide range of movements (Fig. 10.13).

Ligaments

1.Capsular ligament. Surrounds the joint. In general, it is thick but loose, and is thickest dorsally and laterally.

2.Lateral ligament. A broad band which strengthens flip pancnlp lat*vrnl1-\r

1.The anterior ligament

2.The posterior ligaments are oblique bands run-1 ning downwards and medially.

Relations

Anteriorly, the joint is covered by the muscles of the thenar eminence. Posteriorly, there are long and shor extensors of the thumb. Medially there is the first dorsa interosseous muscle, and the radial artery! (passing from the dorsal to the palmar aspect of the hand through the interosseous space). Laterally, there is the tendon of the abductor pollicis longus.

Blood Supply

Radial vessels supply blood to the synovial mem- j brane and capsule of the joint.

Nerve Supply

First digital branch of median nerve supplies the capsule of the joint.

Movements

Flexion and extension of the thumb take place in the ! plane of the palm, and abduction and adduction at right angles to the plane of the palm. In apposition, the thumb crosses the palm and touches other fingers. Flexion is associated with medial rotation, and extension with lateral rotation at the joint.

Circumduction is a combination of different move-ments mentioned. The following muscles bring about the movements (Figs 10.16, 10.17).

1. Flexion.   (i) Flexor pollicis brevis
                     (ii) Opponens pollicis.
2. Extension.   (i) Abductor pollicis longus
                     (ii) Extensor pollicis brevis (iii) Extensor pollicis longus.
3. Abduction.   (i) Abductor pollicis brevis
                     (ii) Abductor pollicis longus.
1.Adduction.   Adductor pollicis
2.Opposition.   (i) Opponens pollicis
                     (ii) Flexor pollicis brevis.

The adductor pollicis and the flexor pollicis longus exert pressure on the opposed fingers.

METACARPOPHALANGEAL JOINTS ~

Type

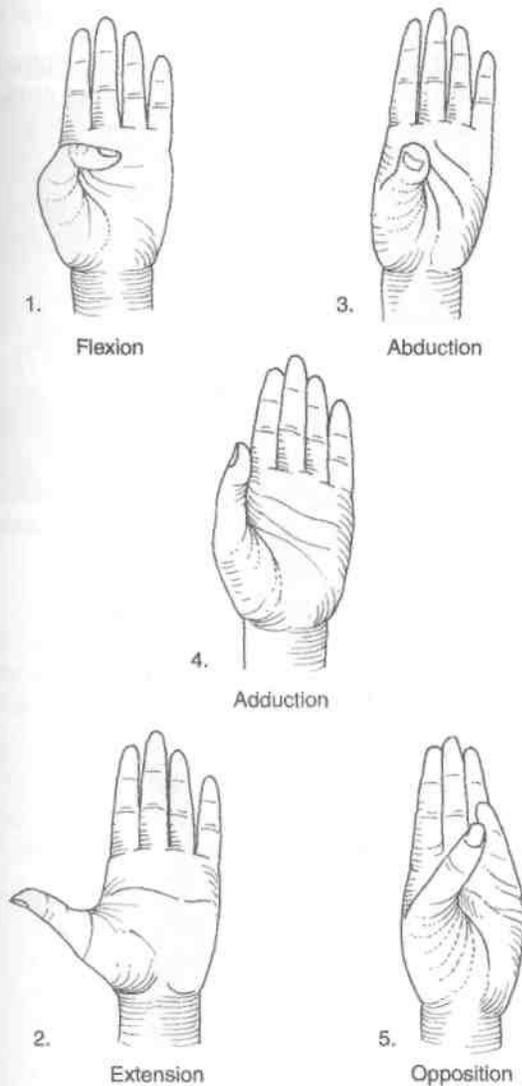Metacarpophalangeal joints are synovial joints of the condylar variety.

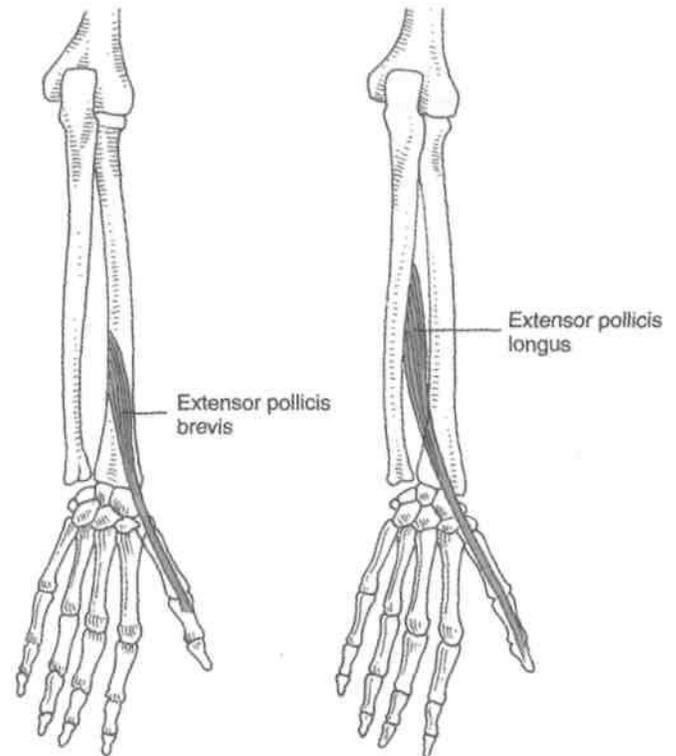Fig. 10.16: Movements of the thumb.

Fig. 10.17: The extensors of the joints of thumb.

Movements at First Joint and Muscles Producing them

1. Flexion: Flexor poinds longus and brevis
2. Extension: Extensor pollicis longus and brevis
3. Abduction: Abductor pollicis brevis
4. Adduction: Adductor pollicis

Movements at Second to Fifth Joints and Muscles Producing them

1. Flexion: Interossei and lumbricals.
2. Extension: Extensors of the fingers (Fig. 10.15).
3. Abduction: Dorsal interossei.
4. Adduction: Palmar interossei.
5. Circumduction: Above muscles in sequence.

INTERPHALANGEAL JOINTS
(PROXIMAL AND DISTAL)

Type

Hinge variety of synovial joints (Fig. 10.18).

Ligaments

Similar to the metacarpophalangeal joints, that is one palmar fibrocartilaginous ligament and two collateral bands running downwards and forwards.

Ligaments

Each joint has the following ligaments.

1. *Capsular ligament:* This is thick in front and thin behind.

2. *Palmar ligament:* This is a strong fibrocartilaginous plate which replaces the anterior part of the capsule. It is more firmly attached to the phalanx than to the metacarpal. The various palmar ligaments of the metacarpophalangeal joints are joined to one another by the deep transverse metacarpal ligament.

3. *Medial and lateral collateral ligaments:* These *are* oblique bands placed at the sides of the joint. Each runs downwards and forwards from the head of the metacarpal bone to the base of the phalanx. These are taut in flexion and relaxed in extension.

Movements at Interphalangeal Joint of the Thumb

Flexion: Flexor pollicis longus
Extension: Extensor pollicis longus.

Movements at Second to Fifth Digits

1. *Flexion.* Flexor digitorum superficialis at the proximal interphalangeal joint, and the flexor digitorum profundus at the distal joint (Fig. 10.19).
2. *Extension.* Interossei and lumbricals.

Segmental innervation of Movements of Upper UflH

Figure 10.20 shows the segments of the spinal cord responsible for movements of the various joints of the upper limb.

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Additional Reading

^^ ^ {1970} ^ *Physiology of Joints*, churchill Livingstone London
M^^ ^ and *Basmian* jy (1977). *Muscles and Movements.* Krieffer Publishing Co. New York.
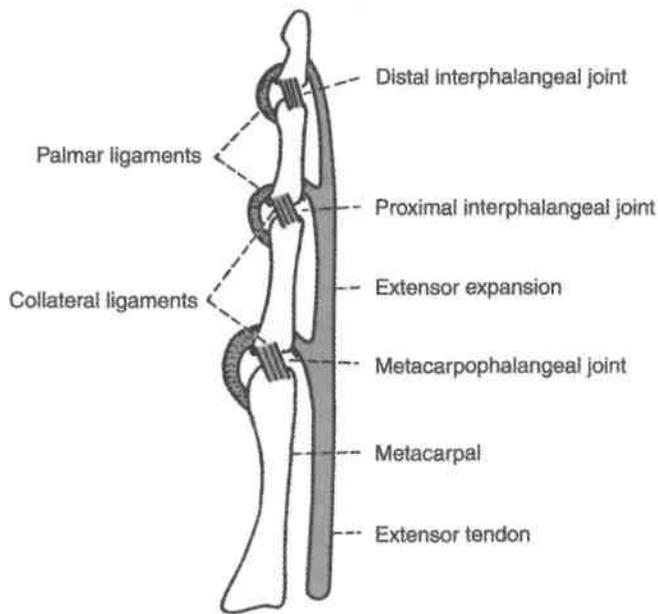
Fig. 10.18: The joints of the fingers.

- Distal interphalangeal joint
- Palmar ligaments
- Proximal interphalangeal joint
- Extensor expansion
- Collateral ligaments
- Metacarpophalangeal joint
- Metacarpal
- Extensor tendon
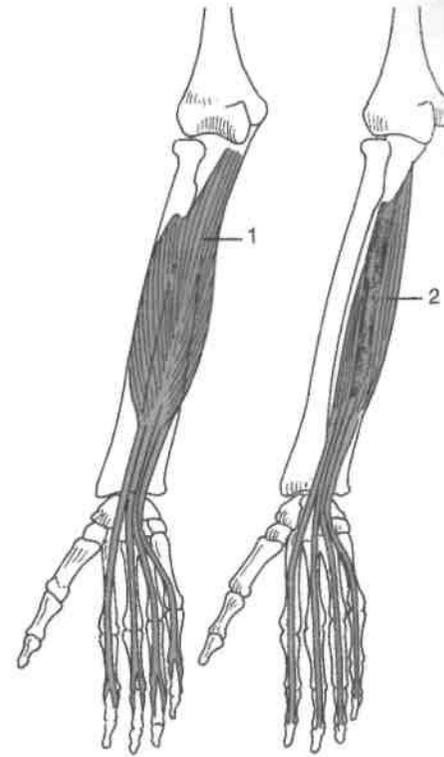
Fig. 10.19: 1. Flexor digitorum superficialis; 2. Flexor digitorum profundus.
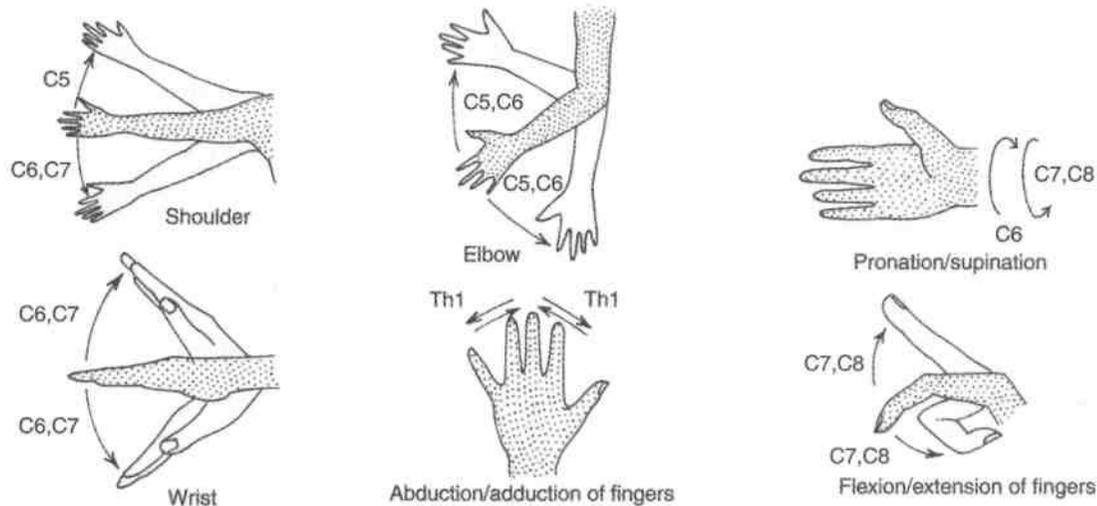

Fig. 10.20: Segmental innervation of movements of the upper limb.

11

Miscellaneous Topics
Surface Marking, Radiological Anatomy, Sympathetic Innervation, Embryology, and Comparison of Upper and Lower Limbs

Surface marking is the projection of the deeper structures on the surface. Its importance lies in various medical and surgical procedures.

Bones cast a shadow in the radiographs, which can be examined carefully to detect age of the person, dislocation, fracture, and asymmetry between the two sides.

Sympathetic innervation of the blood vessels is important. Afterall the blood in the body is limited, and it has to perform diverse functions from 'head to toe'. Sympathetic nerves do manage to regulate the blood flow.

Limbs develop as appendages to the trunk. Emancipated upper limb's development is slightly faster than the weight-bearing lower limb.

Comparison of upper and lower limbs is quite interesting, as these were developed on a similar plan. Because of orthograde and plantigrade posture in man there are modifications to suit these necessities.

SURFACE MARKING

SURFACE LANDMARKS

The bony landmarks seen in different regions of the upper limb have been described in appropriate sections.

The surface marking of important structures is given in this chapter.

Axillary Artery

Hold the arm at right angles to the trunk with the palm directed upwards. The artery is then marked as a straight line by joining the following two points.

  (i) Midpoint of the clavicle.

 (ii) The second point at the junction of the anterior 1/3 and posterior 2/3 of the lateral wall of axilla at its lower limit where the arterial pulsations can be felt (Fig. 4.12).

At its termination the axillary artery, along with the accompanying nerves, forms a prominence which lies behind another projection caused by the biceps and coracobrachialis.

Brachial Artery

Brachial artery is marked by joining the following two points.

 (i) A point at the junction of the anterior 1/3 and posterior 2/3 of the lateral wall of the axilla at its lower limit. Here the axillary artery ends and the brachial artery begins.

(ii) The second point, at the level of the neck of the radius medial to the tendons of the biceps brachii (Fig. 8.7).

Thus the artery begins on the medial side of the upper part of the arm, and runs downwards and slightly laterally to end in front of the elbow. At its termination it bifurcates into the radial and ulnar arteries.

Radial Artery

In the Forearm

Radial artery is marked by joining the following points. (i) A point in front of the elbow at the level of the neck of the radius medial to the tendons of the biceps brachii. (ii)   The second point at the wrist between the anterior border of the radius laterally and the tendon of the flexor carpi radialis medially, where the radial pulse is commonly felt (Fig. 9.11). Its course is curved with a gentle convexity to the lateral side.

In the Hand

Radial artery is marked by joining the following three points.

(i)   A point at the wrist between the anterior border of the radius and the tendon of the flexor carpi radialis. (ii)   A second points just below the tip of the styloid process of the radius (Fig. 9.48). (iii)   The third point at the proximal end of the first intermetacarpal space. In this part of its course, the artery runs obliquely downwards and backwards deep to the tendons of the abductor pollicis longus, the extensor pollicis brevis, and superficial to the lateral ligament of the wrist joint. Thus it passes through the anatomical snuff box to reach the proximal end of the first interosseous space.

Ulnar Artery

Ulnar artery is marked by joining the following three points.
(i)   A point in front of the elbow at the level of the neck of the radius medial to the tendon of the biceps brachii (Figs 9.11, 9.13). (ii)   A second point at the junction of the upper 1/3 and lower 2/3 of the medial border of the forearm (lateral to the ulnar nerve), (iii)   The third point lateral to the pisiform bone. Thus the course of the ulnar artery is oblique in its upper 1/3, and vertical in its lower 2/3. The ulnar nerve lies just medial to the ulnar artery in the lower 2/3 of its course. The ulnar artery continues in the palm as the superficial palmar arch.

Superficial Palmar Arch

Superficial palmar arch is formed by the direct continuation of the ulnar artery, and is marked as a curved line by joining the following points.

(i)   A point just lateral and distal to the pisiform bone (Fig. 9.30). (ii)   The second point on the hook of the hamate bone, (iii)   The third point on the distal border of the thenar eminence in line with the cleft between the index and middle fingers. The convexity of the arch is directed towards the fingers, and its most distal point is situated at the j level of the distal border of the fully extended thumb.

Deep Palmar Arch

Deep palmar arch is formed as the direct continuation of the radial artery. It has a slight convexity towards the fingers. It is marked by a more or less horizontal line, 4 cm (F/2") long, just distal to the hook of the hamate bone (Fig. 9.30).

The deep palmar arch lies 1.2 cm \}/i") proximal to the superficial palmar arch across the metacarpals, immediately distal to their bases. The deep branch of ulnar nerve lies in its concavity.

~   THE NERVES

Axillary Nerve with its Divisions

Axillary nerve with its divisions is marked as a horizontal line on the deltoid muscle, 2 cm above the midpoint between the tip of the acromion process and the insertion of the deltid (Fig. 8.21).

Intramuscular injections in the deltoid are given in the lower part of the muscle nearer to its insertion to avoid injury to the nerve and its accompanying vessels.

Musculocutaneous Nerve

Musculocutaneous nerve is marked by joining the following two points.

(i)   A point lateral to the axillary artery 3 err above its termination (Fig. 8.7). (ii) A point lateral to the tendon of the biceps brachii muscle 2 cm above the bend of the elbow. (Here it pierces the deep fascia anc continues as the lateral cutaneous nerve o the forearm).

Median Nerve

In the Arm

Mark the brachial artery. The nerve is then marke(lateral to the artery in the upper half, and medial ti the artery in the lower half of *the arm.* The nerv crosses the artery anteriorly in the middle of the am (Fig. 8.7).

In the Forearm

Median nerve is marked by joining the following two points, (i) A point medial to the brachial artery at the bend of the elbow.
' (ii) A point in front of the wrist, over the tendon of the palmaris longus or 1 cm medial to the tendon of the flexor carpi radialis (Fig. 9.14).

In the Hand

Median nerve enters the palm by passing deep to flexor retinaculum, immediately below which it divides into lateral and medial branches. Lateral branch supplies the three muscles of thenar eminence and gives two branches to the thumb, and one to lateral side of index finger. Medial branch gives branches for the adjacent sides of index, middle and
I ring fingers. The lateral three and a half nail beds are
I also supplied (Fig. 9.21).

I Radial **Nerve I**

In the Arm

I Radial nerve is marked by joining the following points.
(i) The first point is at the junction of the anterior 1 /3 and posterior 2/3 of the lateral wall of the axilla at its lower limit (Fig. 4.12). (ii) The second point is at the junction of the upper upper 1/3 and lower 2/3 of a line joining the lateral epicondyle with the insertion of the deltoid (Fig. 8.21). (iii)   The third point is on the front of the elbow at the level of the lateral epicondyle 1 cm lateral to the tendon of the biceps brachii (Fig. 9.14). The first and second points are joined across the back of the arm to mark the oblique course of the ' radial nerve in the radial (spiral) groove (posterior compartment). The second and third points are joined on the front of the arm to mark the vertical course of the nerve in the anterior compartment.

In the Forearm

Superficial branch of radial nerve is marked by joining the following three points.
(i) A point 1 cm lateral to the biceps tendon at the level of the lateral epicondyle (Fig. 9.14).
(ii) The second point at the junction of the upper 2/3 and lower 1/3 of the lateral border of the forearm just lateral to the radial artery.
(iii) The third point at the anatomical snuff box.
The nerve is vertical in its course between points one and two. At the second point it inclines backwards to reach the snuff box.

The nerve is closely related to the lateral side of the radial artery only in the middle 1/3 of the forearm.

Ulnar Nerve

In the Arm

Ulnar nerve is marked by joining the following points.
(i) A point at the j unction of the anterior 1/3 and posterior 2/3 of the lateral wall of the axilla at its lower limit (lower border of the teres major muscle) (Fig. 8.7).
(ii) The second point at the middle of the medial border of the arm. (iii) The third point behind the base of the medial epicondyle of the humerus.

In the Forearm

Ulnar nerve is marked by joining the following two points.
(i) A point on the back of the base of the medial epicondyle of the humerus (Fig. 9.14).
(ii) The second point lateral to the pisiform bone.
In the lower 2/3 of the forearm, the ulnar nerve lies medial to the ulnar artery.

*In **the Hand***

Ulnar nerve lies superficial to the medial part of flexor retinaculum and medial to ulnar vessels where it divides into superficial and deep branches. The superficial branch supplies medial one and half digits including their nail beds. The deep branch passes backwards between pisiform and hook of hamate to lie in the concavity of the deep palmar arch (Fig. 9.21).

Posterior Interosseous Nerve or Deep Branch of Radial Nerve

It is marked by joining the following three points.
(a) A point 1 cm lateral to the biceps tendon at the level of the lateral epicondyle (Fig. 8.21).
(b) The second point at the junction of the upper 1/3 and lower 2/3 of a line joining the middle of the posterior aspect of the head of the radius to the dorsal tubercle at the lower end of the radius or Lister's tubercle (Fig. 9.48).
(c) The third point on the back of the wrist 1 cm medial to the dorsal tubercle.

THE JOINTS

Shoulder Joint

The anterior margin of the glenoid cavity corresponds to the lower half of the shoulder joint. It is marked by a line 3 cm long drawn downwards from a point just

lateral to the tip of the coracoid process. The line is slightly concave laterally.

Elbow Joint

The joint line is situated 2 cm below the line joining the two epicondyles, and slopes downwards and medially. This slope is responsible for the carrying angle.

Wrist Joint

The joint line is concave downwards, and is marked by joining the styloid processes of the radius and ulna.

RETINACULA

Flexor Retinaculum

Flexor retinaculum is marked by joining the following four points.

  (i)   Pisiform bone (Fig. 9.18).
 (ii)   Tubercle of the scaphoid bone.
(iii)   Hook of the hamate bone.
 (iv)   Crest of the trapezium.

The upper border is obtained by joining the first and second points, and the lower border by joining the third and fourth points. The upper border is concave upwards, and the lower border is concave downwards.

Extensor Retinaculum

Extensor retinaculum is an oblique band directed downwards and medially, and is about 2 cm broad (vertically). Laterally, it is attached to the lower salient part of the anterior border of the radius, and medially to the medial side of the carpus (pisiform and triquetral bones) and to the styloid process of the ulna (Fig. 9.43).

SYNOVIAL SHEATHS OF THE FLEXOR TENDONS

Common Flexor Synovial Sheath (Ulnar Bursa)

Above the flexor retinaculum (or lower transverse crease of the wrist) it extends into the forearm for about 2.5 cm. Here its medial border corresponds to the lateral edge of the tendon of the flexor carpi ulnaris, and its lateral border corresponds roughly to the tendon of the palmaris longus.

Ulnar bursa becomes narrower behind the flexor retinaculum, and broadens out below it.

Most of it terminates at the level of the upper transverse creases of the palm, but the medial part is continued up to the distal transverse crease of the little finger.

Synovial Sheaths for the Tendon of Flexor Pollicis ^ Longus (Radial Bursa)

Radial bursa is a narrow tube which is coextensive I with the ulnar bursa in the forearm and wrist. Belo™ the flexor retinaculum it is continued into the thumbH up to its distal crease.

Digital Synovial Sheaths

The synovial sheaths of the flexor tendons of the index, middle and ring fingers extend from the necks I of the metacarpal bones (corresponding roughly to I the lower transverse crease of the palm) to the bases of the terminal phalanges.

RADIOLOGICAL ANATOMY OF UPPER LIMB J

General Remarks

In the case of the limbs plain radiography is mainly I required. For complete information it is always I advisable to have anteroposterior (AP) as well as I lateral views; and as far as possible radiographs of I the opposite limb should be available for comparison. I The skeleton, owing to its high radiopacity, forms the I most striking feature in plain skiagrams. In general the following information can be obtained from plain I skiagrams of the limbs.

1. *Fractures* are seen as breaks in the surface I continuity of the bone. A fracture line is usually irregular and asymmetrical. An epiphyseal line of an incompletely ossified bone, seen as a gap, should not ! be mistaken for a fracture: it has regular margins, and is bilaterally symmetrical. Supernumerary or | accessory bones are also symmetrical.

2. *Dislocations* are seen as deranged or distorted I relations between the articular bony surfaces forming a joint.

1. Below the age of 25 years the age of a person can be determined from the knowledge of ossification of the bones.

2. Certain *deficiency diseases* like rickets and scurvy can be diagnosed.

3. *Infections* (osteomyelitis) and growths (osteoma, osteoclastoma, osteosarcoma, etc.) can be diagnosed. A localized rarefaction of a bone may indicate an infection.

4. *Congenital absence or fusion* of bones can be seen.

Reading Plain Skiagrams of Limbs

1. Identify the view of the picture, anteroposterior (AP) or lateral. Each view shows a specific shape and arrangement of the bones.

2. Identify all the bones and their different parts visible in the given radiogram. Normal overlappings and 'end-on' appearances of bones in different views should be carefully studied.

3. Study the normal relations of the bones forming joints. The articular cartilage is radiolucent and does not cast any shadow. The radiological 'joint space' indicates the size of the articular cartilages. Normally tile joint space is about 2-5 mm in adults.

4. Study the various epiphyses visible in young bones and try to determine the age of the person concerned.

The Shoulder

A. The following are seen in an AP view of the shoulder (Fig. 11. 1A and B).

L *The* upper end of *the* humerus, including the head; greater and lesser tuberosities and infer tubercular sulcus.
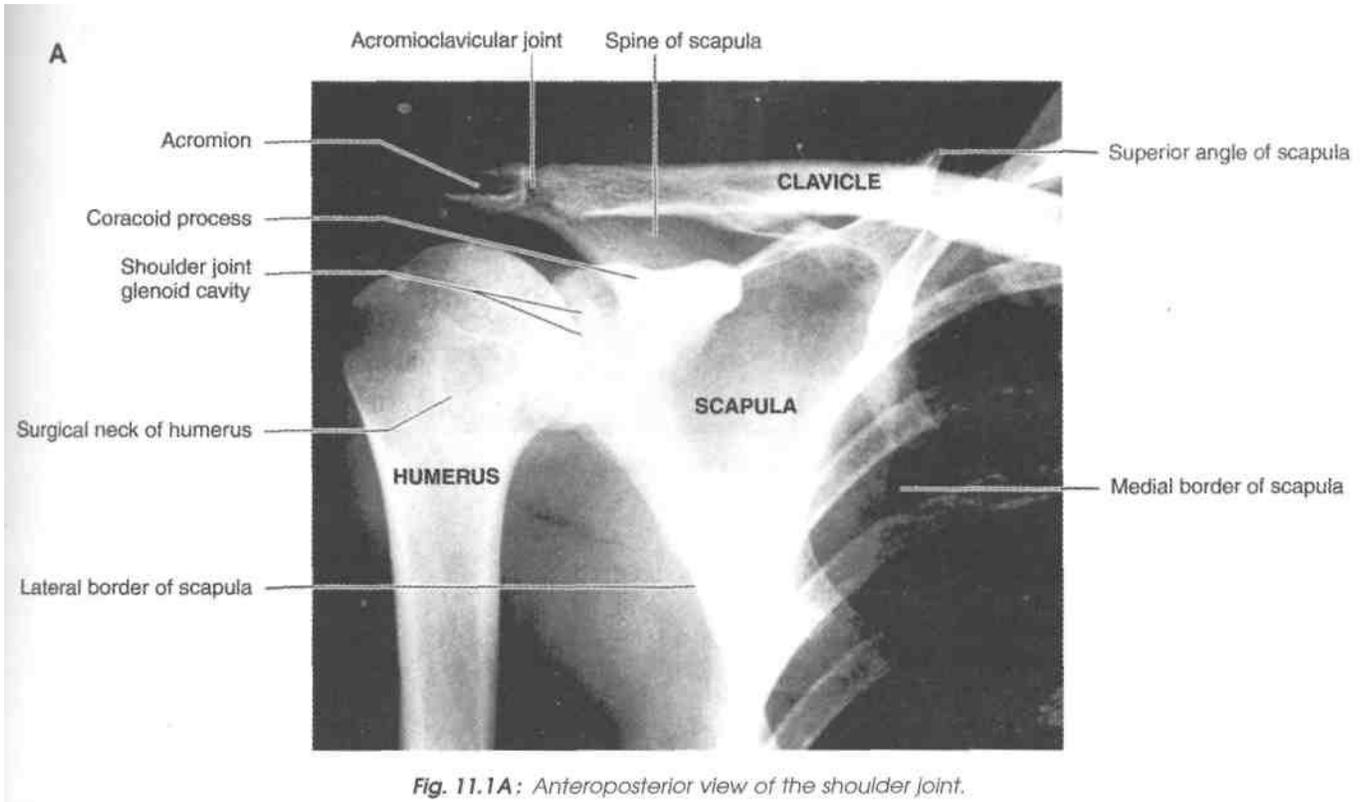
Fig. 11.1A: *Anteroposterior view of the shoulder joint.*

Acromioclavicular joint
Spine of scapula
Acromion
Superior angle of scapula
CLAVICLE
Coracoid process
Shoulder joint glenoid cavity
SCAPULA
Surgical neck of humerus
Medial border of scapula
HUMERUS
Lateral border of scapula
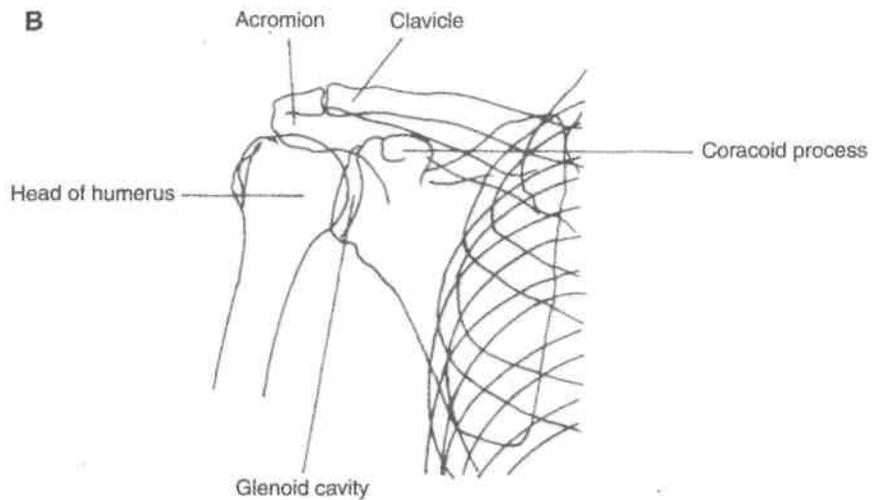
Fig. 11.1B: *Line drawing of Fig. 11.1A.*

Acromion
Clavicle
Coracoid process
Head of humerus
Glenoid cavity

A

Lateral supracondylar ridge

Lateral epicondyle

Fig. 11.2A: Anteropo

B

Humerus

Medial epicondyle

Olecranon

Lateral epicondyle

Head

Tuberosity

Radius

Ulna
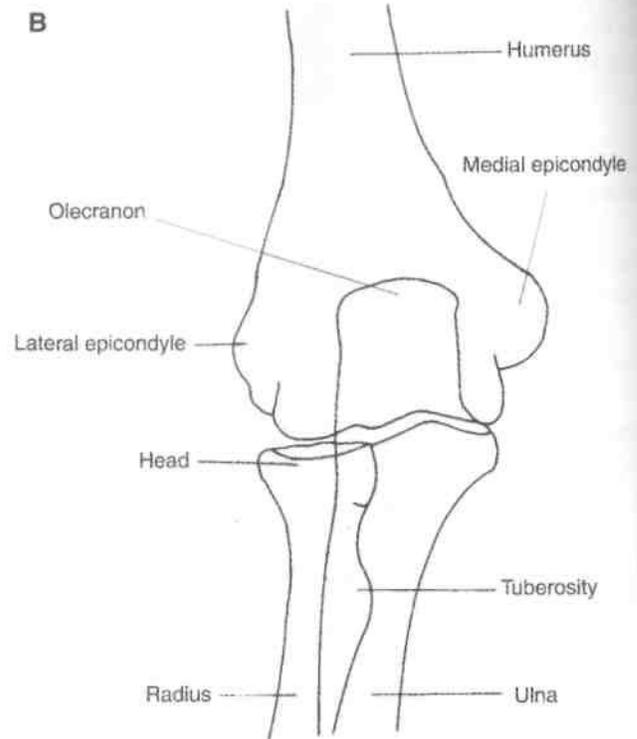
Fig. 11.2B: Line drawing of Fig. 11.2A.

1. The scapula, including the glenoid cavity, coracoid (seen end-on), acromion, the lateral, medial and superior borders, and the superior and inferior angles. The suprascapular notch may be seen.

2. The clavicle, except for its medial end.

3. Upper part of the thoracic cage, including the upper ribs.

B. Study the normal appearance of the following joints.

1. *Shoulder Joint.* The glenoid cavity articulates only with the lower half of the head of the humerus (when the arm is in the anatomical position). The upper part of the head lies beneath the acromion process. The greater tuberosity forms the lateral most bony point in the shoulder region.

2. Acromioclavicular joint.

C. Note the epiphyses if any, and determine the age with the help of ossifications described with individual bones.

The Elbow

A. Identify the following bones in an AP and lateral views of the elbow (Figs 11.2A and B, 11.3A and B).

The lower end of the humerus, including the medial and lateral epicondyles, the medial and lateral supracondylar ridges, the trochlea, the capitulum and the olecranon fossa.

A

Head of radius   Radial tuberosity

Trochlea   Olecranon   Superior radioulnar joint
            process
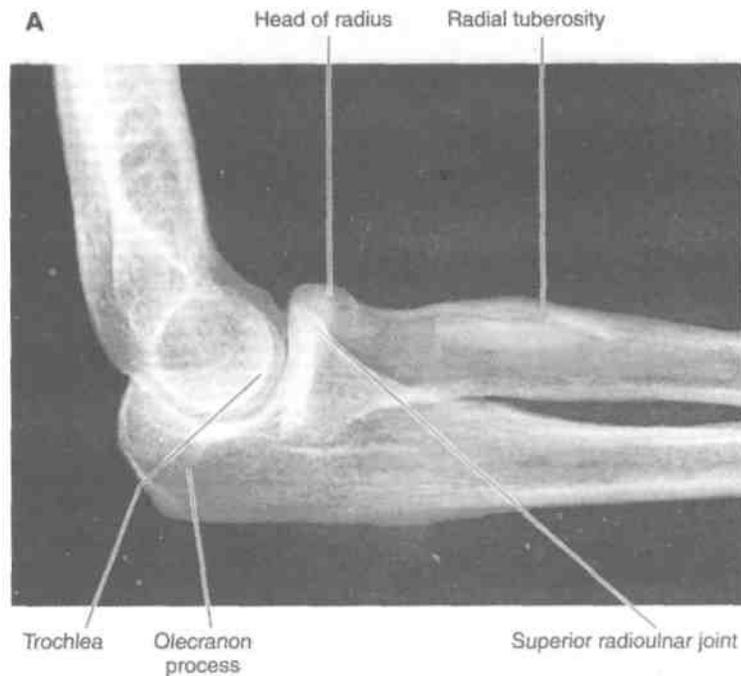
Fig. 11.3A: *Lateral view of the elbow joint.*

B

— Humerus

Medial epicondyle —

— Radius
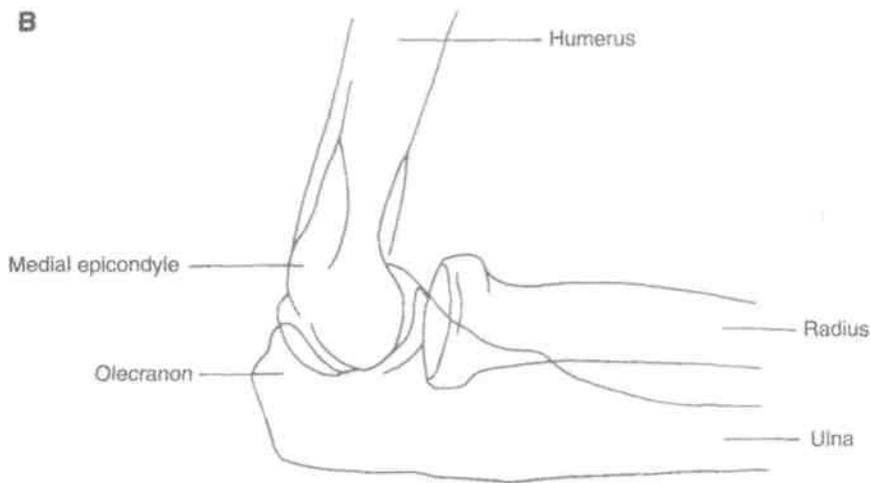
Olecranon —

— Ulna

Fig. 11.3B: *Line drawing of Fig. 11.3A.*

2. The upper end of the ulna, including the olecranon and coronoid processes.

3. The upper end of the radius including its head, neck and tuberosity.

n oi ɹ ii_   i   ,,, f,, . ,

B. Study the normal appearance ol the following joints in AP view.

  1 Elbow joint

  2. Superior radioulnar joint.

C. Note the olecranon and coronoid processes in a lateral view of the elbow

D. Note the epiphyses (if any) and determine the age with the help of ossifications described with individual bones.

The Hand

  , . , . ,,   .   . _ , .

A. Identify the following bones in an AP skiagram ,p.   11 4A and B)

  1. The lower end of the radius with its styloid

                                               ɹ

"

  2. The lower end of the ulna with its styloid

pi ~-

3. The eight carpal bones. Note the overlapping of the triquetral and pisiform bones; and of the trapezium with the trapezoid. Also identify the tubercle of the scaphoid and the hook of the hamate,

4. The five metacarpal bones.

A
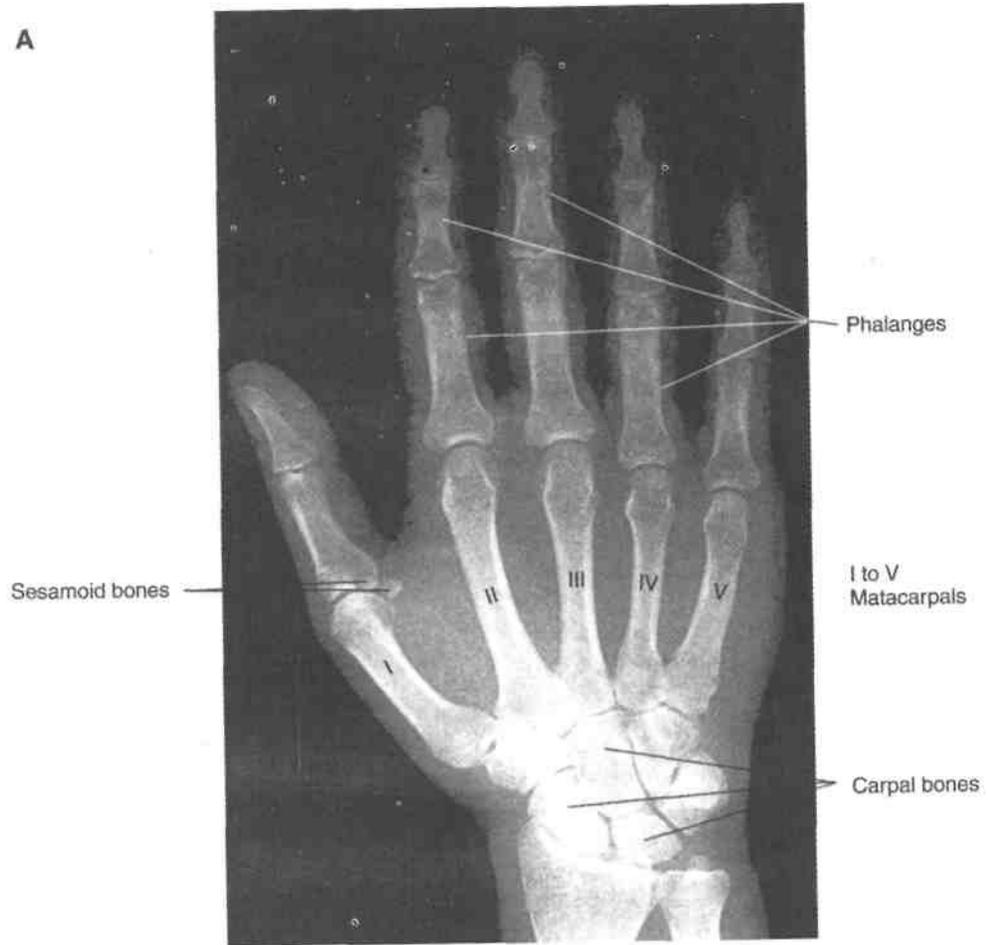
Fig. 11.4A: Anteroposterior view of the hand.

Phalanges

Sesamoid bones

I to V
Matacarpals

I   II   III   IV   V

Carpal bones

B

Distal phalanges

Middle phalanges

Proximal phalanges

Sesamoid bones

Metacarpals
Capitate
Hamate
Pisiform
Triquetral
Lunate

Trapezoid

Trapezium

Scaphoid

Radius

Ulna
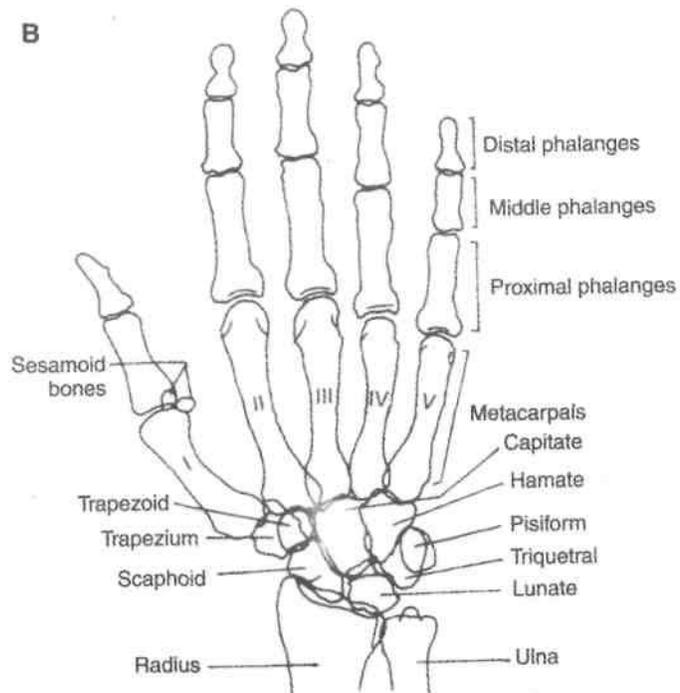
Fig. 11.4B: Line drawing of Fig. 11.4A.

1.The fourteen phalanges.

2.The sesamoid bones present in relation to the thumb, and occasionally in relation to the other fingers.

B. Study the normal appearance of these joints.

1.The wrist joint.

2.The inferior radioulnar joint.

3.The intercarpal, carpometacarpal, metacarpophalangeal and interphalangeal joints.

C. Note the following bones in a lateral skiagram.

1.Lunate.

2.Scaphoid.

3.Capitate.

4.Trapezium.

D. Note the epiphyses and other incomplete ossifications, and determine the age with the help of ossifications described with individual bones.

SYMPATHETIC INNERVATION_____

1.Sympathetic nerves for the upper limb are derived from spinal segments T2 to T6. Most of the vasoconstrictor fibres supplying the arteries emerge from the segments T2 and T3. The preganglionic fibres arise from lateral horn cells and emerge from the spinal cord through ventral nerve roots. Passing through white rami communicans they reach the sympathetic chain. They ascend within the chain and end mostly in the cervicothoracic (stellate) ganglion.

2.Postganglionic fibres arise in the cervicothoracic ganglion. They pass through grey rami communicans to reach the nerve roots forming the brachial plexus.

3.The arteries of skeletal muscles are dilated by sympathetic activity. For the skin, however, these nerves are vasomotor, sudomotor and pilomotor.

4.Sympathetic denervation of the upper limb is done in conditions of vascular spasm Raynaud's disease, or in organic arterial disease where spasm is also present. Arteries of the upper limb can be denervated surgically by cutting the sympathetic chain below the third thoracic ganglion, severing the rami communicans connected with the second and third thoracic ganglia, or cutting intradurally the ventral roots of the second and third thoracic spinal nerves. The white ramus to the cervicothoracic ganglion is not cut, partly because its distribution to the upper limb is negligible, but mainly because this avoids Horner's syndrome.

THE UPPER LIMB   ~

1.The upper limb bud appears on the ventrolateral aspect of body wall opposite the lower cervical segments at the end of the fourth week of embryonic life. The development of the upper limb precedes that of the lower limb by a few days.

2.Most investigators believe that the muscles of the upper limb develop *in situ* from the local mesoderm, and do not receive any contribution from the somites.

3.Early in the seventh week the upper limb bud rotates laterally through 90 degrees along its longitudinal axis so that the preaxial (radial) border faces laterally.

4.The axial artery of the upper limb develops from the seventh cervical intersegmental artery. In adults it persists as the axillary, brachial, anterior interosseous arteries and as deep palmar arch. The other arteries of the limb are secondary outgrowths from the axial artery.

DEVELOPMENT OF SKIN, MUSCLES, VERTEBRAE
_____AND RIBS_____

By third week of intrauterine life, the para-axial mesoderm on either side of notochord gets segmented to form somites. Each somite gets divided into two parts — dermomyotome and sclerotome.

Dermomyotome forms dermis of skin and its myotome component gets divided into epimere and hypomere. Epimere forms the muscles innvervated by dorsal primary rami, while hypomere forms the muscles innervated by ventral primary rami.

Muscles of head and neck are branchial in origin. Muscles of back develop from epimere, muscles of trunk or body develop from hypomere, muscles of limb develop *in situ.*

Skin: Epidermis, hair follicles, sweat and sebaceous glands develop from ectoderm; dermis is formed from dermomyotome.

Sclerotome: Cells of sclerotome proliferate: i. Ventrolaterally, to form transverse processes of vertebra. In the thoracic
  region, its costal element portion enlarges to form the ribs;

 ii. Dorsally, to surround the spinal cord and forms the pedicles, laminae and spine;

 iii. Ventromedially, to surround the notochord.

The segments are separated by intersegmental mesenchyme. Each segment is subdivided into a cranial and a caudal part, separated by loose mesenchyme.

Soon the caudal part of one segment fuses with the cranial part of adjacent lower segment including intersegmental mesenchyme to form the vertebral body.

Loose mesenchyme between cranial and caudal parts of the segments form the intervertebral disc (IVD). The notochord regresses from the region of the vertebral body, while it persists in the region of intervertebral disc to form the nucleus pulposus,! which forms the central part of IVD. Its peripheral part is formed by the annulus fibrosus. Nucleus pulposus may herniate posteriorly to press on the spinal nerve roots. The condition is called the 'slipped] disc'.

COMPARISON OF UPPER LIMB AND LOWER LIMB

	Upper Limb	Lower Limb
General	The upper limb is for range and variety of movements. Thumb assisted by palm and fingers has the power of holding articles.	Lower limb with long and heavy bones supports and stabilises the body,
	Upper limb bud rotates laterally, so that the thumb points laterally. Nerve supply-ventral rami of Cervical 5-8 and Thoracic 1 segments of spinal cord. Musculocutaneous, median and ulnar nerves supply the flexor aspects of the limb, while the radial nerve supplies the triceps brachii (extensor of elbow) and its branch the posterior interosseous supplies the extensors of wrist.	Lower limb bud rotates medially, so that big toe points medially. Nerve supply-ventral rami of lumbar 2-5 and sacral 1-3 segments of spinal cord. Sciatic and one of its terminal branch the tibial nerve supplies ■ the flexor aspect of the limb. The other terminal branchB of sciatic nerve, i.e. common peroneal, supplies the extensors of ankle joint (dorsiflexors) through its deep I peroneal branch. Its superficial branch supplies the peroneal muscles of the leg. Femoral supplies the quadriceps femoris (extensor of knee) while obturator nerve supplies the adductors.
	Arm	*Thigh*
Bones	Humerus is the longest bone of upper limb	Femur is the longest bone of lower limb and of the body.
Joints	Shoulder joint is multiaxial joint	Hip joint is also multiaxial joint
Muscles	Anteriorly: biceps, brachialis and coracobrachialis supplied by musculocutaneous nerve. Posteriorly: triceps brachii supplied by radial nerve	Posteriorly: Hamstrings supplied by sciatic, Anteriorly: Quadriceps by femoral Medially: Adductors by obturator nerve.
Nerves	Musculocutaneous for anterior compartment of arm. Radial for posterior compartment. Coracobrachialis equivalent to medial compartment of arm also supplied by musculocutaneous nerve.	Sciatic for posterior compartment of thigh, femoral for > anterior compartment of thigh, obturator for adductor muscles of medial compartment of thigh,
Branches	Muscular, cutaneous, articular/genicular, vascular and terminal branches	Same
Arteries	Axillary, brachial, profunda (deep) brachii	Femoral, popliteal and profunda femoris (deep).
	Forearm	*Leg*
Bones	Radius: preaxial bone Ulna: postaxial bone	Tibia: preaxial bone Fibula: postaxial bone
Joints	Elbow joint formed by humerus, radius and ulna, communicates with superior radioulnar joint. Forearm is characterised by superior and inferior radioulnar joints. These are both pivot variety of synovial joints permitting rotatory movements of pronation and supination, e.g. meant for picking up food and putting it in the mouth.	Knee joint formed by femur, tibia and patella. Fibula does not participate in knee joint. An additional bone (sesamoid) patella makes its appearance. This is an *important weight-bearing joint.*

	Upper Limb	Lower Limb
Muscles	Palmaris longus Flexor digitorum profundus Flexor pollicis longus Flexor digitorum superficial Flexor carpi ulnaris Flexor carpi radialis Abductor pollicis longus Extensor digitorum Extensor pollicis longus Anterior aspect: Flexors of wrist and digits and pronators of forearm Posterior aspect: Extensors of wrist and digits and supinator.	Plantaris Flexor digitorum longus Flexor hallucis longus Soleus and flexor digitorum brevis Gastrocnemius (medial head) Gastrocnemius (lateral head) Tibialis anterior Extensor digitorum longus Extensor hallucis longus Anterior aspect: Dorsiflexors of ankle joint Posterior aspect: Plantar flexors (flexors) of ankle joint. Lateral aspect: Evertors of subtalar joint.
Nerves	Median nerve for $6V2$ muscles and ulnar nerve for $1^{1}/2$ muscles of anterior aspect of forearm. These are flexors of wrist and pronators of forearm. Posterior interosseous nerve or deep branch of radial supplies the extensors of the wrist and the supinator muscles of forearm. It winds around radius (preaxial bone) and corresponds to deep peroneal nerve. The superficial branch of radial nerve corresponds to the superficial peroneal nerve.	Tibial nerve for all the plantar flexors of the ankle joint. Common peroneal winds around neck of fibula (postaxial bone) and divides into superficial and deep branches. The deep peroneal supplies dorsiflexors (extensors) of the ankle joint. The superficial peroneal nerve supplies a separate lateral compartment of leg.
Arteries	Brachial divides into radial and ulnar branches in the cubital fossa. Radial corresponds to anterior tibial artery.	Popliteal divides into anterior tibial and posterior tibial in the popliteal fossa. Posterior tibial corresponds to ulnar artery.
	Hand	Foot
Bones and Joints	There are 8 small carpal bones occupying very small area of the hand. First carpometacarpal joint, i.e. joint between trapezium and base of 1st metacarpal is a unique joint. It is of saddle variety and permits a versatile movement of opposition in addition to other movements. This permits the hand to hold things, e.g. doll, pencil, food, bat, etc. Opponens pollicis is specially for opposition.	7 big tarsal bones occupying half of the foot. There are special joints between talus, calcaneus and navicular, i.e. subtalar and talocalcaneonavicular joints. They permit the movements of inversion and and eversion (raising the medial border/lateral border of the foot) for walking on the uneven surfaces. This movement of inversion is similar to supination and of eversion to pronation of forearm. Flexor digitorum accessorius is distinct muscle to straighten the action of flexor digitorum longus tendons in line with the toes on which these act. Tibialis anterior and tibialis posterior and peroneus longus reach the sole for the movements of inversion (first two) and eversion (last one) respectively.
Nerves	Median nerve supplies 5 muscles of hand including 1st and 2nd lumbricals (abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, 1st and 2nd lumbricals). Ulnar nerve corresponds to lateral plantar nerve and supplies 15 intrinsic muscles of the hand.	Medial plantar supplies four muscles of the sole including 1st lumbrical (abductor hallucis, flexor hallucis brevis, flexor digitorum brevis, 1st lumbrical). Lateral plantar corresponds to ulnar nerve and supplies 14 intrinsic muscles of the sole
Muscles	Muscles which enter the palm from forearm, e.g. flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus are supplied by the nerves of the forearm. 1st and 2nd lumbricals are unipennate and are supplied by median nerve. 3rd and 4th are bipennate being supplied by deep branch of ulnar nerve.	Muscles which enter the sole from the leg, e.g. flexor digitorum longus, flexor hallucis longus, tibialis posterior, peroneus longus are supplied by the nerves of the leg. 1st lumbrical is unipennate and is supplied by medial plantar, 2nd-4th are bipennate being supplied by deep branch of lateral plantar nerve.
Blood vessels	No muscle on dorsum of hand. Radial artery corresponds to anterior tibial while ulnar artery corresponds to posterior tibial artery. Ulnar artery divides into superficial and deep branches. There	Extensor digitorum brevis present on dorsum of foot. Posterior tibial artery divides into medial plantar and lateral plantar branches. There is only one arch, the plantar arch formed by lateral plantar and dorsalis

	Upper Limb	*Lower Limb*
	are two palmar arches, superficial and deep. The superficial arch mainly is formed by ulnar artery and deep arch is formed mainly by the radial artery.	pedis (continuation of anterior tibial) arteries,
	Cephalic vein is along the preaxial border	Corresponding vein is great saphenous vein with perforators.
	Basilic vein runs along the postaxial border of the limb and terminates in the middle of the arm.	Corresponding vein is short saphenous vein, but it terminates in the popliteal fossa
Axis	The axis of movement of adduction and abduction is through the third digit or middle finger. So the middle finger has two dorsal interossei muscles.	The axis passes through the 2nd digit. So 2nd toe possesses two dorsal interossei muscles,
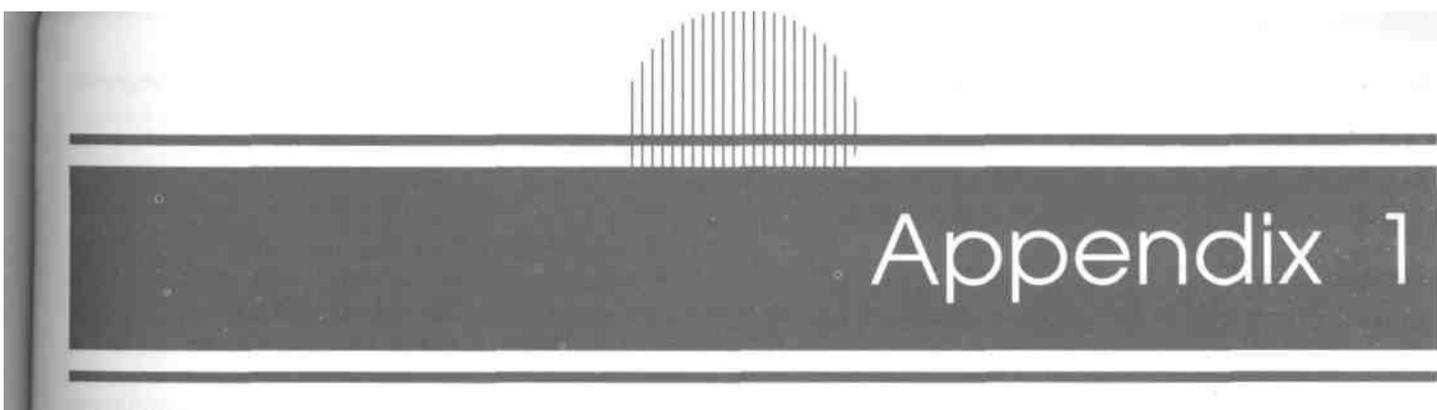
Since nerves are the most important and precious component of our body, this appendix has been dedicated to the nerves of the upper limb. Most of the nerves course through different regions of the upper limb and have been described in parts in the respective regions. In this appendix, the course of the entire nerve from origin to its termination including the branches and clinical aspects has been described briefly.

A brief account of histological features of skin, skeletal muscle, cartilage, bone, blood vessel, peripheral nerve, and ganglia has also been included.

Five sample clinicoanatomical problems have been given to get an insight into the patient's problems. In addition, twenty sample multiple choice questions (MCQs) have been put here, for revision of the subject studied.

NERVES OF THE UPPER LIMB

BRACHIAL PLEXUS

Brachial plexus is the plexus formed by ventral rami of C5,6,7,8 and Tl nerves (Fig. 4.7). These rami or roots unite, divide, unite again and divide so that most of the muscles get nerve supply more than one root. Also each branch of brachial plexus gets formed by one, two, three or more roots/rami. So, damage to one root will not cause paralysis of one muscle. These nerve roots carry motor, sensory and sympathetic fibres to the skin and muscles supplied by them. The nerve roots receive sympathetic fibres from middle and inferior cervical and first thoracic ganglia.

A. *Five Ventral Rami C5, C6, C7, C8 and Tl form Brachial Plexus*

Branches from Rami

1. Dorsal scapular or nerve to rhomboideus is given off from C5 for rhomboideus major and rhomboideus minor, responsible for retraction of the scapula.

2. Long thoracic from C 6, 7, 8 for serratus anterior. Paralysis of the nerve leads to 'winging of scapula' when protraction is attempted (Fig. 4.10).

B. Ventral Rami of C5 and 6 Join to form Upper Trunk, Ventcal Ramus of C7 Remains Single to form Middle Trunk; Ventral Rami of C8 and Tl Join to form Lower Trunk

Branches of Upper Trunk

1.Suprascapular nerve for supraspinatus and infraspinatus.
2.Nerve to subclavius for subclavius and a root to phrenic nerve.

C. Each Trunk Divides into Dorsal and Ventral Divisions

Thus there are three ventral divisions for ventral aspect and three dorsal divisions for dorsal aspect of the limb.

D & E. Cords and their Branches

Ventral divisions of upper and middle trunks join to form lateral cord.

Branches of Lateral Cord

1.Lateral pectoral nerve for pectoralis major and minor.
2.Musculocutaneous nerve for coracobrachialis, two heads of biceps brachii and brachialis.
3.Lateral root of median nerve joins with its medial root to form median nerve.

Ventral Division of Lower Trunk Remains Single and forms Medial Cord

Branches of Medial Cord:

1.Medial pectoral nerve for pectoralis major and minor.
2.Medial cutaneous nerve of arm.
3.Medial cutaneous nerve of forearm.

1.Medial root of median j oins with the lateral root to form median nerve for six and a half muscles of forearm and five muscles of lateral side of palm.

2.Ulnar nerve supplies one and a half muscles of forearm and 15 intrinsic muscles of palm.

Posterior Cord

Dorsal divisions of upper, middle and lower trunks join together to form *posterior cord.*

Branches of Posterior Cord:

1.Upper subscapular for subscapularis, a multi-pennate muscle.

2.Thoracodorsal nerve for latissimus dorsi.

3.Lower subscapular for subscapularis and teres major.

4.Axillary nerve for deltoid and skin over the lower half of deltoid and teres minor. $_m$

5.Radial nerve for extensors of elbow, wrist, metacarpophalangeal joints and supinator.

Thus a total of 17 branches are given off from the plexus, including 2 from roots, 2 from trunks and 13 from cords.

Erb's Paralysis

Erb's point is the segment where C5 and C6 roots join to form upper trunk, supracapsular and nerve to subclavius are given and ventral and dorsal divisions of upper trunk start (Fig. 4.8). In injury to this point, the abductors and lateral rotators of shoulder, flexors of elbow and supinators are paralysed. Arm hangs by the side. It is rotated medially extended at elbow joint, pronated at forearm, cutaneous loss on lateral side of arm and forearm, for example a policeman taking a tip (Fig. 4.9).

Klumpke's Paralysis

Damage to C8 and Tl segments is called Klumpke's paralysis. Small intrinsic muscles of hand are affected. It leads to 'complete claw hand', i.e. extension of metacarpophalangeal joints and flexion of inter-phalangeal joints, loss of sensation on medial side of forearm. If Tl is injured proximal to the white ramus communicans to first thoracic sympathetic ganglion, there is an associated Horner's syndrome. This is characterised by miosis or narrow pupil, partial ptosis or drooping of eyelid, enophthalmos or eye pushed inside the bony orbit and anhidrosis or absence of sweating on the side of lesion.

(MUSCULOCUTANEOUS NERVE

Musculocutaneous nerve is so named as it supplies I muscles of front of arm and skin of lateral side of forearm.'**)

Root value Ventral rami of C5, 6 and 7 segments I of spinal cord.

Course

Musculocutaneous nerve is a branch of the lateral cord of brachial plexus (Fig. 8.8), lies lateral to axillary and upper part of brachial artery. It supplies coracobrachialis pierces the muscle to lie in f intermuscular septum between biceps brachii ai brachialis muscles, both of which are supplied by | this nerve. At the crease of elbow it becomes cutaneous. The nerve is called the lateral cutaneous | nerve of forearm which supplies skin of lateral side | of forearm both on the front and back.

Branches

Muscular	Coracobrachialis, long head of biceps brachii, short head of biceps brachii, I and brachialis.
Cutaneous	Lateral side of forearm both on the front and the back.
Articular	Elbow joint.

AXILLARY OR CIRCUMFLEX NERVE   ~j

Axillary or circumflex nerve is called axillary as it runs through the upper part of axilla though it does not supply any structure there. It used to be called circumflex as it goes round the surgical neck of humerus (Figs 7.6, 8.12, 8.24).

Root value Ventral rami of C5,6 segments of spinal cord.

Course

Axillary or circumflex nerve is the smaller terminal branch of posterior cord (Fig. 4.7). It passes backwards through the quadrangular space (bounded by subscapularis above, teres major below, long head of triceps brachii medially and surgical neck of humerus laterally) (Fig. 7.11). Here it lies below the capsule of the shoulder joint. As it is about to pass behind the surgical neck of humerus it divides into an anterior and posterior divisions. Their branches are:

Branches of Axillary (or Circumflex) Nerve

The branches of axillary nerve are presented in Table **ALL**

*\ **Table fck-f: Branch s of axillary nerve**			
»	*Trunk*	*Anterior division*	*Posterior division*
Muscular	—	Deltoid (most part)	Deltoid (posterior part) and teres minor. The nerve to teres minor is characterised by the presence of a pseudoganglion
Cutaneous	—	—	Upper lateral cutaneous nerve of arm
Articular	Shoulder joint	—	

CLINICAL ANATOMY

Injury to axillary/circumflex nerve causes paralysis of deltoid muscle. There is flattening of the shoulder region.

Motor loss: Paralysis of deltoid muscle Active movement of abduction of shoulder from 15°- 90° is not possible.

Sensory loss: Loss of sensation over lower half of deltoid muscle.

RADIAL NERVE

Radial nerve is the thickest branch of brachial plexus. *Root value* Ventral rami of C5-C8, Tl segments of spinal cord (Fig. 4.7).

Course

Axilla: Radial nerve lies against the muscles forming the posterior wall of axilla, i.e. subscapularis, teres major and latissimus dorsi. It then lies in the lower triangular space between teres major, long head of triceps brachii and shaft of humerus. It gives two muscular and one cutaneous branch in the axilla (Fig. 8.24).

Radial Sulcus: Radial nerve enters through the lower triangular space into the radial sulcus, where it lies between the long and medial heads of triceps brachii along with profunda brachii vessels (Fig. 8.10). Long and lateral heads form the roof of the radial sulcus. It leaves the sulcus by piercing the lateral intermuscular septum. In the sulcus, it gives three muscular and two cutaneous branches (Fig. 8.12).

Front of Arm: Radial nerve enters the lower lateral part of arm and lies between brachialis on the medial side and brachioradialis with extensor carpi radialis longus on the lateral side. It supplies the latter two muscles and also brachialis (lateral part). Tne nerve descends deep in this interval to reach the lateral epicondyle, where it ends by dividing into its two

terminal branches—the superficial and deep or posterior interosseous branches (Figs 8.16, 9.14).

Posterior interosseous branch: Lies in the lateral part of cubital fossa, where it supplies extensor carpi radialis brevis and supinator muscles. Then it enters into the back of forearm by passing through supinator muscle. There the nerve supplies abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor digitorum, extensor indicis, extensor digiti minimi and extensor carpi ulnaris. It ends in a pseudoganglion branches of which supply the wrist joint (Fig. 9.50).

Superficial branch: Is given off in the cubital fossa and runs on the lateral side of forearm accompanied by radial artery in the upper two-thirds of forearm (Fig. 9.13). Then it bends posteriorly to supply the lateral half of dorsum of hand and lateral two and a half digits till distal interphalangeal joints. Its branches cross over the anatomical snuff box (Fig. 9.31).

Branches of Radial Nerve

The branches of radial nerve are presented in Table Al.2.

CLINICAL ANATOMY

Radial nerve may be injured in radial groove during fracture of humerus of that region. It may also be damaged by improper use of the crutch, or 'Saturday night palsy' If it is injured in axilla there is complete loss of active extension of elbow joint as all branches to triceps get paralysed. In addition, it will lead to wrist drop (Fig. 9.47).

If it is injured in the radial sulcus, there is weakness of elbow extension with wrist drop. If it is injured at level of lateral epicondyle, the extension ' of elbow is normal but there is wrist drop.

Wrtet -Arog, TMsams, inafoyifrj ti extejad the. wrist and metacarpophalangeal joints. The joints of fingers can be extended by interossei and

Table A1.2: Branches of radial nerve

	Axilla	*Radial sulcus*		*Lateral side of arm*
Muscular	Long head of triceps Medial head of triceps	Lateral head Medial head		Brachioradialis Extensor carpi radialis longus Lateral part of brachialis (proprioceptive)
Cutaneous				
Cutaneous		Posterior cutaneous nerve of arm	Posterior cutaneous nerve of forearm Lower lateral cutaneous nerve of arm	
Vascular			To profunda brachii artery	
Terminal				Superficial and deep or posterior interosseous branches

lumbricals. The sensory loss is minimal, as there is quite a lot of overlapping of cutaneous branches. There are no articular loss or vasomotor changes. Trophic changes are seen in long-standing cases in the muscles of back of arm and back of forearm.

<h1 style="text-align:center">MEDIAN NERVE</h1>

Median nerve is called median as it runs in th< median plane of the forearm.

Root Value

Ventral rami of C5-C8, Tl segments of spinal cord

Course

In axilla: Median nerve is formed by two roots lateral root from lateral cord and medial root fron medial cord of brachial plexus. Medial root crosses the axillary artery to join the lateral root. The mediar nerve runs on the lateral side of axillary artery (Fig 8.10).

In arm: Median nerve continues to run on th(lateral side of brachial artery till the middle of arm where it crosses in front of the artery, passes anterio: to elbow joint into the forearm (Fig. 8.17).

In forearm: Median nerve passes through cubita fossa, leaves it between two heads of pronator teres then deep to fibrous arch of flexor digitorun superficialis. Adheres to deep surface of the muscle leaves the muscle, along its lateral border. Lastly i is placed deep to palmaris longus to enter pain under the flexor retinaculum. It gives plenty o branches in cubital fossa and forearm.

In Palm: Median nerve lies medial to the muscles of thenar eminence, which it supplies. It also gives cutaneous branches to lateral three and a half digits and their nail beds and skin of distal phalanges on dorsum (Fig. 2.31).

Branches of Median Nerve

The branches of median nerve are presented in Table Al.3.

<h4 style="text-align:center">CLINICAL ANATOMY</h4>

Usually median nerve is injured above the elbow. If it is injured, muscles supplied by it in cubital fossa, forearm and hand are paralysed.

Motor loss: Four and a half flexors of forearm and two pronators of forearm leading to 'pointing index finger'; of thenar eminence muscles and 1st and 2nd lumbricals. These muscles are responsible for the gross movements of fingers. So, it is called labourer's nerve.

Cutaneous loss: Lateral two-thirds of palm, loss of sensation on lateral three and a half digits including dorsum of distal phalanges.

Articular loss: Joints of lateral three digits.

Vasomotor changes: Oedema, pigmentation of skin, nails get friable and dryness of skin.

Trophic changes: Flattening of forearm muscles except the medial side. Flattening of thenar eminence leading to ape-like hand. Ulcers on the tips of lateral three and a half digits.

Carpal Tunnel Syndrome

Carpal tunnel syndrome is the commonest condition affecting this nerve. There is flattening

Table A1.3: Branches of median nerve

	Axilla and arm	*Cubital fossa*	*Forearm*	*Hand*
Muscular	Pronator teres in lower part of arm	Flexor carpi radialis, flexor digitorum superficialis, palmaris longus	Anterior interosseous which supplies: lateral half of flexor digitorum profundus, pronator quadratus, and flexor pollicis longus	Recurrent branch for abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, 1st lumbrical and 2nd lumbrical (Fig. 9.21)
	Cutaneous		Palmar cutaneous branch for lateral two-thirds of palm	Two digital branches to thumb, one to lateral side of index finger. Two to adjacent sides of index and middle fingers, two to adjacent sides middle and ring fingers. These branches also supply dorsal aspects of distal phalanges of lateral three and a half digits.
	Articular and vascular	Brachial artery	Elbow joint	Give vascular and articular branches to joints of hand.

in

of thenar eminence (ape-like hand), loss of sensation over three and a half lateral digits and partial clawing of index and middle fingers due to paralysis of 1st and 2nd lumbricals. The skin of the palm retains its sensations as palmar cutaneous branch is given off above the flexor retinaculum and it passes superficial to it. There is oedema, pigmentation and dryness of skin with friable nails over lateral three and a half digits.

<div align="center">

ULNAR NERVE

</div>

Ulnar nerve is named so as it runs along the media] or ulnar side of the upper limb.

Root value Ventral rami of C8 and Tl. It also manages fibres from C7 from the lateral root oi median nerve (Fig. 4.7).

Course

Axilla: Ulnar nerve lies in the axilla between the axillary vein and axillary artery on a deeper plane, Runs downwards with the brachial artery in its proximal part (Fig. 8.10). At the middle of humerus it pierces the medial intermuscular septum to lie on its back and descends on the back of media] epicondyle, where it can be palpated. Palpation causes tingling sensations (Fig. 8.12).

Forearm: Ulnar nerve enters the forearm bj passing between two heads of flexor carpi ulnaris.

There it lies on medial part of flexor digitorum profundus. It gets the company of ulnar artery in lower two-thirds of forearm (Fig. 9.13). It gives two muscular and two cutaneous branches. Finally it lies to the medial part of flexor retinaculum to enter palm. At the distal border of retinaculum the nerve divides into its superficial and deep branches (Figs 9.32, 9.33).

Palm: Superficial branch supplies palmaris brevis and digital branches to medial one and a half digits. Deep branch supplies most of the intrinsic muscles of the hand. At first it supplies three muscles of hypothenar eminence, running in the concavity of deep palmar arch it gives branches to 4th and 3rd lumbricals, 4,3,2,1 dorsal interossei and 4,3,2,1 palmar interossei to end in adductor pollicis, Since it supplies intrinsic muscles of hand responsible for finer movements, this nerve is called 'musicians nerve' (Fig 9.21).

Branches of the Ulnar Nerve

The branches of ulnar nerve are presented in Table Al.4.

<div align="center">

CLINICAL ANATOMY

</div>

Ulnar nerve is mostly injured at the wrist. It leads to motor loss of the muscles of palm mentioned above; sensory loss in the medial one and a half digits including nail beds, dorsum of distal phalanges.

Table A1.4: Branches of ulnar nerve

	Forearm	Hand (Fig. 9.21)
Muscular	Medial half of flexor digitorum profunds, flexor carpi ulnaris	Superficial branch; palmaris brevis. Deep branch-Hypothenar eminence muscles, medial two lumbricals, 4-1 dorsal and palmar interossei and adductor pollicis
Cutaneous/Digital	Dorsal cutaneous branch for medial half of dorsum of hand. Palmar cutaneous branch for medial one-third of palm.Digital branches to medial one and a half fingers, nail beds and dorsal distal phalanges	
Vascular/Articular	Also supplies digital vessels and joints of medial side of hand	

Vasomotor changes: Oedema, dry pigmented skin, friable nails.

Trophic changes: Loss of hypothenar eminence, prominence of metacarpal bones due to paralysis of interossei. Palm shows 'guttering' between the metacarpals.

Position: Partial clawing of hand with hyper-extension of metacarpophalangeal and flexion of interphalangeal joints. The clawing is less in index and middle fingers.

If ulnar nerve is injured at the elbow, the clawing of the fingers is less, because medial half of flexor digitorum profundus (flexor of proximal and distal interphalangeal joints) also gets paralysed. It is called 'action of paradox'.

If both ulnar and median nerves gets paralysed, there is complete claw-hand.

HISTOLOGICAL FEATURES

Skin

Skin is the outer garment of the body. It is of twc types: thick skin found in palm/sole, and thin oi hairy skin over the rest of the body. Histologically it is composed of: external layer the epidermis and ar inner layer, the dermis. The epithelium of epidermis is stratified squamous keratinised type, and comprises: (i) stratum basale, (ii) stratum spinosun (thick layer), (iii) stratum granulosum, (iv) stratun lucidum, and (v) stratum corneum. Dermis consists of outer papillary layer and inner or deeper reticulai layer. It contains capillaries, nerve endings, ducts oi sweat glands and hair follicle.

Appendages of skin are nail, hair, sebaceous glands arrector pili muscles and sweat glands.

Skeletal muscle: It is the most abundant type of muscle comprises about 40% of the body weight. The I muscle is surrounded all over by epimysium. Each muscle fasciculus is surrounded by perimysium and each fibre is covered by endomysium. Each muscle fibre or cell is a multinucleated cylinder, with alternate dark and light bands and peripheral multiple nuclei. These fibres are not attached to each other by cell junctions. These fibres do not branch.

Cartilage

Cartilage is a specialised dense tissue. It is seen in the respiratory system, pinna, ends of bones forming the joint. Cartilage is surrounded on outside by perichondrium, consisting of outer fibrous and inner vascular and chondrogenic layer. The cartilage is classified into three types: hyaline, elastic and fibrocartilage. Hyaline cartilage is found in nose, trachea, lungs. Chondrocytes are seen in groups of 2 or 4. Matrix surrounds the cells, fibres are invisible.

Elastic cartilage is found in pinna, epiglottis and arytenoid cartilage. The cartilage cells are singly placed. The matrix shows many elastic fibres.

White fibrocartilage is found in menisci of knee joint, intra-articular disc and annulus fibrosus of intervertebral discs. The chondrocytes are fewer and are arranged parallel to the fibre bundles. The matrix contains numerous thick collagen bundles.

Growth in the cartilage occurs from the peri-chondrium - the appositional growth. It also grows from within, called the interstitial growth.

Bone

Histologically the bone is of two types: compact seen in the shaft of bone, and cancellous seen at the end of bone deep to thin layer of compact bone.

The bone on the external surface is surrounded by the periosteum, made of outer fibrous and inner cellular layer with osteogenic cells.

The bony tissue is seen as lamellae. In compact bone, these are arranged around the whole circumference of bone beneath the periosteum. These are called 'circumferential lamellae'. Lamellae arranged around the Haversian canal are called 'Haversian lamellae' and lamellae in between the Haversian lamellae are called 'interstitial lamellae'. Between these lamellae are spaces or lacunae which house the osteocytes. The lacunae are connected to Haversian canal and other lacunae by canaliculi. This type of bone contains more bony tissue and less spaces. In spongy/cancellous/trabecular bone, the lamellae form plates which surround larger spaces filled with bone marrow.

Bone only grows by apposition from the surface.

Bloodvessels

Arteries and veins constitute blood vessel. Both these are made of three layers. These are tunica intima, tunica media and tunica adventitia from within outwards. The differences lie in the proportion of these layers.

Artery - Tunica intima comprises the squamous inner lining. Tunica media forms two-thirds of arterial wall and comprises smooth muscle fibres and elastic fibres.

Tunica adventitia forms outer one-third and is composed of collagen fibres.

Vein - Tunica intima comprises the squamous lining. Tunica media forms one-third of thickness of wall and is composed of muscle fibres and collagen fibres. Tunica adventitia forms two-thirds of thickness of the wall, formed chiefly of collagen fibres. The lumen of vein is mostly visible with red blood cell in it.

Peripheral Nerve

The whole nerve is covered by epineurium. The nerve bundles are covered by perineurium while each nerve fibre is surrounded by endoneurium. Deep to endoneurium lies the neurilemma forming the cell membrane of the process of neuron. Next to it is the thick myelin sheath with nodes. In the area of internode, Schwann cells are visible. Deep to myelin sheath is the single axon enclosed in the axolemma. Transverse section of nerve depicts axon, myelin and neurilemma.

Ganglia

Spinal ganglion or dorsal root ganglion shows collection of neurons and collection of nerve fibres in groups. Autonomic ganglion shows neurons and nerve fibres scattered.

CLINICOANATOMICAL PROBLEMS

1. A 50-year-old man fell off his bicycle. He heard a cracking noise and felt severe pain in his right shoulder region. He noted that the lateral part of the shoulder drooped and medial end of clavicle was elevated.

   Clinicoanatomical problems:
   ?Which is the common site of fracture of clavicle and why?
   ?Why did his shoulder droop down?

   Ans. The clavicle gets fractured at the junction of medial two-thirds and lateral one-third. This is the weak point as it lies at the junction of two opposing curvatures.

   The shoulder drooped down, because of the weight of the unsupported shoulder.

2. A young man practicing tennis complained of severe pain over lateral part of his right elbow. The pain was pin pointed over his lateral epicondyle.

   Clinicoanatomical problems:
   ?Why does pain occur over lateral epicondyle during tennis games?
   ?Which other games can cause similar pain?

   Ans. The pain is due to lateral epicondylitis also called tennis elbow. This is due to repeated microtrauma to the common extensor origin of extensor muscles of the forearm. It can also occur in swimming, gymnastics, baseball, golf, i.e. any sport which involves strenuous use of the extensors of the forearm.

3. A 55-year-old woman complained of abnormal sensations in her right thumb, index, middle and part of ring fingers. Her pain increased during night. There was weakness of her thumb movements.

   Clinicoanatomical problems:
   Which nerve was affected and where? Name the syndrome.

   Ans. Median nerve is affected while it travels deep to the flexor retinaculum. The syndrome is 'carpal tunnel syndrome'. There are abnormal sensation in lateral .three and a half digits, but there is no loss of sensation over lateral two- thirds of palm. The nerve supply of this area is from palmar cutaneous branch of median nerve which passes superficial to the flexor retinaculum.

4. A 70-year-old lady fell on her left forearm. She heard a crack in the wrist. There was swelling and a bend just proximal to wrist with lateral deviation of the hand.

    Clinicoanatomical problems:

    ?Which forearm bone is fractured?

    ?Reason of bend just proximal to wrist?

    ?Which joint can be subluxated?

    Ans. There is fracture of the distal end of radius. The backward bend just proximal to the wrist is due to the pull of extensor muscles on the distal segment of radius. The inferior radioulnar joint is usually subluxated.

5. A 45-year-old woman complained of a firm painless mass in the upper lateral quadrant of her left breast. The nipple was also raised. Axillary lymph nodes were palpable and firm. It was diagnosed as cancer breast.

    Clinicoanatomical problems:

    ?Where does the lymph from upper lateral quadrant drain?

    ?What causes the elevation of the nipple.

    Ans. The lymph from the upper lateral quadrant drains mainly into the pectoral group of axillary lymph nodes. The lymphatics also drain into supraclavicular and infraclavicular lymph nodes.

    Blockage of some lymph vessels by the cancer cells causes oedema of skin with dimpled appearance. This is called 'peau d'orange'. When cancer cells invade the suspensory ligaments, glandular tissue or the ducts, there is retraction of the nipple.

MULTIPLE CHOICE QUESTIONS

A. Select the best response:

1. The site of injury in Erb's paralysis is:
    a. Upper trunk of brachial plexus
    b. Lower trunk of brachial plexus
    c. Anterior division of lower trunk
    d. Posterior cord of brachial plexus

2. The lymphatics from the thumb and its web drain into the following group of axillary lymph nodes:
    a. Anterior
    b. Posterior
    c. Central
    d. Apical

3. The spinal segments which supply the small muscles of the hand are:
    a. C5, C6
    b. C6, C7
    c. C7, C8
    d. C8, Tl

4. The carpal tunnel contains all the following structures except:
    a. Median nerve
    b. Ulnar nerve
    c. Flexor pollicis longus tendon
    d. Flexor digitorum superficialis tendons.

5. The bone which develops by intramembranous ossification is:
    a. Humerus
    b. Scapula
    c. Clavicle
    d. Pisiform

6. The nerve which lies behind the medial epicondyle of humerus is:
    a. Musculocutaneous
    b. Ulnar
    c. Radial
    d. Median

7. Which of the following muscle is the flexor of distal interphalangeal joint
    a. Flexor digitorum superficialis
    b. Flexor digitorum profundus
    c. Lumbricals
    d. Palmar interossei

8. The important structures in the cubital fossa from medial to lateral are:
    a. Brachial artery, median nerve, tendon of biceps brachii and superficial branch of radial nerve
    b. Median nerve, tendon of biceps brachii, brachial artery and superficial branch of radial nerve.
    c. Median nerve, brachial artery, tendon oi biceps brachii, superficial branch of radial nerve.
    d. Median nerve, brachial artery, superficia branch of radial nerve and tendon of biceps brachii.

9. The most commonly used vein for blood sampling and intravenous injection is:
    a. Basilic vein
    b. Cephalic vein
    c. Axillary vein
    d. Median cubital vein

10. The supination and pronation movements of forearm take place at:
    a. Superior and inferior radioulnar joints.
    b. Elbow and superior radioulnar joints.
    c. Inferior radioulnar and wrist joints.
    d. Only superior radioulnar joint.

B. Match the following on the left side with their appropriate answers on the right side:

11. The nerve injury and the clinical signs:
    a. Radial nerve   i. Claw hand
    b. Median nerve   ii. Wrist drop
    c. Long thoracic nerve iii. Ape thumb
    d. Ulnar nerve   iv. Winging of scapula

12. Tendon reflexes and segmental innervation:
    a. Triceps   i. C5, C6, C7
    b. Biceps brachii   ii. C5, C6
    c. Brachioradialis   iii. C6, C7, C8

13. Muscles and the movements at shoulder joints:
    a. Supraspinatus   i. Medial rotation
    b. Subscapularis   ii. Lateral rotation
    c. Latissimus dorsi   iii. Abduction
    d. Teres minor   iv. Extension

14. Muscles and their nerve supply
    a. Deltoid   i. Ulnar
    b. Supinator   ii. Median
    c. 1st lumbrical   iii. Axillary
    d. Adductor pollicis   iv. Radial

15. Sensory innervation of skin
    a. Palmar surface of ring and   i. C3, C4
       little finger
    b. Palmar surface of thumb and   ii. C8
       index finger
    c. Medial aspect of arm   iii. T1,T2
    d. Tip of the shoulder   iv. C6

C. For each of the incomplete statements or questions below, one or more completions or answers given is/are correct. Select.
    A. If only 1, 2 and 3 are correct
    B. If only 1 and 3 are correct
    C. If only 2 and 4 are correct
    D. If only 4 is correct
    E. If all are correct

16. Injury to the median nerve in the arm would affect
    1. Pronation of the forearm
    2. Flexion of the wrist
    3. Flexion of the thumb
    4. Supination of the forearm

17. Which of the following is/are true regarding humerus?
    1. The head of the humerus commonly dislocates posteriorly.
    2. Common sites of fracture are surgical neck, shaft and supracondylar region
    3. Lower end is the growing end.
    4. Axillary, radial and ulnar nerves are directly related to the bone.

18. Clavicle
    1. Is a long bone
    2. Develops by intramembranous ossification
    3. Is the first bone to ossify
    4. Has a well-developed medullary cavity.

19. In Erb's paralysis.
    1. Abduction and lateral rotation of the arm are lost.
    2. Flexion and pronation of the forearm are lost
    3. Biceps and supinator jerks are lost
    4. Sensations are lost over the medial side of the arm.

20. Which of the following statements are true regarding 'mammary gland'.
    1. It is modified sweat gland
    2. Lies in superficial fascia
    3. 75% of the lymph from mammary gland drains into axillary lymph nodes
    4. Some lymphatic vessels communicate with the lymph vessels of opposite side.

Answers to Multiple Choice Questions

1. a
2. d
3. d
4. b
5. c
6. b
7. b
8. c
9. d
10. a
11. a-ii   b-iii   c-iv   d-i
12. a-iii   b-ii   c-i
13. a-iii   b-i   c-iv   d -li

14.a-iii   b-iv   c-ii   d - i   18. A

15.a-ii   b-iv   c-iii   d-i   19. B

16.A   20. E

17.C ,

12

Introduction to the Thorax
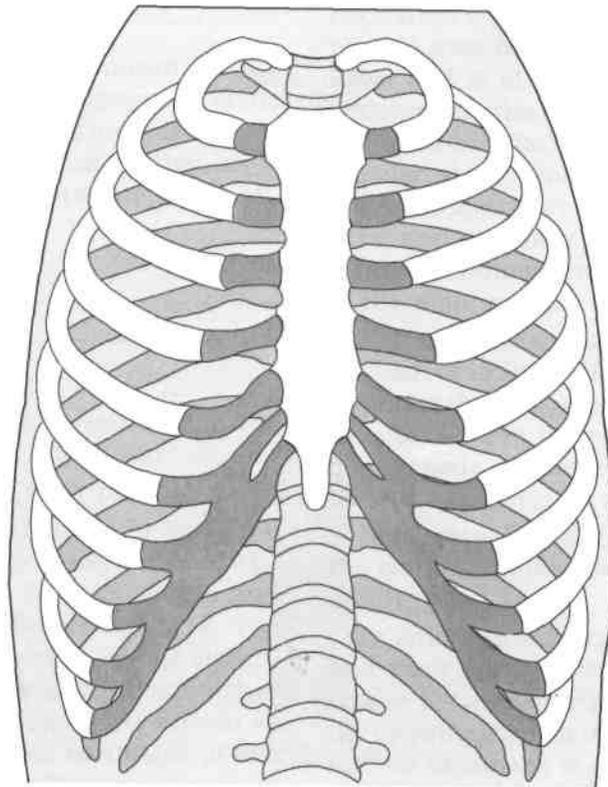
T^horax forms the upper part of the trunk of the body. It permits boarding and lodging of not only the thoracic viscera, but also provides necessary shelter to some of the abdominal viscera.

The trunk of the body is divided by the *diaphragm* into an upper part, called the *thorax,* and a lower part, called the *abdomen.* The thorax is supported by a skeletal framework, *thoracic cage.* The thoracic cavity contains the principal organs of respiration -the lungs and of circulation - the heart, both of which are vital for life.

THE SKELETON OF THE THORAX

The skeleton of the thorax is also known as the thoracic cage. It is an osseocartilaginous, elastic cage which is primarily designed for increasing and decreasing the intrathoracic pressure, so that air is sucked into the lungs during inspiration and expelled during expiration.

| FORMATION

Anteriorly by the sternum (Figs 12.1, 12.2).

Posteriorly by the 12 thoracic vertebrae and the intervening intervertebral discs (Fig. 12.3).

On each side by 12 ribs with their cartilages.

Each rib articulates posteriorly with the vertebral column. Anteriorly, only the upper seven ribs articulate with the sternum through their cartilages and these are called true or vertebrosternal ribs. The costal cartilages of the next three ribs, i.e. the eighth, ninth and tenth, end by joining the next higher costal cartilage. These ribs are, therefore, known as *vertebrochondral ribs.* The costal cartilages of the seventh, eighth, ninth and tenth ribs form the costal margin. The anterior ends of the eleventh and twelfth

ribs are free: these are called floating or vertebral ribs. The vertebrochondral and vertebral ribs, i.e. the last five ribs are also called false ribs because they do not articulate with the sternum.

The costovertebral, manubriosternal and chon-drosternal joints permit movements of the thoracic cage during breathing.

SHAPE ~~

The thorax resembles a truncated cone which is narrow above and broad below (Fig. 12.4). The narrow upper end is continuous with the root of the neck from which it is partly separated by the suprapleural membrane or Sibson's fascia. The broad or lower end is almost completely separated from the abdomen by the diaphragm which is deeply concave downwards. The thoracic cavity is actually much smaller than what it appears to be because the narrow upper part appears broad due to the shoulders, and the lower part is greatly encroached upon by the abdominal cavity due to the upward convexity of the diaphragm.

In transverse section, the thorax is reniform (bean-shaped, or kidney-shaped). The transverse diameter is greater than the anteroposterior diameter. However, in infants below the age of two years, it is circular. In quadrupeds, the anteroposterior diameter is greater than the transverse, as shown in Fig. 12.5.

In infants, the ribs are horizontal and as a result the respiration is purely abdominal, by action of the diaphragm.

In adults, the thorax is oval. The ribs are oblique and their movements alternately increase and decrease the diameters of the thorax. This results in the drawing in of air into the thorax called *inspiration* and its expulsion is called *expiration.* This is called *thoracic respiration.* In the adult, we, therefore, have both abdominal and thoracic respiration.

First rib
Manubrium
Body of sternum
Costal cartilages
Ribs
Xiphoid process
Costal margin

12.1

Body of sternum
Manubrium
First rib
4th thoracic vertebra
5th rib
9th thoracic vertebra
10th rib
12th thoracic vertebra
12th rib
Costal cartilages
Xiphisternum

12.2

Thoracic vertebrae
1st rib
5th rib
10th rib
12th rib
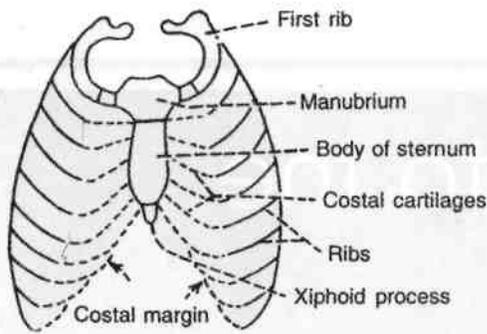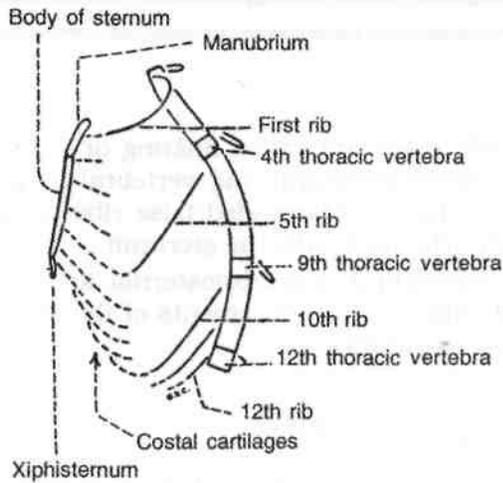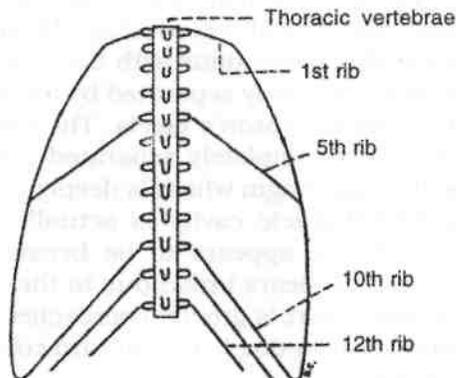
12.3

Figs 12.1 to 12.3: *Shape and construction of the thoracic cage as seen from the front (Fig. 12.1), from the lateral side (Fig. 12.2), and from behind (Fig. 12.3).*

Neck
Suprapleural membrane
Shoulder
Thorax
Diaphragm
Abdomen
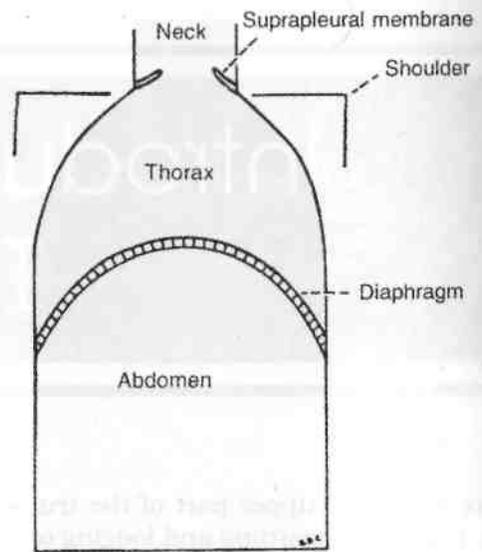
Fig. 12.4: *Scheme to show how the size of the thoracic cavity is reduced by the upward projection of the diaphragm, and by the inward projection of the shoulders.*

Human adult

Infants

Quadrupeds
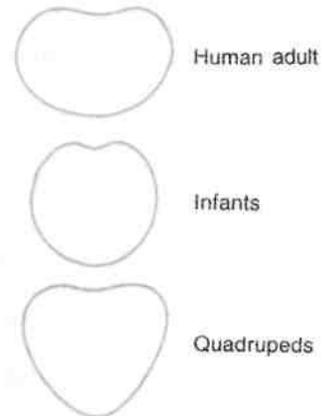
Fig. 12.5: *The shape of the thorax as seen in transverse section.*

^^^^^H
CLINICAL ANATOMY

1. The chest wall of the child is highly elastic, and fractures of the ribs are, therefore, rare. In adults, the ribs may be fractured by direct or indirect violence. In indirect violence, like crushing injury, the rib fractures at its weakest point located at the angle. The upper two ribs which are protected by the clavicle, and the lower two ribs which are free to swing are least commonly injured.

2. A cervical rib is a rib attached to vertebra C7. It occurs in about 0.5% of subjects. Such a rib may exert pressure on the lower trunk of the brachial plexus which arches over a cervical rib. Such a person complains paraesthesiae or abnormal sensations along the ulnar border of the forearm, and wasting of the small muscles of the hand supplied by segment Tl. Vascular changes may also occur.

3. In coarctation or narrowing of the aorta, the posterior intercostal arteries get enlarged greatly to provide a collateral circulation. Pressure of the enlarged arteries produces characteristic notching on the ribs.

The narrow upper end of the thorax, which is continuous with the neck, is called the inlet of the thorax (Fig. 12.6). It is kidney-shaped. Its transverse diameter is 10-12.5 cm. The anteroposterior diameter is about 5 cm.

Boundaries

Anteriorly: Upper border of the manubrium sterni.

Posteriorly: Superior surface of the body of the first thoracic vertebra.

On each side: First rib with its cartilage.

The plane of the inlet is directed downwards and forwards with an obliquity of about 45 degrees. The anterior part of the inlet lies 3.7 cm below the posterior part, so that the upper border of the manubrium sterni lies at the level of the upper border of the third thoracic vertebra.

Diaphragm or Partition at the Inlet of the Thorax

The diaphragm is in two halves, right and left, with a cleft in between. Each half is also known as Sibson's fascia or suprapleural membrane. It partly separates the thorax from the neck. The membrane is triangular in shape. Its apex is attached to the tip of the transverse process of the seventh cervical vertebra and the base to the inner border of the first rib and its cartilage. Morphologically it is regarded as the flattened tendon of the scalenus minimus (pleuralis) muscle. Functionally, it provides rigidity to the thoracic inlet, so that the root of the neck is not

puffed up and down during respiration. The inferior surface of the membrane is fused to the cervical pleura, beneath which lies the apex of the lung. Its superior surface is related to the subclavian vessels and other structures at the root of the neck (Figs 12.7, 12.8).

Structures Passing through the Inlet of Thorax

Viscera

Trachea, oesophagus, apices of the lungs with pleura, remains of the thymus. Figure 12.9 depicts the structures passing through the inlet of the thorax. *Large vessels*

Brachiocephalic artery on right side.

Left common carotid artery and the left subclavian artery on the left side. Right and left brachiocephalic veins. *Smaller vessels*

Right and left internal thoracic arteries.

Right and left superior intercostal arteries.

Right and left first posterior intercostal veins.

Inferior thyroid veins.

Nerves

Right and left phrenic nerves.

Right and left vagus nerves.

Right and left sympathetic trunks.

Right and left first thoracic nerves as they ascend across the first rib to join the brachial plexus. *Muscles*

Sternohyoid, sternothyroid and longus colli.
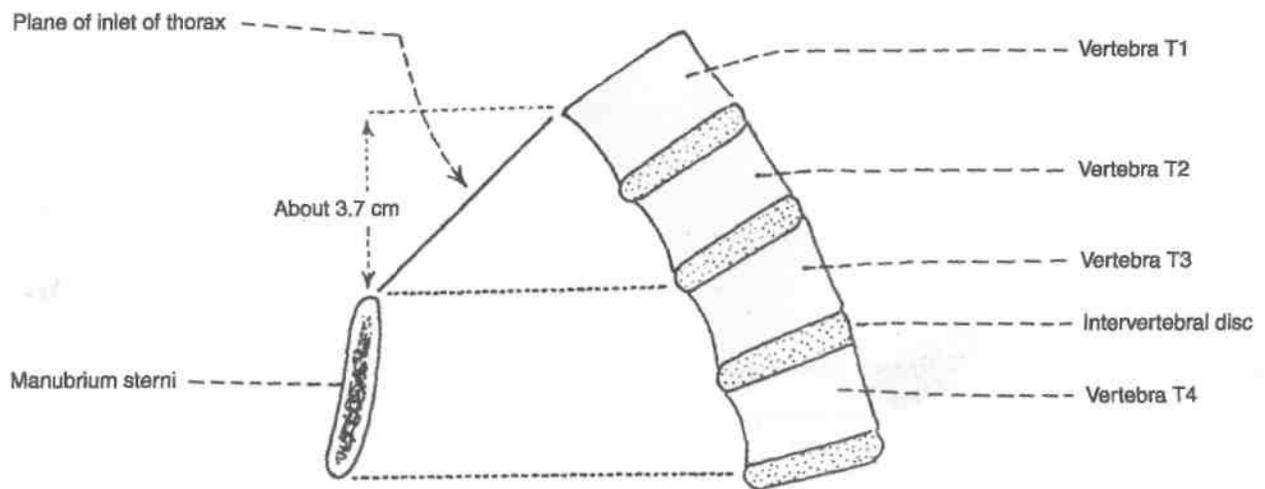
Fig. 12.6: The plane of the inlet of the thorax.

Scalenus medius

Insertion of scalenus medius

Brachial plexus

Cervical dome of pl

Insertion of scalenus anterior

Subclavian artery

Subclavian vein

First costal cartilage
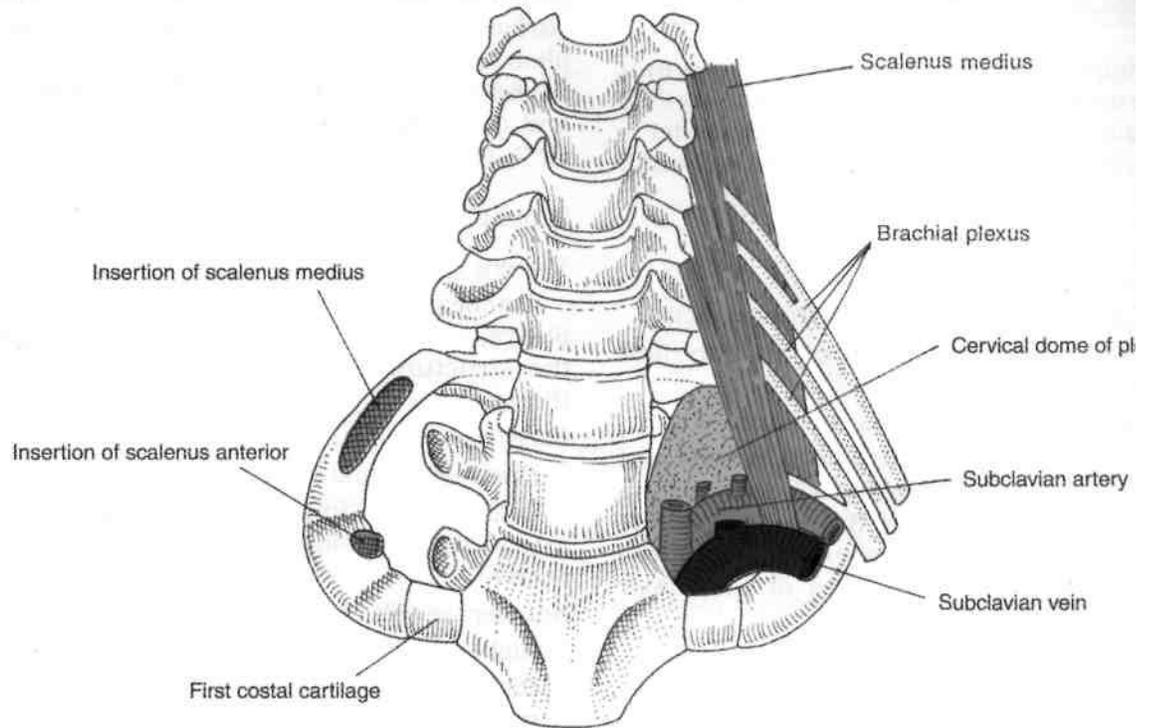
Fig. 12.7: *Thoracic inlet showing cervical dome of the pleura on left side of body and its relationship to inner borde*

A

B
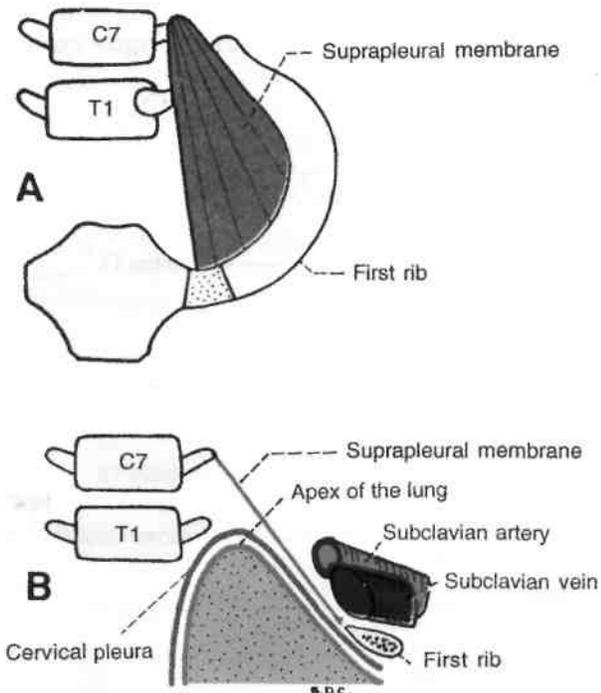
Fig. 12.8: The suprapleural membrane: (A) Surface view, (B) Sectional view.

Thoracic Inlet Syndrome: Two structures arch over the first rib: the subclavian artery and first thoracic nerve. These structures may be pulled or pressed by a cervical rib or by variations in the insertion of the scalenus anterior. The symptoms may, therefore, be vascular, neural, or both.

THE INFERIOR APERTURE/OUTLET OF THE THORAX

The inferior operture is the broad end of the thorax which surrounds the upper part of the abdominal cavity, but is separated from it by the diaphragm.

Boundaries

Anteriorly: Infrasternal angle between the two costal margins.

Posteriorly: Inferior surface of the body of the twelfth thoracic vertebra.

On each side: (i) Costal margin formed by the cartilages of seventh to twelfth ribs.

Diaphragm at the Outlet of Thorax

The outlet is closed by a large musculotendinous partition, called the diaphragm—the *thoracoabdo-*
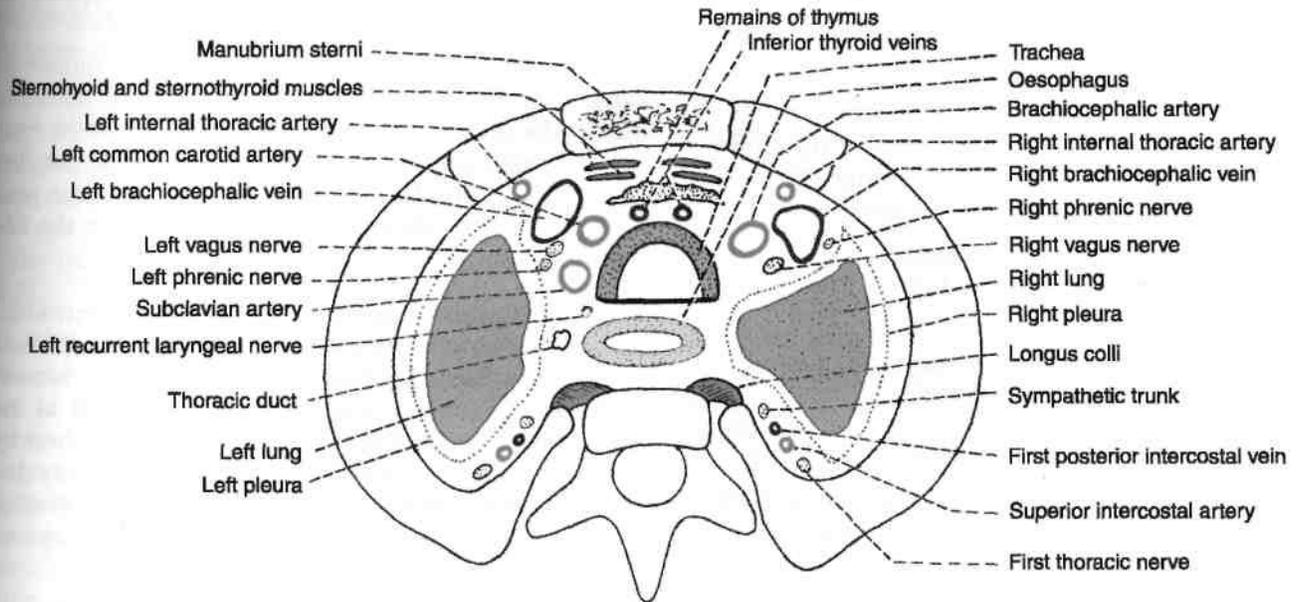
Fig. 12.9: *Structures passing through the inlet of the thorax.*

minal diaphragm—which separates the thorax from the abdomen.

Structures passing through the diaphragm

There are three large, and several small, openings in the diaphragm which allow passage to structures from thorax to abdomen or *vice versa* (Fig. 12.10).

Large Openings in the Diaphragm

aortic opening is osseoaponeurotic. It lies twelfth thoracic vertebra.

It transmits: (i) the aorta, (ii) the thoracic duct, and (iii) the azygos vein.

B. The *oesophageal opening* lies in the muscular part of the diaphragm, at the level of the tenth thoracic vertebra. It transmits: (i) the oesophagus, (ii) the gastric (vagus) nerves, and (iii) the oesophageal branches of the left gastric artery, with some oesophageal veins that accompany the arteries.

c. The *vena caval opening* lies in the central tendon of the diaphragm at the level of the eighth A. The thoracic vertebra. It transmits: (i) the inferior vena at the lower border of the cava, and (ii) branches of the right phrenic nerve.
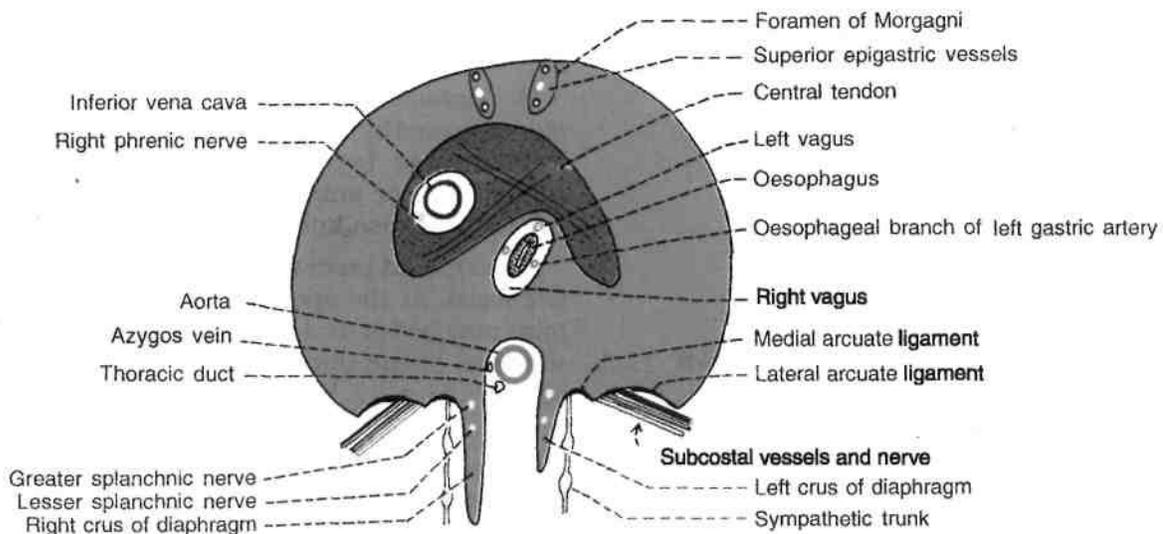
Fig. 12.10: *Structures passing through the diaphragm.*

Small Openings in the Diaphragm

(a) Each crus of the diaphragm is pierced by the greater and lesser splanchnic nerves. The left crus is pierced in addition by the hemiazygos vein.

(b) The sympathetic chain passes from the thorax to the abdomen behind the medial arcuate ligament also called the medial lumbocostal arch.

(c) The subcostal nerve and vessels pass behind the lateral arcuate ligament or lateral lumbocostal arch.

(d) The superior epigastric vessels and some lymphatics pass between the xiphoid and costal (7th costal cartilage) origins of the diaphragm. This gap is known as Larry's space or foramen of Morgagni.

(e) The musculophrenic vessels pierce the diaphragm at the level of ninth costal cartilage.

(fj Several small veins pass through minute apertures in the central tendon.

SURFACE LANDMARKS OF THE THORAX   ~

Bony Landmarks

1. *Suprasternal or jugular notch* (Fig. 12.11). It is felt just above the superior border of the manubrium between the sternal ends of the clavicles. It lies at the level of the lower border of the body of the second
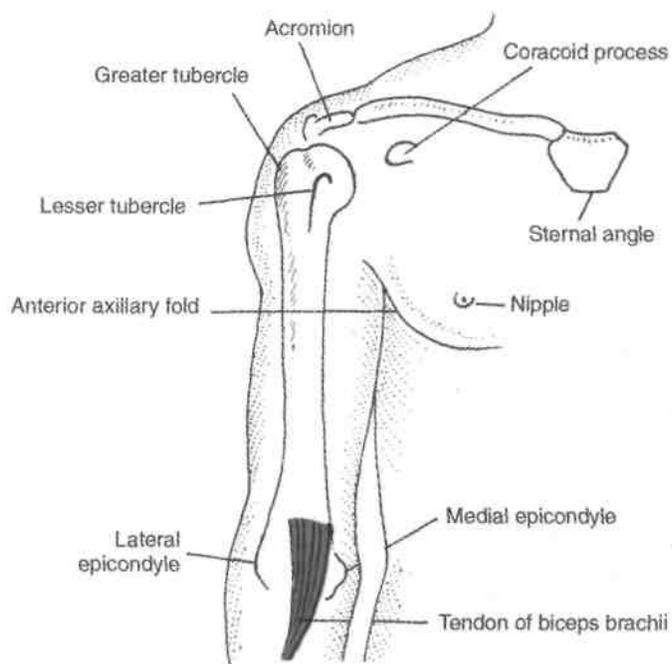
Fig. 12.11: Surface landmarks: Anterior aspect of shoulder axilla, arm and elbow regions.

thoracic vertebra. The trachea can be palpated in this notch.

2. *Sternal angle of Louis:* It is felt as a transverse ridge about 5 cm below the suprasternal notch. It] marks the manubriosternal joint, and lies at the level of the second costal cartilage anteriorly, and the disc between the fourth and fifth thoracic vertebrae pos teriorly. This is an important landmark for the fol-l lowing reasons:

  i. The ribs are counted from this level downwards.] There is no other reliable point (anteriorly) from which the ribs may be counted. The second costal cartilage and rib lie at the level of the sternal angle. The ribs are counted from here by tracing the finger downwards and laterally (be- I cause the lower costal cartilages are crowded and the anterior parts of the intercostal spaces are very narrow).

  ii. It marks the plane which separates the superior mediastinum from the inferior mediastinum.

  iii. The ascending aorta ends at this level.

  iv. The arch of the aorta begins and also ends at this level.

  v. The descending aorta begins at this level.

  vi. The trachea divides into two principal bronchi.

  vii. The azygos vein arches over the root of the right lung and opens into the superior vena cava.

  viii. The pulmonary trunk divides into two pulmonary arteries just below this level.

  ix. The thoracic duct crosses from the right to the left side at the level of the fifth thoracic vertebra and reaches the left side at the level of the sternal angle.

  x. It marks the upper limit of the base of the heart.

  xi. The cardiac plexuses are situated at the same level.

3. *Xiphisternal joint.* The costal margin on each side is formed by the seventh to tenth costal cartilages. Between the two costal margins there lies the infrasternal or subcostal angle. The depression in the angle is also known as the epigastric fossa.

The xiphoid process lies in the floor of the epigastric fossa. At the apex of the angle the xiphisternal joint may be felt as a short transverse ridge. It lies at the level of the upper border of the ninth thoracic vertebra (Fig. 12.1).

4. *Costal cartilages.* The *second* costal cartilage is attached to the sternal angle. The *seventh* cartilage bounds the upper part of the infrasternal angle. The lateral border of the rectus abdominis or the linea semilunaris joins the costal margin at the tip of the

ninth costal cartilage, through which also passes the midclavicular plane. The tenth costal cartilage forms the lower part of the costal margin (Figs 12.1, 12.2).

5. *Ribs*. The scapula overlies the second to seventh ribs on the posterolateral aspect of the chest wall. The tenth rib is the lowest point, lies at the level of the third lumbar vertebra. Though the eleventh rib is longer than the twelfth, both of them are confined to the back and are not seen from the front (Fig. 12.2).

6. *Thoracic vertebral spines*. The first prominent spine felt at the lower part of the back of the neck is that of the *seventh cervical vertebra or vertebra prominens*. Below this spine, all the thoracic spines can be palpated along the posterior median line (Fig. 12.3). The third thoracic spine lies at the level of the roots of the spines of the scapulae. The seventh thoracic spine lies at the level of the inferior angles of the scapulae.

Soft Tissue Landmarks

1. *The nipple*. The position of the nipple varies considerably in females, but in males it usually lies in the fourth intercostal space about 10 cm from the midsternal line (Fig. 12.11).

2. *Apex beat*. It is a visible and palpable cardiac impulse in the left fifth intercostal space 9 cm from the midsternal line, or medial to the midclavicular line.

3 *Trachea*. It is palpable in the suprasternal notch midway between the two clavicles.

4. *Midclavicular or lateral vertical or mammary plane*. It is a vertical plane passing through the midinguinal point and the tip of the ninth costal cartilage (Fig. 15.9).

5. *Midaxillary line*. It passes vertically between the two folds of the axilla (Fig. 15.9).

6. *Scapular line*. It passes vertically along the inferior angle of the scapula.

13

Bones and Joints of Thorax

Tme thorax is an osseocartilaginous cavity or cage for various viscera, providing them due support and protection. This cage is not static, but dynamic, as it moves at its various joints, increasing or decreasing the various diameters of the cavity for an extremely important process of respiration, which is life for all of us.

BONES OF THE THORAX

THE RIBS OR COSTAE

1. There are 12 ribs on each side forming the greater part of the thoracic skeleton. The number may be increased by development of a cervical or a lumbar rib; or the number may be reduced to 11 by the absence of the twelfth rib.

2. The ribs are bony arches arranged one below the other (Fig. 13.1). The gaps between the ribs are called intercostal spaces. The spaces are deeper in front than behind, and deeper between the upper than between the lower ribs.

3. The ribs are placed obliquely, the upper ribs being less oblique than the lower. The obliquity reaches its maximum at the ninth rib, and thereafter it gradually decreases to the twelfth rib.

4. The length of the ribs increases from the first to the seventh ribs, and then gradually decreases from the eighth to twelfth ribs.

5. The breadth of the ribs decreases from above downwards. In the upper ten ribs, the anterior ends are broader than the posterior ends.

6. The first 7 ribs which are connected through their cartilages to the sternum are called true ribs, or vertebrosternal ribs. The remaining five are false ribs. Out of these the cartilages of the eighth, ninth and tenth ribs are joined to the next higher cartilage and are known as vertebrochondral ribs. The anterior

ends of the eleventh and twelfth ribs are free and are called floating ribs or vertebral ribs.

7. The first two and last three ribs have special features, and are atypical ribs. The third to ninth ribs are typical ribs.

Typical Ribs

Side determination

1.The anterior end bears a concave depression. The posterior end bears a head, a neck and a tubercle.

2.The shaft is convex outwards and there is costal groove situated along the lower part of its inner surface, so that the lower border is thin and the upper border rounded.
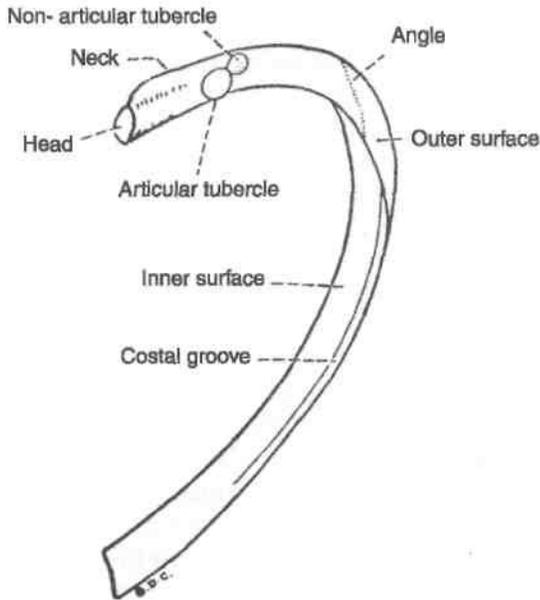
Fig. 13.1: A typical rib of the right side.

Features of a Typical Rib

Each rib has two ends, anterior and posterior. Its shaft comprises upper and lower borders, and outer and inner surfaces.

The *anterior end* is oval and concave for articulation with its costal cartilage.

The *posterior or vertebral end* is made up of the following parts:

1. The *head* has two facets that are separated by a crest. The lower larger facet articulates with the body of the numerically corresponding vertebra while the upper smaller facet articulates with the next higher vertebra (Fig. 13.2).

Fig. 13.3: A costal arch (side view).

3. The *upper border* is thick and has outer and inner lips.

Attachments and Relations of a Typical Rib

1. The crest of the head provides attachment to the intra-articular ligament of the costovertebral joint.
2. Anteriorly, the head provides attachment to the radiate ligament (Fig. 13.4) and is related to the sympathetic chain and to the costal pleura.

Fig. 13.2: A typical rib viewed obliquely from behind.
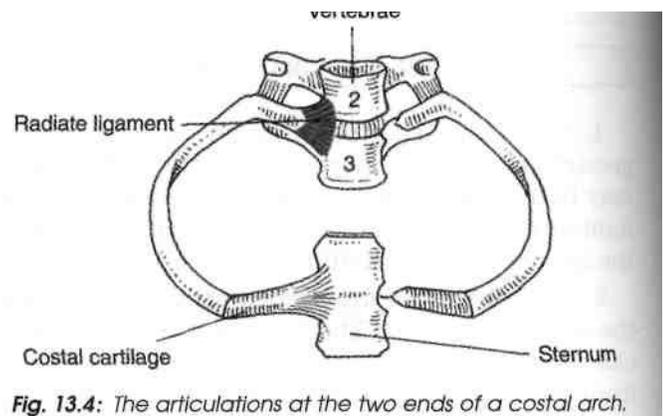
Fig. 13.4: The articulations at the two ends of a costal arch.

1. The neck lies in front of the transverse process of its own vertebra, and has two surfaces; anterior and posterior and two borders; superior and inferior. The anterior surface of the neck is smooth. The posterior surface is rough. The superior border or crest of the neck is thin. The inferior border is rounded.

2. The *tubercle* is placed on the outer surface of the rib at the junction of the neck and shaft. Its medial part is articular and forms the costotransverse joint with the transverse process of the corresponding vertebra. The lateral part is non-articular.

The shaft is flattened so that it has two surfaces: outer and inner and two borders: upper and lower. The shaft is curved with its convexity outwards (Fig. 13.3). It is bent at the *angle* which is situated about 5 cm lateral to the tubercle. It is also twisted at the angle.

1. The *outer surface.* The angle is marked by an oblique line on the outer surface directed downwards and laterally.

2. The *inner surface* is smooth and covered by the pleura. This surface is marked by a ridge which is continuous behind with the lower border of the neck. The costal groove lies between this ridge and the inferior border. The costal groove contains the posterior intercostal vessels and intercostal nerve.

3. *Attachments to the neck:*
   (i) The anterior surface is covered by costal pleura.
   (ii) The inferior costotransverse ligament is attached to the rough posterior surface (Fig. 13.5).
   (iii) The two laminae of the superior costotransverse ligament are attached to the crest of the neck (Fig. 13.6).

1. The lateral non-articular part of the *tubercle* gives attachment to the lateral costotransverse ligament.

2. *Attachments on the shaft*
   (i) The thoracolumbar fascia and the lateral fibres of the sacrospinalis muscle are attached
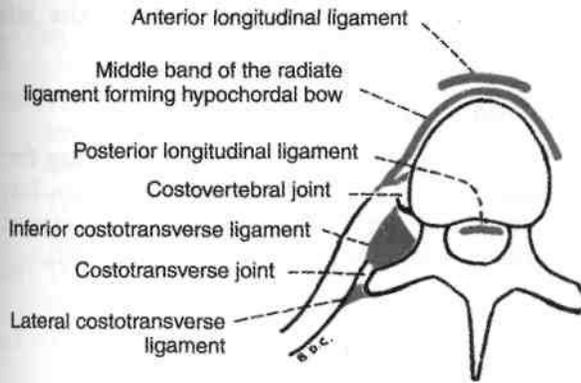
Fig. 13.5: *Attachments and articulations of the posterior end of c typical rib.*
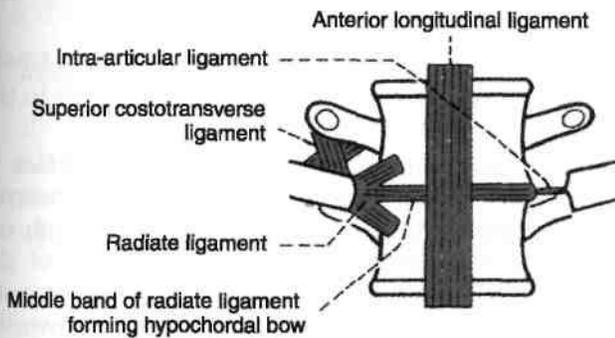
Fig. 13.6: *The superior costotransverse, radiate and intra-articula ligaments*

to the angle. Medial to the angle, the *levator costae* and the sacrospinalis are attached. About 5 cm from the anterior end there is an indistinct oblique line, known as the anterior angle, which separates the origins of the *external oblique* from *serratus anterior;* in case of fifth to eighth ribs. The anterior angle also separates the origin of external oblique from that of latissimus dorsi in case of ninth and tenth ribs.

(ii) The interna/intercostaimuscle arises from the floor of the costal groove. The *intercostalis intimus* arises from the middle two-fourths of the ridge above the groove. The *subcostalis* is attached to the inner surfaces of the lower ribs.

{ill} The external intercostal muscle is attached on the outer lip of the upper border, while the internal intercostal and intercostalis intimi are attached on the inner lip of the upper border.

Ossification of a Typical Rib

A typical rib ossifies in cartilage from: (a) one primary centre (for the shaft) which appears, near the angle,

at about the eighth week of intrauterine life; and (b) three secondary centres, one for the head and two for the tubercle, which appear at about sixteenth years and unite with the rest of the bone at about 25 years.

The First Rib

Identification

1. It is the shortest, broadest and most curved rib.

2. The shaft is not twisted.

3. It is flattened from above downwards so that it has superior and inferior surfaces; and outer and inner borders.

Side Determination

1. The anterior end is larger, thicker and pitted. The posterior end is small and rounded.

2. The outer border is convex.

3. The upper surface of the shaft is crossed obliquely by two shallow grooves separated by a ridge. The ridge is enlarged at the inner border of the rib to form the scalene tubercle.

When the rib is placed on a horizontal plane, i.e. with the superior surface facing upwards, both the ends of the rib touch the surface.

Features of the First Rib

1. The *anterior end* is larger and thicker than that in the other ribs. It is continuous with the first costal cartilage.

2. *The posterior end comprises the following:*

a. The *head* is small and rounded. It articulate" with the body of first thoracic vertebra.

b. The neck is rounded and directed laterally, upwards and backwards.

c. The *tubercle* is large. It coincides with the angle of the rib. It articulates with the transverse process of first thoracic vertebra to form the costotransverse joint.

3. The *shaft (body)* has two surfaces: upper and lower and two borders: outer and inner.

a. The *upper surface* is marked by two shallow grooves, separated near the inner border by the scalene tubercle.

b. The *lower surface* is smooth and has no costal groove.

c. The *outer border* is convex, thick behind and thin in front.

d. The *inner border* is concave.

Attachments and Relations of the First Rib

1.Anteriorly, the neck is related from medial to lateral side to: (i) the sympathetic chain, (ii) the first posterior intercostal vein, (iii) the intercostal artery, and (iv) the first thoracic nerve (Fig. 13.7).

2.Superiorly, the neck is related to: (i) the deep cervical vessels, and (ii) the eighth cervical nerve.

3.The anterior groove on the superior surface of the shaft lodges the subclavian vein, and the posterior groove lodges the subclavian artery and the lower trunk of the brachial plexus.

4.The structures attached to the upper surface of the shaft are:

(i) the origin of the subclavius muscle at the anterior end;

(ii) the attachment of the costoclavicular ligament at the anterior end behind the subclavius;

(iii) the insertion of the scalenus anterior on the scalene tubercle; and

(iv) the insertion of the scalenus medius on the elongated rough area behind the groove for the subclavian artery.

1.The lower surface of the shaft is covered by costal pleura and is related near its outer border to the small first intercostal nerve which is very small.

2.The outer border gives origin to: (i) the external intercostal muscle, and (ii) the upper part of the first digitation of the serratus anterior, just behind the groove for the subclavian artery. The thick portion of the outer border is covered by the scalenus posterior.

3.The inner border gives attachment to the suprapleural membrane.

First posterior intercostal vein
Superior intercostal artery
Ventral ramus of C8
Ventral ramus of T1
Scalenus medius
Serratus anterior
Sympathetic trunk
Scalenus anterior
Lower trunk of brachial plexus
Groove for subclavian artery
Groove for subclavian vein
Costoclavicular ligament
Subclavius muscle

Fig. 13.7: *Superior view of the first rib (left side).*

8. The tubercle gives attachment to the lateral costotransverse ligament.

Ossification

The first rib ossifies from one primary centre for the shaft and only two secondary centres, one for the head and the other for the tubercle. Otherwise its ossification is similar to that of a typical rib.

The Second Rib

Features

The features of the second rib are as follows.

1.The length is twice that of the first rib.

2.The shaft is sharply curved, like that of the first rib.

3.The non-articular part of the tubercle is small.

4.The angle is slight and is situated close to the tubercle.

5.The shaft has no twist. The outer surface is convex and faces more -upwards than outwards. I Near its middle it is marked by a large rough tubercle. This tubercle is a unique feature of the 1 second rib. The inner surface of the shaft is smooth I and concave. It faces more downwards than inwards. There is a short costal groove on the posterior part of this surface.

The posterior part of the upper border has distinct outer and inner lips. The part of the outer lip just in front of the angle is rough.

Attachments

1.The rough tubercle on the outer surface gives origin to one and a half digitations of the serratus anterior muscle.

2.The rough part of the upper border receives the insertion of the scalenus posterior.

The Tenth Rib

The tenth rib closely resembles a typical rib, but is (i) shorter and (ii) has only a single facet on the head, for the body of the tenth thoracic vertebra.

The Eleventh and Twelfth Ribs

Eleventh and twelfth ribs are short. They have pointed ends. The necks and tubercles are absent. The angle and costal groove are poorly marked in the eleventh rib; and are absent in the twelfth rib.

Attachment and Relations of the Twelfth Rib

1. The capsular and radiate ligaments are attached to the head of the rib.
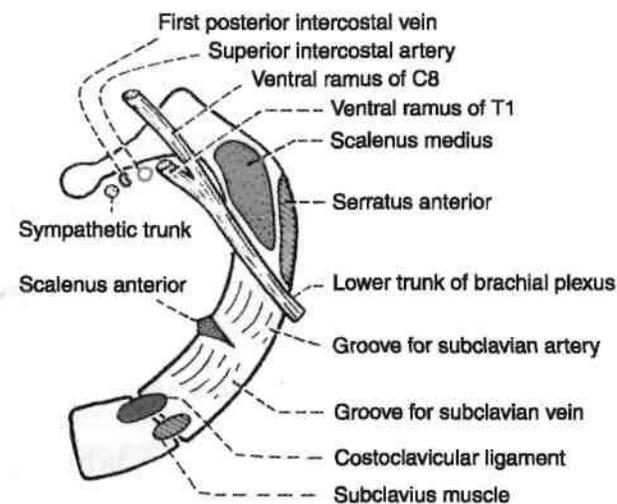
2. The following are attached on the inner sur face:

(i)   The quadratus lumborum is inserted into the lower part of the medial half to two-thirds of this surface (Fig. 13.8A). (ii)   The fascia covering the quadratus lumborum

is also attached to this part of the rib. (iii)   The internal intercostal muscle is inserted

near the upper border, (iv)   The costodiaphragmatic recess of the pleura

is related to the medial three-fourths of the costal surface. (v)   The diaphragm takes origin from the anterior

end of this surface.

3. The following are attached to the outer surface:

A *Attachments on the medial half*

(i)   Costotransverse ligament (Fig. 13.8B).
(ii)   Lumbocostal ligament
(iii)   Lowest levator costae
(iv)   Iliocostalis and longissimus parts of sacrospi-nalis.

B. *Attachments on the lateral half*

(i)   Insertion of serratus posterior inferior (ii)   Origin of latissimus dorsi (iii)   Origin of external oblique muscle of abdomen

4. The intercostal muscles are attached to the upper border.

Fig. 13.8: *The right twelfth rib. (A) Inner surface. (B) Outer surface.*

5. The structures attached to the lower border are:

(i)   Middle layer of thoracolumbar fascia, (ii) Lateral arcuate ligament, at the lateral border of the quadratus lumborum. (iii)   Lumbocostal ligament near the head, extending to the transverse process of first lumbar vertebra.

Ossification

The eleventh and twelfth ribs ossify from one primary centre for the shaft and one secondary centre for the head.

THE COSTAL CARTILAGES

The costal cartilages represent the unossified anterior parts of the ribs. They are made up of hyaline cartilage. They contribute materially to the elasticity of the thoracic wall.

The medial ends of the costal cartilages of the first seven ribs are attached directly to the sternum. The eighth, ninth and tenth cartilages articulate with one another and form the costal margin. The cartilages of the eleventh and twelfth ribs are small. Their ends are free and lie in the muscles of the abdominal wall.

The direction of the costal cartilages is variable. As the first costal cartilage approaches the sternum it descends a little. The second cartilage is horizontal. The third ascends slightly. The remaining costal cartilages are angular. They continue the downward course of the rib for some distance, and then turn upwards to reach either the sternum or the next higher costal cartilage.

Each cartilage has two surfaces: anterior and posterior; two borders: superior and inferior and two ends: lateral and medial.

Attachments on Costal Cartilages

Anterior Surface

1.This surface of the first costal cartilage articulates with the clavicle and takes part in forming the sternoclavicular joint. It gives attachment to: (i) the sternoclavicular articular disc, (ii) the joint capsule, (iii) the sternoclavicular ligament, and (iv) the sub-clavius muscle.

2.The second to seventh costal cartilages give origin to the pectoralis major.

3.The remaining cartilages are covered by and give partial attachment to some of the flat muscles of the anterior abdominal wall. The internal oblique muscle is attached to the seventh, eighth and ninth
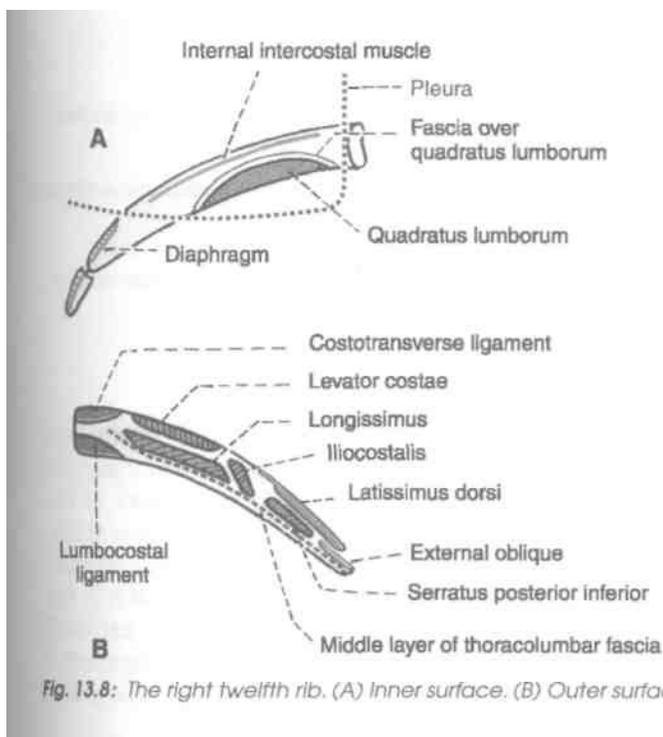
cartilages: and the rectus abdominis to the fifth, sixth and seventh cartilages.

Posterior Surface

1.The first cartilage gives origin to the sternothyroid muscle.

2.The second to sixth cartilages receive the insertion of the sternocostalis.

3.The seventh to twelfth cartilages give attachment to the transversus abdominis and to the diaphragm.

Superior and Inferior Borders

1.The borders give attachment to the internal intercostal muscles and the external intercostal membranes of the spaces concerned.

2.The fifth to ninth cartilages articulate with one another at the points of their maximum convexity, to form synovial joints.

Lateral end

The lateral end of each cartilage forms a primary cartilaginous joint with the rib concerned.

Medial end

1.The first cartilage forms a primary cartilaginous joint with the manubrium.

2.The second to seventh cartilages form synovial joints with the sternum.

3.The eighth, ninth and tenth cartilages are connected to the next higher cartilage.

4.The ends of the eleventh and twelfth cartilages are pointed and free.

THE STERNUM

The sternum is a flat bone, forming the anterior median part of the thoracic skeleton. In shape, it resembles a short sword. The upper part, corresponding to the handle is called the *manubrium*. The middle part, resembling the blade is called the body. The lowest tapering part forming the point of the sword is the *xiphoid process* or xiphisternum.

The sternum is about 17 cm long. It is longer in males than in females (Figs 13.9, 13.10).

The Manubrium

The manubrium is quadrilateral in shape. It is the thickest and strongest part of the sternum. It has two surfaces: anterior and posterior and four borders: superior, inferior, and two lateral.
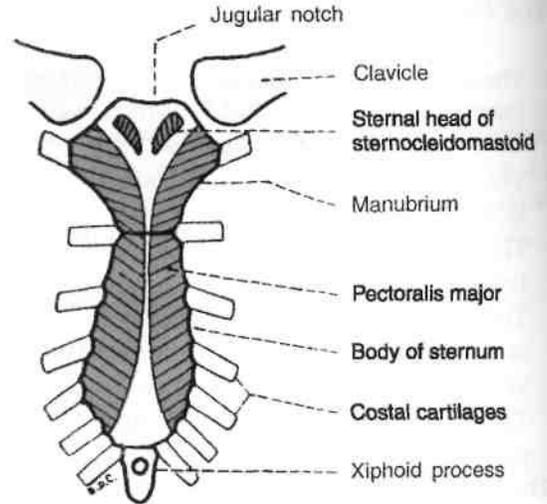
Fig. 13.9: The sternum: Anterior aspect.
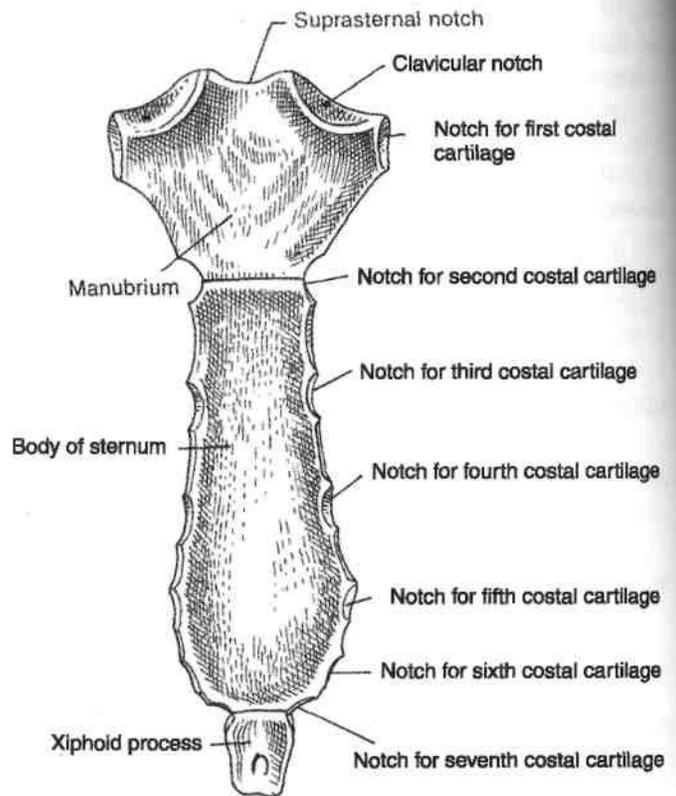
Fig. 13.10: The sternum: Posterior aspect.

The *anterior surface* is convex from side to side and concave from above downwards. The *posterior surface* is concave and forms the anterior boundary of the superior mediastinum. The *superior border* is thick, rounded and concave. It is marked by the suprasternal notch or jugular notch or interclavicular notch in the median part, and by the clavicular notch on each side. The clavicular notch articulates with the medial end of the clavicle to form the sternoclavicular joint.

The *inferior border* forms a secondary cartilaginous joint with the body of the sternum. The manubrium makes a slight angle with the body, convex forwards, called the sternal angle of Louis. The *lateral border* forms a primary cartilaginous joint with the first costal cartilage, and present a demi-facet for synovial articulation with the upper part of the second costal cartilage.

Attachments on the Manubrium

1. The anterior surface gives origin on either side to: (i) the pectoralis major, and (ii) the sternal head of the sternocleidomastoid (Fig. 13.11).

2. The posterior surface gives origin to: (i) the sternohyoid in upper part, and (ii) the sternothyroid in lower part. The lower half of this surface is related to the arch of the aorta. The upper half is related to the left brachiocephalic vein, the brachiocephalic artery, the left common carotid artery and the left subclavian artery. The lateral portions of the surface are related to the corresponding lung and pleura.

3. The suprasternal notch gives attachment to the lower fibres of the interclavicular ligament, and to the two subdivisions of the investing layer of cervical fascia.

4. The margins of each clavicular notch give attachment to the capsule of the corresponding sternoclavicular joint.

The Body of the Sternum

The body is longer, narrower and thinner than the manubrium. It is widest close to its lower end opposite the articulation with the fifth costal cartilage. It has two surfaces: anterior and posterior; two lateral borders and two ends: upper and lower.

1. The *anterior surface* is nearly flat and directed forwards and slightly upwards. It is marked by three ill-defined transverse ridges, indicating the lines of fusion of the four small segments called sternebrae.

2. The posterior surface is slightly concave and is marked by less distinct transverse lines.

3. The lateral borders form synovial joints with the lower part of the second costal cartilage, the third to sixth costal cartilages, and the upper half of the seventh costal cartilage (Fig. 13.11).

4. The upper end forms a secondary cartilaginous joint with the manubrium, at the sternal angle.

5. The lower end is narrow and forms a primary cartilaginous joint with the xiphisternum.

Attachments on the Body of the Sternum

1. The anterior surface gives origin on either side to the pectoralis major muscle.

2. The lower part of the posterior surface gives origin on either side to the sternocostalis muscle.

3. On the right side of the median plane, the posterior surface is related to the anterior border of the right lung and pleura. On the left side the upper two pieces of the body are related to the left lung and pleura, and the lower two pieces to the pericardium (Fig. 13.12).

4. Between the facets for articulation with the costal cartilages, the lateral borders provide attachment to the external intercostal membranes and to the internal intercostal muscles.

Fig. 13.11: The sternum. Lateral aspect.
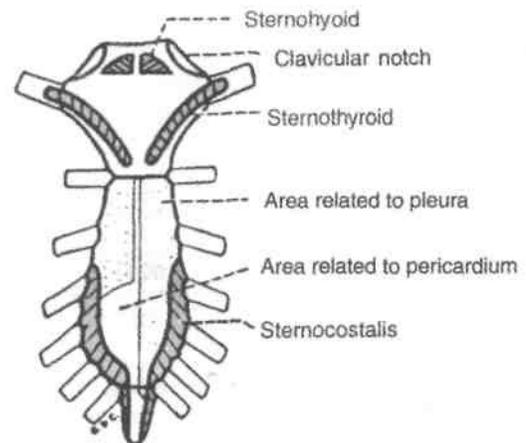
Fig. 13.12: Attachments on the posterior surface of the sternum.

The Xiphoid Process

The xiphoid process is the smallest part of the sternum. It is at first cartilaginous, but in the adult it becomes ossified near its upper end. It varies greatly in shape and may be bifid or perforated. It lies in the floor of the epigastric fossa.

Attachments on the Xiphoid Process

1. The anterior surface provides insertion to the medial fibres of the rectus abdominis, and to the aponeuroses of the external and internal oblique muscles of the abdomen.
2. The posterior surface gives origin to the diaphragm. It is related to the anterior surface of the liver.
3. The lateral borders of the xiphoid process give attachment to the aponeuroses of the internal oblique and transversus abdominis muscles.
4. The upper end forms a primary cartilaginous joint with the body of the sternum.
5. The lower end affords attachment to the linea alba.

Development and Ossification

The sternum develops by fusion of two sternal plates formed on either side of the midline. The fusion of the two plates takes place in a craniocaudal direction. Nonfusion of the plates causes ectopia cordis, where the heart lies uncovered on the surface. Partial fusion of the plates may lead to the formation of sternal foramina, bifid xiphoid process, etc.

In the cartilaginous sternum, five double bony centres appear from above downwards during the fifth, sixth, seventh, eighth and ninth fetal months. The upper centre forms the manubrium. The other centres form four sternebrae, which fuse with each other from below upwards during puberty. Fusion is complete by 25 years of age. The manubriosternal joint which is a secondary cartilaginous usually persists throughout life. In only about 10% of subjects, fusion may occur in old age.

The centre for the xiphoid process appears during the third year or later. It fuses with the body at about 40 years.

1. Bone marrow for examination is usually obtained by manubriosternal puncture.
2. The slight movements that take place at the manubriosternal joint are essential for movements of the ribs.
3. In the anomaly called 'funnel chest', the sternum is depressed.
4. In another anomaly called 'pigeon chest', there is forward projection of the sternum like the keel of a boat, and flattening of the chest wall on either side.

The vertebral column is made up of 33 vertebrae; seven cervical, twelve thoracic, five lumbar, five sacral and four coccygeal. In the thoracic, lumbar I and sacral regions, the number of vertebrae corresponds to the number of spinal nerves, each nerve I lying below the corresponding vertebra. In the cervical 1 region, there are eight nerves, the upper seven lying I above the corresponding vertebrae and the eighth below the seventh vertebra. In the coccygeal region, there is only one coccygeal nerve.

Sometimes the vertebrae are also grouped accord- I ing to their mobility. The movable or true vertebrae I include the seven cervical, twelve thoracic and five | lumbar vertebrae, making a total of 24. Twelve thoracic vertebrae have ribs attached to them. The fixed or false vertebrae include those of the sacrum and coccyx.

The length of the spine is about 70 cm in males and about 60 cm in females. The intervertebral discs contribute one-fifth of the length of the vertebral column.

As a result of variations in the width of the vertebrae, the vertebral column can be said to be made up of four pyramids (Fig. 13.13). This arrangement has a functional bearing. The narrowing of the vertebral column at the level of the disc between fourth thoracic and fifth thoracic vertebrae is partly compensated for by the transmission of weight to the lower thoracic region through the sternum and ribs.

THE VERTEBRAL COLUMN

The Vertebral Column as a Whole

The vertebral column is also called the spine, the spinal column, or back bone. It is the central axis of the body. It supports the body weight and transmits it to the ground through the lower limbs.

Curvatures of the Vertebral Column

In Sagittal Plane

1. *Primary curves* are present at birth and due to the shape of the vertebral bodies. The primary curves are thoracic and sacral.both of which are concave forwards.
2. *Secondary curves are* postural and are mainly due to the shape of the intervertebral disc. The

Disc between C7 and T1

Disc between T4 and T5

Disc between L5 and S1
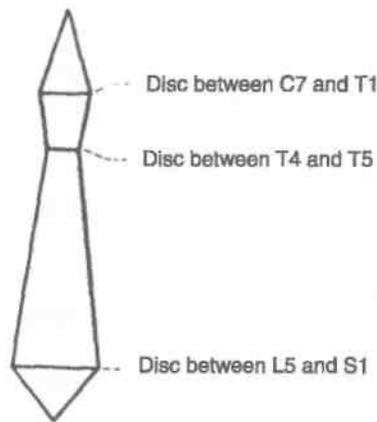
Fig. 13.13: *Scheme to show that the vertebral column is divisible into a number of pyramidal segments.*

secondary or compensatory curves are cervical and lumbar, both of which are convex forwards. The cervical curve appear during four to five months after birth when the infant starts supporting its head: the lumbar curve appears during twelve to eighteen months when the child assumes the upright posture.

In Coronal Plane (lateral curve)

There is slight lateral curve in the thoracic region with its concavity towards the left. It is possible due to the greater use of the right upper limb and the pressure of the aorta.

The curvatures add to the elasticity of the spine, and the number of curves gives it a higher resistance to weight than would be afforded by a single curve.

Parts of a Typical Vertebra

A typical vertebra is made up of the following parts. 1. The *body* lies anteriorly. It is shaped like a short cylinder, being rounded from side to side and having flat upper and lower surfaces that are attached to those of adjoining vertebrae by intervertebral discs (Fig. 13.14).

Body

Vertebral foramen

Superior costal facet

Pedicle

Transverse process

Facet for tubercle of rib

Superior articular process

Spine

Lamina
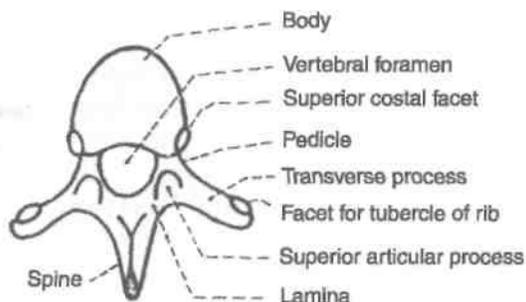
Fig. 13.14: *Typical thoracic vertebra, superior aspect.*

1. The *pedicles:* right and left are short rounded bars that project backwards, and somewhat laterally, from the posterior aspect of the body.

2. Each pedicle is continuous, posteromedially, with a vertical plate of bone called the *lamina.* The laminae of the two sides pass backwards and medially to meet in the midline. The pedicles and laminae together constitute the *vertebral or neural arch.*

3. Bounded anteriorly by the posterior aspect of the body, on the sides by the pedicles, and behind by the lamina, there is a large *vertebral foramen.*

Each vertebral foramen forms a short segment of the vertebral canal that runs through the whole length of the vertebral column and lodges the spinal cord.

1. Passing backwards and usually downwards from the junction of the two laminae there is the spine or spinous process (Fig. 13.15).

2. Passing laterally and usually somewhat downwards from the junction of each pedicle and the corresponding lamina, there is a *transverse process.* The spinous and transverse processes serve as levers for muscles acting on the vertebral column.

Superior costal facet

Superior articular process

Costal facet on the transverse process for tubercle of rib

Inferior articular process

Inferior costal facet

Spine

Inferior vertebral notch
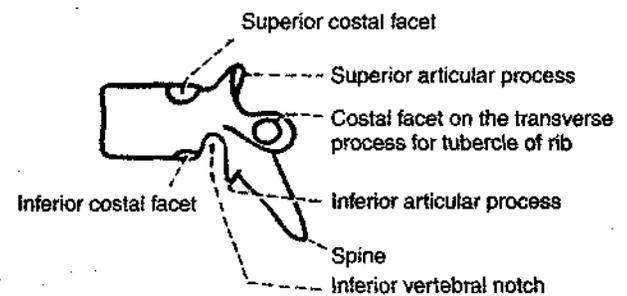
Fig. 13.15: *Typical thoracic vertebra, lateral view.*

From a morphological point of view the transverse processes are made up of two elements, the transverse element and the costal element. In the thoracic region, the two elements remain separate, and the costal elements form the ribs. In the rest of the vertebral column, the derivatives of costal element are different from those derived from transverse element. This is shown in Table 13.1.

7. Projecting upwards from the junction of the pedicle and the lamina there is on either side, a *superior articular process;* and projecting downwards there is an *inferior articularprocess* (Fig. 13.16). Each process bears a smooth articular facet: the superior facet is directed posteriorly and somewhat laterally, and the inferior facet is directed forwards and somewhat medially. The superior facet of one vertebra articulates with the inferior facet of the vertebra above it. Two adjoining vertebrae, therefore, articu-

Table 13.1: The transverse and costal elements of the vertebrae

Region	The transverse element	The costal element
1. Thoracic vertebrae	Forms the descriptive transverse process.	Forms the rib.
2. Cervical vertebrae	It fuses with the costal element and forms the medial part of the posterior wall of the foramen transversarium.	(i) Anterior wall of foramen transversarium (ii) anterior tubercle, (iii) costotransverse bar, (iv) posterior tubercle, and (v) lateral part of the posterior wall of the foramen.
1.Lumbar vertebrae	Forms the accessory process.	Forms the real (descriptive) transverse process.
2.Sacrum	It fuses with the costal element to form the posterior part of the lateral mass.	Forms the anterior part of the lateral mass.
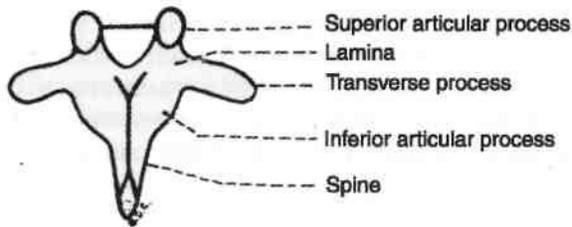
Fig. 13.16: Typical thoracic vertebra, posterior aspect.

late at three joints—two between the right and left articular processes, and one between the bodies of the vertebrae through the intervertebral disc.

8. The pedicle is much narrower in vertical diameter than the body and is attached nearer its upper border. As a result there is a large *inferior vertebral notch* below the pedicle. The notch is bounded in front by the posterior surface of the body of the vertebra, and behind by the inferior articular process. Above the pedicle there is a much shallower *superior vertebral notch.* The superior and inferior notches of adjoining vertebrae join to form the *intervertebral foramina* which give passage to the dorsal and ventral rami of the spinal nerves emerging from the spinal cord.

The Thoracic Vertebrae

Identification

The thoracic vertebrae are identified by the presence of costal facets on the sides of the vertebral bodies. The costal facets may be two or only one on each side. There are 12 thoracic vertebrae, out of which the second to eighth are typical, and the remaining five (first, ninth, tenth, eleventh and twelfth) are atypical.

Typical Thoracic Vertebra

A. The body is heart-shaped with roughly the same measurements from side to side and anteroposteriorly. On each side it bears two costal demifacets. The *superior costal demifacet* is larger and placed on the upper border of the body near the pedicle. It articulates with the head of the numeri cally corresponding rib. The *inferior costal demifacet* is smaller and placed on the lower border in front of the inferior vertebral notch. It articulates with the next lower rib.

B. *The vertebral foramen* is comparatively small and circular.

C. *The vertebral arch*

1.The *pedicles* are directed straight backwards. The superior vertebral notch is shallow, while the inferior vertebral notch is deep and conspicuous.

2.The *laminae* overlap each other from above.

3.The superzorarti'cuiarprocessesprojectupwards from the junction of the pedicles and laminae. The articular facets are flat and are directed backwards and a little laterally and upwards. This direction permits rotatory movements of the spine.

4.The *inferior articular processes* are fused to the laminae. Their articular facets are directed forwards and slightly downwards and medially.

5.The *transverse processes* are large, and are directed laterally and backwards from the junction of the pedicles and laminae. The anterior surface of each process bears a facet near its tip, for articulation with the tubercle of the corresponding rib. In the upper six vertebrae, the costal facets on the transverse processes are concave, and face forwards and laterally. In lower six, the facets are flat and face upwards, laterally and slightly forwards (see costotransverse joints below).

6. The *spine* is long, and is directed downwards and backwards. The fifth to ninth spines are the longest, more vertical and overlap each other. The upper and lower spines are less oblique in direction.

Attachments on a Typical Thoracic Vertebra

1. The upper and lower borders of the body give attachment, in front and behind respectively to the anterior and posterior longitudinal ligaments.

2. The upper borders and lower parts of the anterior surfaces of the laminae provide attachment to the ligamenta flava.

3. The transverse process gives attachment to: (i)the lateral costotransverse ligament at the tip, (ii) the superior costotransverse ligament along the lower border; (iii) the inferior costotransverse ligament along the anterior surface; (iv) the intertransverse muscles to upper and lower borders; and (v) the levator costae on the posterior surface.

4. The spines give attachment to the supraspinous and interspinous ligaments. They also give attachment to several muscles including the trapezius, the rhomboideus, the latissimus dorsi, the serrati posterior, superior and inferior, and many deep muscles of the back.

Ossification of a Thoracic Vertebra

The ossification is similar to that of a typical vertebra. It ossifies in cartilage from three primary and five secondary centres.

The three primary centres, one for the centrum and one for each half of the neural arch, appear during eighth to ninth week of fetal life. At birth the vertebra consists of three parts, the centrum and two halves of the neural arch. The two halves of the neural arch fuse posteriorly during the first year of life. The neural arch is joined with the centrum by the neurocentral synchondrosis. Bony fusion occurs here during the third to sixth years of life.

Five secondary centres: one for the upper surface and one for the lower surface of the body, one for each transverse process, and one for the spine appear at about the 15th year and fuse with the rest of the vertebra at about the 25th year.

Failure of fusion of the two halves of the neural arch results in 'spina bifida'. Sometimes the body ossifies from two primary centres, and if one centre fails to develop, one half, right or left of the body is missing. This results in a hemivertebra and lateral bend in the vertebral column or scoliosis.

Jlfie *First Thoracic Vertebra*

1. The body of this vertebra resembles that of a cervical vertebra. It is broad and not heart-shaped.

Its upper surface is lipped laterally and bevelled anteriorly.

The superior costal facet on the body is complete (Fig. 13.17). It articulates with the head of the first rib. The inferior costal facet is a 'demifacet' for the second rib.

1. The spine is thick, long and nearly horizontal.

2. The superior vertebral notches are well marked, as in cervical vertebrae.

The Ninth Thoracic Vertebra

The ninth thoracic vertebra resembles a typical thoracic vertebra except that the body has only the superior costal demifacets. The inferior costal facets are absent (Fig. 13.17).

The Tenth Thoracic Vertebra

The tenth thoracic vertebra resembles a typical thoracic vertebra except that the body has a single complete superior costal facet on each side, extending on to the root of the pedicle (Fig. 13.17).
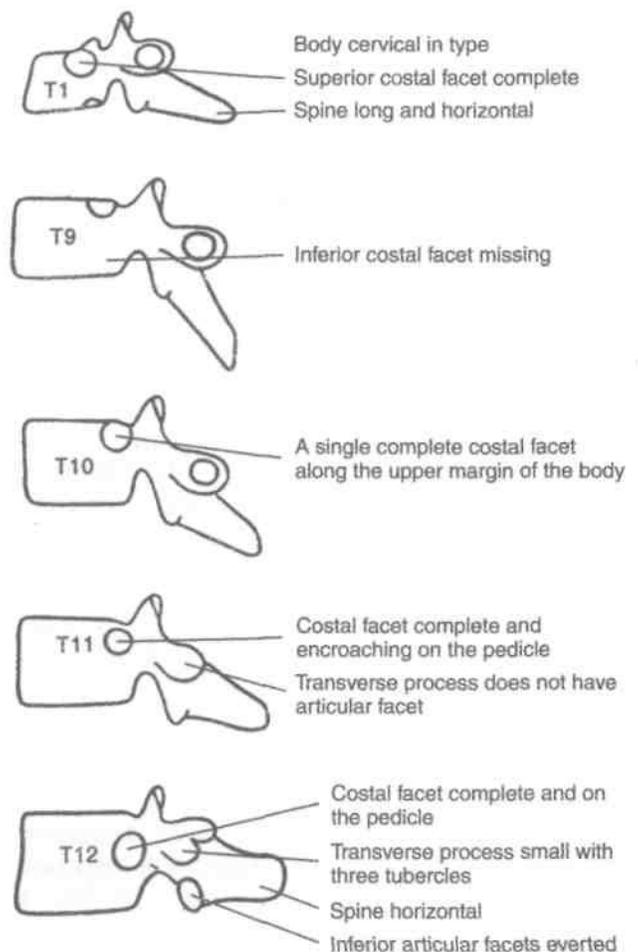
Fig. 13.17: Features of atypical thoracic vertebrae.

The Eleventh Thoracic Vertebrae

1. The body has a single large costal facet on each side, extending on to the upper part of the pedicle (Fig. 13.17).
2. The transverse process is small, and has no articular facet.

Sometimes it is difficult to differentiate between thoracic tenth and eleventh vertebrae.

The Twelfth Thoracic Vertebra

1. The shape of the body, pedicles, transverse processes and spine are similar to those of a lumbar vertebra. However, the body bears a single costal facet on each side, which lies more on the lower part of the pedicle than on the body.
2. The transverse process is small and has no facet, but has superior, inferior and lateral tubercles (Fig. 13.17).
3. The inferior articular facets are lumbar in type. These are everted and are directed laterally, but the superior articular facets are thoracic in type.

JOINTS OF THE THORAX

Manubriosternal Joint

Manubriosternal joint is a secondary cartilaginous joint. It permits slight movements of the body of the sternum on the manubrium during respiration. In about 10% of subjects, the joint may be obliterated by fusion of the two bones.

Costovertebral Joints

The head of a typical rib articulates with its own vertebra, and also with the body of the next higher vertebra, to form two plane synovial joints separated by an intra-articular ligament. This ligament is attached to the ridge on the head of the rib and to the intervertebral disc. Other ligaments of the joint include a capsular ligament and a triradiate ligament. The middle band of the triradiate ligament forms the hypochordal bow (Fig. 13.5), uniting the joints of the two sides.

Costotransverse Joints

The tubercle of a typical rib articulates with the transverse process of the corresponding vertebra to form a synovial joint. The capsular ligament is strengthened by three costotransverse ligaments. The superior costotransverse ligament has two laminae which extend from the crest on the neck of the rib to the transverse process of the vertebra above. The inferior costotransverse ligament passes

from the posterior surface of the neck to the transversa process of its own vertebra. The lateral costotransverse! ligament connects the lateral non-articular part of 1 the tubercle to the tip of the transverse process. 1 The articular facets on the tubercles of the upper six ribs are convex, and permit rotation of the rib neck for pump-handle movements of these ribs (Fig. 13.18). Rotation of rib-neck backwards causes I elevation of second to sixth ribs with moving forwards and upwards of the sternum. This increases the anteroposterior diameter of the thorax (Fig. 13.19).
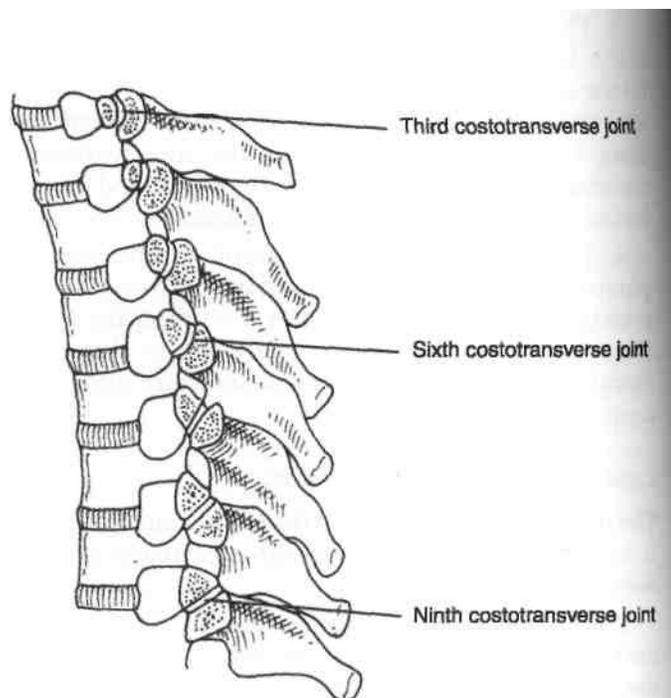
Fig. 13.18: A section through the costotransverse joints from the third to the ninth inclusive. Contrast the concave facets on the upper four with the flattened facets on the lower three transverse processes.

The articular surfaces of the seventh to tenth ribs are flat, permitting up and down gliding movements or bucket-handle movements of the lower ribs. When the neck of seventh to tenth ribs moves upwards, backwards and medially the result is increase in infrasternal angle. This causes increase in transverse diameter of thorax (Fig. 13.20).

For explanation of the terms 'pump-handle' and 'bucket handle' movements see 'Respiratory Movements'.

Costochondral Joints

Each rib is continuous anteriorly with its cartilage, to form a primary cartilaginous joint. No movements are permitted at these joints.
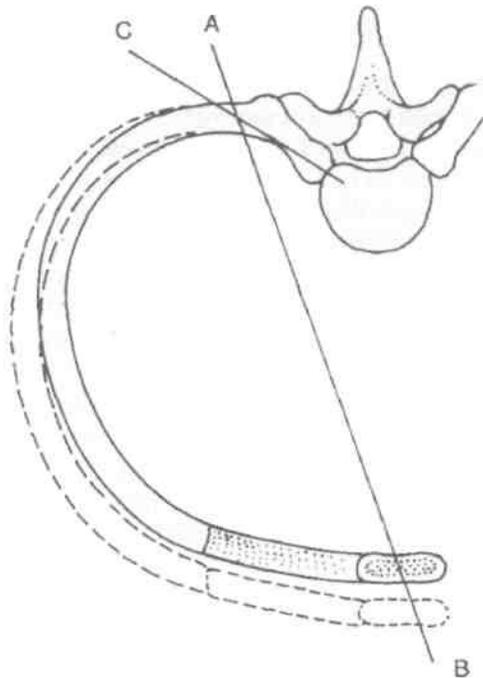
Fig. 13.19: A diagram showing the axes of movement (AB and CD) of a vertebrosternal rib. The interrupted lines indicate the position of the rib in inspiration.
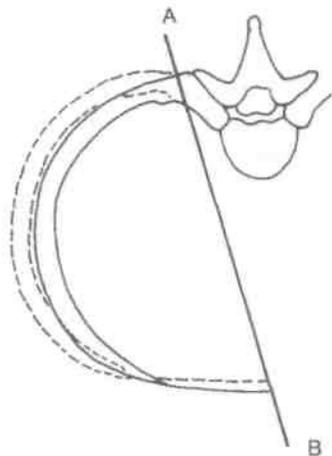
Fig. 13.20: A diagram showing the axes of movement (AB) of a vertebrochondral rib. The interrupted tines indicate the position of the rib in inspiration.

Chondrosternal Joints

The first chondrosternal joint is a primary cartilaginous joint, it does not permit any movement. This helps in the stability of the shoulder girdle and of the upper limb.

The second to seventh costal cartilages articulate with the sternum by synovial joints. Each joint has a single cavity except in the second joint where the cavity is divided in two parts. The joints are held together by the capsular and radiate ligaments.

Interchondral Joints

The fifth to ninth costal cartilages articulate with one another by synovial joints. The tenth cartilage is united to the ninth by fibrous tissue.

The movements taking place at the various joints described above are considered under 'Respiratory Movements'.

Intervertebral Joints

Adjoining vertebrae are connected to each other at three joints. There is a median joint between the vertebral bodies, and two joints—right and left— between the articular processes.

The joints between the articular processes are plane synovial joints.

The joint between the vertebral bodies is a symphysis (secondary cartilaginous joint). The surfaces of the vertebral bodies are lined by thin layers of hyaline cartilage. Between these layers of hyaline cartilage there is a thick plate of fibrocartilage which is called the intervertebral disc.

Intervertebral Discs

These are fibrocartilaginous discs which intervene between the bodies of adjacent vertebrae, and bind them together. Their shape corresponds to that of the vertebral bodies between which they are placed. The thickness of the disc varies in different regions of the vertebral column, and in different parts of the same disc. In the cervical and lumbar regions, the discs are thicker in front than behind, while in the thoracic region they are of uniform thickness. The discs are thinnest in the upper thoracic region, and thickest in the lumbar region.

The discs contribute about one-fifth of the length of the vertebral column. The contribution is greater in the cervical and lumbar regions than in the thoracic region.

Each disc is made up of the following two parts:

1. The *nucleus pulposus* is the central part of the disc. It is soft and gelatinous at birth. It is kept under tension and acts as a hydraulic shock absorber. With advancing age the elasticity of the disc is much reduced (Fig. 13.21).

2. The *annulus fibrosus* forms the peripheral part of the disc. It is made up of a narrower outer zone of collagenous fibres and a wider inner zone of fibrocartilage. The fibres form laminae that are arranged in the form of incomplete rings. The rings are connected by strong fibrous bands. The outer collagenous fibres blend with the anterior and posterior longitudinal ligaments.
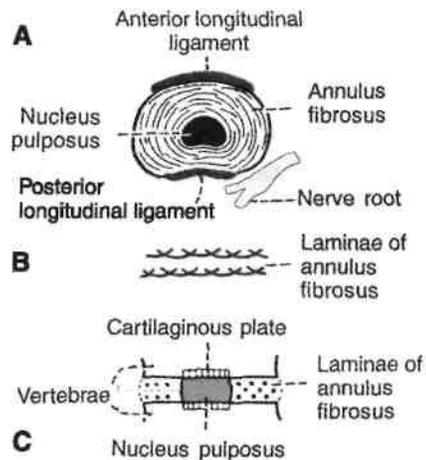
Fig. 13.21: *Structure of an intervertebral disc. (A) Superior view. (B) Arrangement of laminae. (C) Vertical section.*

Functions

1. The intervertebral discs give shape to the vertebral column.

2. They act as a remarkable series of shock absorbers or buffers.

3. Because of their elasticity they allow slight movement of vertebral bodies on each other, more so in the cervical and lumbar regions. When the slight movements at individual discs are added together they become considerable.

Ligaments Connecting Adjacent Vertebrae

Apart from the intervertebral discs and the capsules around the joints between the articular processes, adjacent vertebrae are connected by several ligaments which are as follows:

1. The *anterior longitudinal ligament* passes from the anterior surface of the body of one vertebra to another. Its upper end reaches the basilar part of the occipital bone (Fig. 13.21).

2. The *posterior longitudinal ligamentis* present on the posterior surface of the vertebral bodies within the vertebral canal. Its upper end reaches the body of the axis vertebra beyond which it is continuous with the membrana tectoria.

3. The *in tertransverse ligamen ts* connect adjacent transverse processes.

4. The *interspinous ligaments* connect adiacent spines.

5. The *supraspinous ligaments* connect the tips of the spines of vertebrae from the seventh cervical to the sacrum. In the cervical region, they are replaced by the ligamentum nuchae.

6. The *ligamenta flava* (singular = ligamentum flavum) connect the laminae of adjacent vertebrae. They are made up mainly of elastic tissue.

CLINICAL ANATOMY

In young adults, the discs are very strong. However, after the second decade of life degenerative changes set in resulting in weakness of the annu-lus fibrosus. When such a disc is subjected to strain the annulus fibrosus may rupture leading to prolapse of the nucleus pulposus. This is commonly referred to as disc prolapse. It may occur even after a minor strain. In addition to prolapse of the nucleus pulposus, internal derangements of the disc may also take place.

Disc prolapse is usually posterolateral. The prolapsed nucleus pulposus presses upon adjacent nerve roots and gives rise to pain that radiates along the distribution of the nerve. Such pain along the course of the sciatic nerve is called sciatica. Motor effects, with loss of power and reflexes, may follow. Disc prolapse occurs most frequently in the lower lumbar region. It is also common in the lower cervical region from fifth to seventh cervical vertebrae.

Movements of the Vertebral Column

Movements between adjacent vertebrae occur simultaneously at all the three joints connecting them. Movement between any two vertebrae is slight. However, when the movements between several vertebrae are added together the total range of movement becomes considerable. The movements are those of flexion, extension, lateral flexion and a certain amount of rotation. The range of movement differs in different parts of the vertebral column. This is influenced by the thickness and flexibility of the intervertebral discs and by the orientation of the articular facets. Flexion and extension occur freely in the cervical and lumbar region, but not in the thoracic region. Rotation is free in the thoracic region, and restricted in the lumbar and cervical regions.

RESPIRATORY MOVEMENTS

Introduction

The lungs expand passively during inspiration and retract during expiration. These movements are governed by the following two factors.

(i) Alterations in the capacity of the thorax are brought about by movements of the thoracic wall. Increase in volume of the thoracic cavity creates a negative intrathoracic pressure which sucks air into the lungs. Movements of

the thoracic wall occur chiefly at the costovertebral and manubriosternal joints, (ii) Elastic recoil of the pulmonary alveoli and of the thoracic wall expels air from the lungs during expiration.

Principles of Movements

1.Each rib may be regarded as a lever, the fulcrum of which lies just lateral to the tubercle. Because of the disproportion in the length of the two arms of the lever, the slight movements at the vertebral end of the rib are greatly magnified at the anterior end (Fig. 13.22).

2.The anterior end of the rib is lower than the posterior end. Therefore, during elevation of the rib, the anterior end also moves forwards. This occurs mostly in the vertebrosternal ribs. In this way, the anteroposterior diameter of the thorax is increased. Along with the up and down movements of the second to sixth ribs, the body of the sternum also moves up and down called 'pump-handle movements'.

3.The middle of the shaft of the rib lies at a lower level than the plane passing through the two ends. Therefore, during elevation of the rib, the shaft also moves outwards. This causes increase in the transverse diameter of the thorax.

Long arm
of lever

Short arm
of 'ever

' "—L_.___

i

JI

^ —-

Fulcrum Fig. 13.22:

Diagram comparing a rib to a lever.

Fig. 13.23: *Diagram showing how 'pump-handle' movements of the sternum bring about an increase in the anteroposterior diameter of the thorax.*
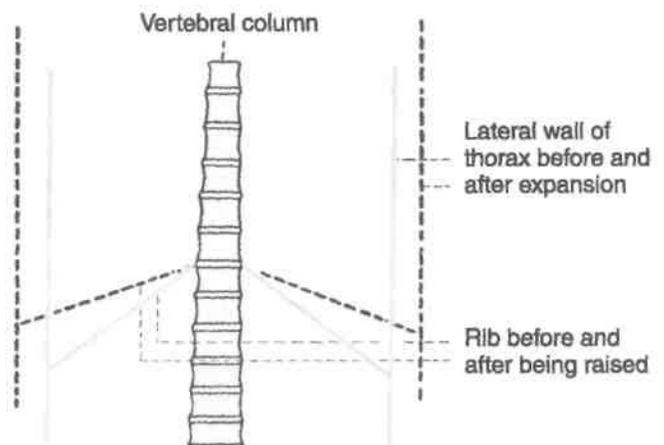
Fig. 13.24: *Scheme showing how 'bucket-handle' movements of the vertebrochondral ribs bring about an increase in the transverse diameter of the thorax.*

Such movements occur in the vertebrochondral ribs, and are called 'bucket-handle' movements (Fig. 13.23).

4. The thorax resembles a cone, tapering up wards. As a result each rib is longer than the next higher rib. On elevation the larger lower rib comes to occupy the position of the smaller upper rib. This also increases the transverse diameter of the thorax (Fig. 13.24).

Summary of the Factors Producing Increase in Diameters of the Thorax

The anteroposterior diameter is increased:
   (i) Mainly by the 'pump-handle' movements of the sternum brought about by elevation of the vertebrosternal second to sixth ribs.

(ii) Partly by elevation of the seventh to tenth vertebrochondral ribs. *The transverse diameter* is increased:

   (i) Mainly by the 'bucket-handle' movements of the seventh to tenth vertebrochondral ribs, (ii) Partly by elevation of the second to sixth vertebrosternal ribs. *The vertical diameteris* increased by descent of the diaphragm as it contracts.

Respiratory Muscles

1.During quiet breathing, inspiration is brought about chiefly by the diaphragm and partly by the intercostal muscles: quiet expiration occurs passively by the elastic recoil of the pulmonary alveoli and thoracic wall.

2.During forced breathing, inspiration is brought about by the diaphragm, the intercostal muscles,

the sternocleidomastoids, the scaleni, the serratus anterior, the pectoralis minor, and the erector spinae. The alaequae nasi open up the external nares.

Forced expiration is brought about by the muscles of the abdominal wall and by the latissimus dorsi.

Respiratory Movements during Different Types of Breathing

Inspiration

1. Quiet Inspiration

(i) The anteroposterior diameter of the thorax is increased by elevation of the second to sixth ribs. The first rib remains fixed.

(ii) The transverse diameter is increased by elevation of the seventh to tenth ribs.

(iii) The vertical diameter is increased by descent of the diaphragm.

2. Deep Inspiration

(i) Movements during quiet inspiration are increased, (ii) The first rib is elevated directly by the scaleni, and indirectly by the sternocleidomastoids, (iii) The concavity of the thoracic spine is reduced by the erector spinae.

3. Forced Inspiration

(i) All the movements described are exaggerated.

(ii) The scapulae are elevated and fixed by the trapezius, the levator scapulae and the rhomboideus, so that the serratus anterior and the pectoralis minor muscles may act on the ribs.

(iii) The action of the erector spinae is appreciably increased.

Expiration

1. Quiet Expiration

The air is expelled mainly by the elastic recoil of the chest wall and pulmonary alveoli, and partly by the tone of the abdominal muscles.

2. Deep and Forced Expiration

Deep and forced expiration is brought about by strong contraction of the abdominal muscles and of the latissimus dorsi.

CLINICAL ANATOMY

In dyspnoea or difficult breathing, the patients are most comfortable on sitting up, leaning forwards and fixing the arms. In the sitting posture, the position of diaphragm is lowest allowing maximum ventilation. Fixation of the arms fixes the scapulae, so that the serratus anterior and pectoralis minor may act on the ribs to good advantage.

The height of the diaphragm in the thorax is variable according to the position of the body and tone of the abdominal muscles. It is highest on lying supine, so the patient is extremely uncomfortable, as he/she needs to exert immensely for inspiration. The diaphragm is lowest while sitting. The patient is quite comfortable as the effort required for inspiration is the least.

The diaphragm is midway in position while standing, but the patient is too ill or exhausted to stand. So dyspnoeic patients feel comfortable while sitting.

14

The Walls of the Thorax

The thorax is covered by muscles of pectoral region of upper limb. In addition, the intercostal muscles and membranes fill up the gaps between adjacent ribs and cartilages. These muscles provide integrity to the thoracic wall. A right and left pair of thoracic nerves fulfil the exact definition of the dermatome.

The posterior intercostal vein, posterior intercostal artery and intercostal nerve (VAN) lie from above downwards in the costal groove of the ribs.

Sympathetic part of autonomic nervous system starts from the lateral horns of thoracic 1 to thoracic 12 segments of the spinal cord. It continues upto lumbar 2 segment.

Coverings of the Thoracic Wall

The thoracic wall is covered from outside to inside by the following structures: skin, superficial fascia, deep fascia, and extrinsic muscles. The extrinsic muscles covering the thorax are as follows.

A. Muscles of the Upper Limb

   i.   Pectoralis major
  ii.   Trapezius
 iii.   Serratus anterior
 iv.   Pectoralis minor
  v.   Latissimus dorsi
 vi.   Levator scapulae
 vii.   Rhomboideus major
viii.   Rhomboideus minor
 ix.   Serratus posterior superior
  x.   Serratus posterior inferior

B. Muscles of the Abdomen

   (i) Rectus abdominis,   (ii) External oblique.

C. Muscles of the Back

Erector spinae (sacrospinalis).

In addition to the muscles listed above, a number of other muscles of the abdomen and of the head and neck are attached to the margins of the two apertures of the thorax.

THORACIC WALL PROPER_____

The thoracic cage forms the skeletal framework of the wall of the thorax. The gaps between the ribs are called intercostal spaces. They are filled by the intercostal muscles and contain the intercostal nerves, vessels and lymphatics.

Intercostal Muscles

These are: (i) the external intercostal muscle, (ii) the internal intercostal muscle, and (iii) the transversus thoracis muscle which is divisible into three parts, namely the subcostalis, the intercostalis intimi and the sternocostalis. The attachments of these muscles are given in Table 14.1.

Extent

The external intercostal muscle extends from the tubercle of the rib posteriorly to the costochondral junction anteriorly. Between the costochondral junction and the sternum it is replaced by the external or anterior intercostal membrane. The posterior end of the muscle is continuous with the posterior fibres of the superior costotransverse ligament (Fig. 14.1).

The internal intercostal muscle extends from the lateral border of the sternum to the angle of the rib. Beyond the angle it becomes continuous with the internal or posterior intercostal membrane, which is continuous with the anterior fibres of the superior costotransverse ligament.

Table 14.1: The attachments of the intercostal muscles (Figs 14.1 to 14.3)

Muscle	Origin	Insertion
1.External intercostal	Lower border of the rib above the space	Outer lip of the upper border of the rib below
2.Internal intercostal	Floor of the costal groove of the rib above	Inner lip of the upper border of the rib below
3.Transversus thoracis		
(A)Subcostalis	Inner surface of the rib near the angle	Inner surface of two or three ribs below
(B)Intercostalis intimi	Middle two-fourths of the ridge above the costal groove	Inner lip of the upper border of the rib below
(C) Sternocostalis	(i) Lower one-third of the posterior surface of the body of the sternum (ii) Posterior surface of the xiphoid (iii) Posterior surface of the costal cartilages of the lower 3 or 4 true ribs near the sternum	Costal cartilages of the 2nd to 6th ribs
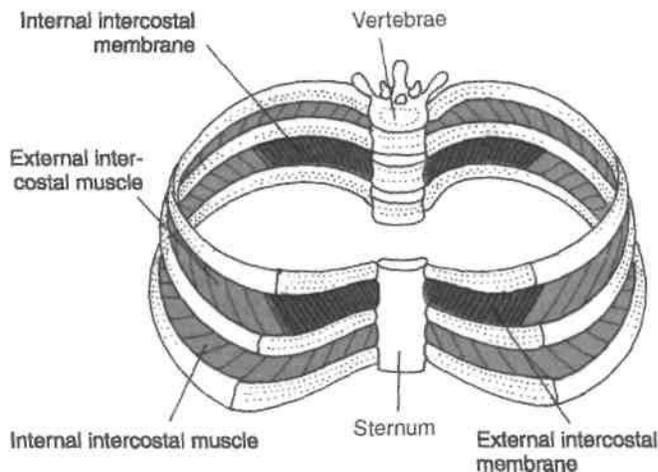
Fig. 14.1: Two layers of a typical intercostal space.

The subcostalis is confined to the posterior part of the lower intercostal spaces only.

The intercostalis intimi is confined to the middle two-fourths of the intercostal spaces (Fig. 14.2J.

The sternocostalis is present in relation to the anterior parts of the upper intercostal spaces.
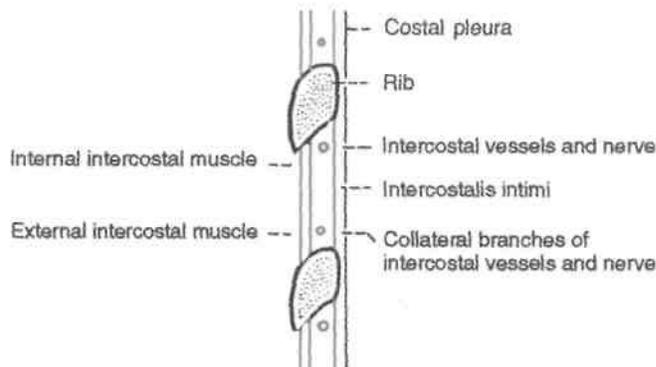
Fig. 14.2: Vertical section through an intercostal space.

Detach the serratus anterior and the pectoralis major muscles from the upper ribs. Note the external intercostal muscle in the second and third intercostal spaces. Its fibres run antero-; inferiorly. Follow it forwards to the external intercostal membrane which replaces it between the costal cartilages.

Cut the external intercostal membrane and muscle along the lower border of two spaces. Reflect them upwards to expose the internal intercostal muscle. The direction of its fibres is posteroinferiorly.

Follow the lateral cutaneous branch of one intercostal nerve to its trunk deep to internal intercostal muscle. Trace the nerve and accompanying vessels round the thoracic wall. Note their collateral branches lying along the upper margin of the rib below. Trace the muscular branches of the trunk of intercostal nerve and its collateral branch. Trace the anterior cutaneous nerve as well.

Identify the deepest muscle in the intercostal space, the innermost intercostal muscle. This muscle is deficient in the anterior and posterior ends of the intercostal spaces, where the neurovascular bundle rests directly on the parietal pleura.

Expose the internal thoracic artery 1 cm from the lateral margin of sternum by carefully removing the intercostal muscles and membranes from the upper three intercostal spaces. Trace the artery through the upper six intercostal spaces and identify its two terminal branches. Trace its vena comitantes upwards till third costal cartilage where

these join lo form internal thoracic vein, whirl drains into the brachiocephalic vein.

Follow the course and branches of both anterior and posterior intercostal arteries including the course and tributaries of azygos vein.

Direction of Fibres

b the anterior part of the intercostal space:

1.The fibres of the external intercostal muscle rur iownwards, forwards and medially

2.The fibres of the internal intercostal run down wards, backwards and laterally, I.e. at right angle tc hose of the external intercostal.

3.The fibres of the transversus thoracis run ir he same direction as those of the internal intercostal

Verve *Supply*

Ul intercostal muscles are supplied by the intercos al nerves of the spaces in which they lie.

\ctions of the Intercostal Muscles

1. The main action of the intercostal muscles is tc >revent retraction of the intercostal spaces during xpiration, and, their bulging outwards during nspiration.

1.The external intercostals, interchondral portions of the internal intercostals, and the levator costae may elevate the ribs during inspiration.

2.The internal intercostals except for the interchondral portions and the transversus thoracis may depress the ribs or cartilages during expiration.

NERVES AND VESSELS OF THE THORACIC WALL

Intercostal Nerves

The intercostal nerves are the anterior primary rami of thoracic one to thoracic eleven (Fig. 14.3) spinal nerves after the dorsal primary ramus has been given off. The anterior primary ramus of the twelfth thoracic nerve forms the subcostal nerve. In addition to supplying the intercostal spaces, the upper two intercostal nerves also supply the upper limb; and the lower five intercostal nerves; seventh to eleventh thoracic also supply abdominal wall. The latter are, therefore, said to be thoracoabdominal nerves. The remaining nerves; third to sixth thoracic supply only the thoracic wall; they are called *typical intercostal nerves.*

The subcostal nerve is distributed to the abdominal wall and to the skin of the buttock.

Course and Relations of a Typical Intercostal Nerve

1. Each nerve passes below the neck of the rib of the same number and enters the costal groove.
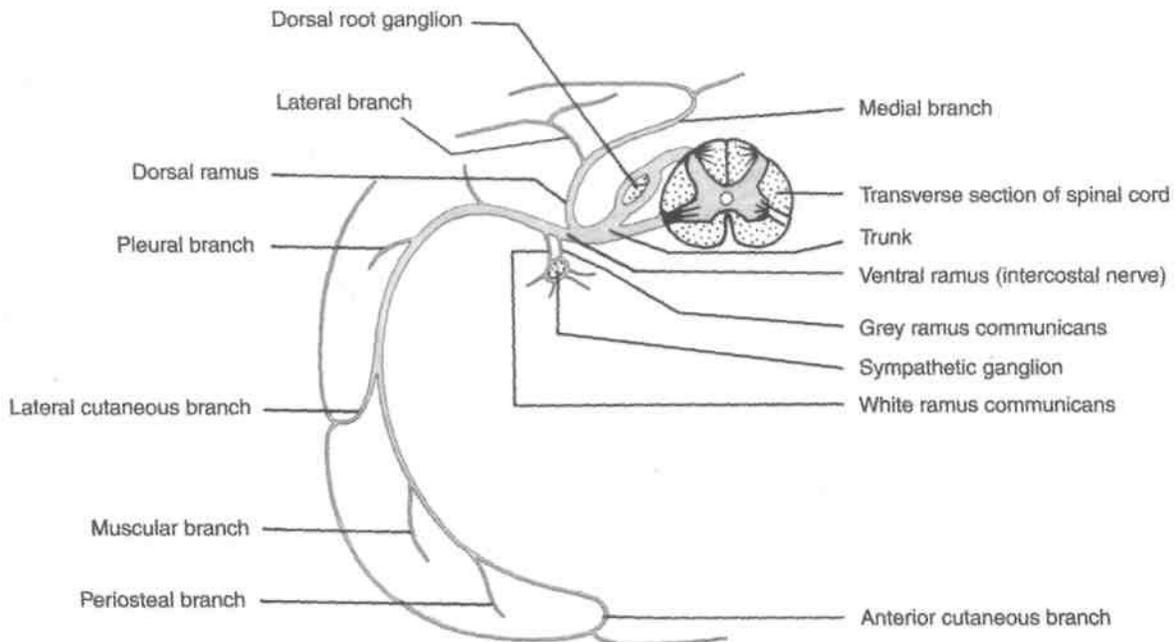
Fig. 14.3: *Typical thoracic spinal nerve. The ventral ramus ls the intercostal nerve.*

2. In the costal groove the nerve lies below the posterior intercostal vessels. The relationship of structures in the costal groove from above downwards is vein-artery-nerve (VAN) (Fig. 14.2).

In the posterior part of the costal groove, the nerve lies between the pleura, with the endothoracic fascia and the internal intercostal membrane.

In the greater part of the space, the nerve lies between the intercostalis intimi and the internal intercostal muscle (Fig. 14.4).

3. Near the sternum the nerve crosses in front of the internal thoracic vessels and the sternocostalis muscle. It then pierces the internal intercostal muscle, the external intercostal membrane and the pectoralis major muscle to terminate as the anterior cutaneous nerve of the thorax.

Branches and Distribution

Muscular Branches

1. Numerous muscular branches supply the intercostal muscles, the transversus thoracis and the serratus posterior superior.
2. A collateral branch arises near the angle of the rib and runs in the lower part of the space in the same neurovascular plane. It supplies muscles of the space. It also supplies the parietal pleura, parietal peritoneum in case of lower nerves and the periosteum of the rib.

Cutaneous Branches

1. The lateral cutaneous branch arises near the angle of the rib and accompanies the main trunk up

to the lateral thoracic wall where it pierces the intercostal muscles and other muscles of the body wall along the midaxillary line. It is distributed to the skin after dividing into anterior and posterior branches.

2. The anterior cutaneous branch emerges on the side of the sternum to supply the overlying skin after dividing into medial and lateral branches.

Communicating Branches

1. Each nerve is connected to a thoracic sympathetic ganglion by a distally placed white and a proximally placed grey ramus communicans.

2. The lateral cutaneous branch of the second intercostal nerve is known as the intercostobrachial nerve. It supplies the skin of the floor of the axilla and of the upper part of the medial side of the arm.

CLINICAL ANATOMY

1. Irritation of the intercostal nerves causes severe pain which is referred to the front of the chest or abdomen, i.e. at the peripheral termination of the nerve. This is known as root pain or girdle pain.

2. Pus from the vertebral column tends to track around the thorax along the course of the neurovascular bundle, and may point at any of the three sites of exit of the branches of a thoracic nerve; one dorsal primary ramus and two cutaneous branches.
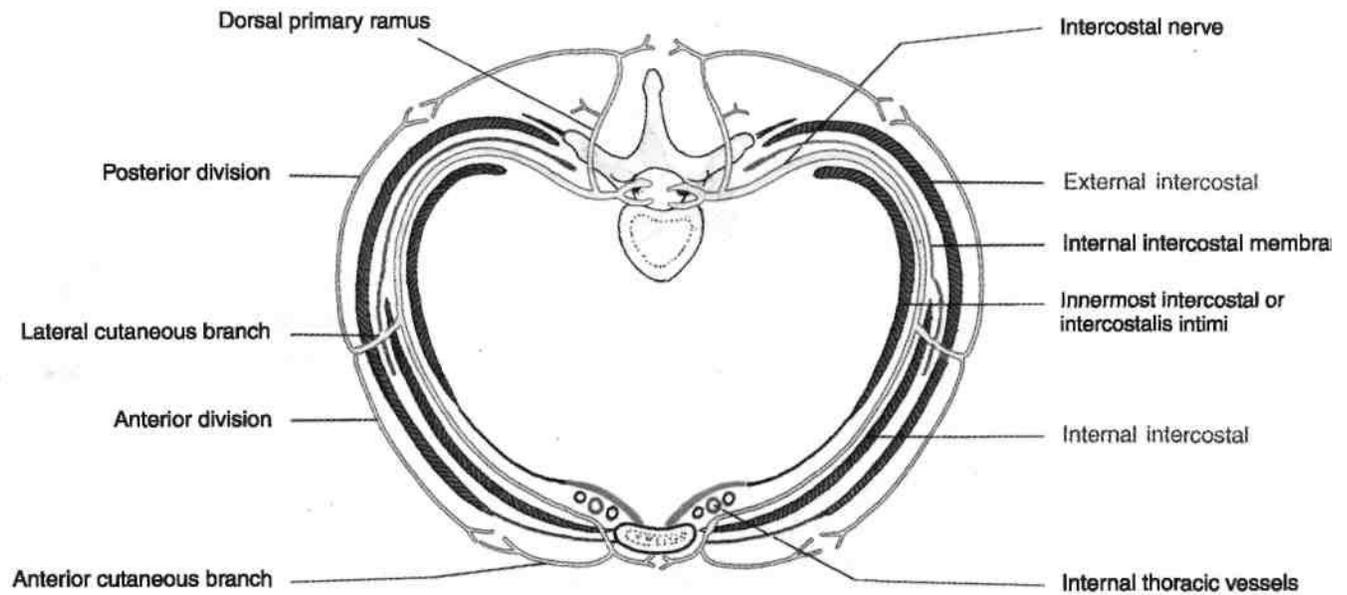
Fig. 14.4: *Scheme showing the course and branches of a typical intercostal nerve.*

, Bercostal Arteries

fr|ach intercostal space contains one posterior inter-°ftstal artery with its collateral branch and two 'interior intercostal arteries. The greater part of the ■ace is supplied by the posterior intercostal artery #lg. 14.5).

msterior Intercostal Arteries

■hese are eleven in number on each side, one in each ■space.

1. The first and second posterior intercostal ■uteries arise from the superior intercostal artery ■which is a branch of the costocervical trunk.

2. The third to eleventh arteries arise from the
1 descending thoracic aorta (Fig. 14.6). no

I *Course and Relations*

In front of the vertebrae: The right posterior
(I intercostal arteries are longer than the left, and pass I behind the oesophagus, the thoracic duct, the azygos I vein and the sympathetic chain (Fig. 14.7).

The left posterior intercostal arteries pass behind I the hemiazygos vein and the sympathetic chain (Fig. 14.5).

In the intercostal space: The artery is accompanied by the intercostal vein and nerve, the relationship from above downwards being vein-artery-nerve (VAN).

The neurovascular bundle runs forwards in the costal groove, first between the pleura and the

internal intercostal membrane and then between the internal intercostal and intercostalis intimi muscles.

Termination

Each posterior intercostal artery ends at the level of the costochondral junction by anastomosing with the upper anterior intercostal artery of the space (Fig. 14.5).

Branches

1. A dorsal branch supplies the muscles and skin of the back, and gives off a spinal branch to the spinal cord and vertebrae (Fig. 14.5).
2. A collateral branch arises near the angle of the rib, descends to the upper border of the lower rib, and ends by anastomosing with the lower anterior intercostal artery of the space.
3. Muscular arteries are given off to the intercostal muscles, the pectoral muscles and the serratus anterior.
4. A lateral cutaneous branch accompanies the nerve of the same name.
5. Mammary branches arise from the second, third and fourth arteries and supply the mammary gland.
6. The right bronchial artery arises from the right third posterior intercostal artery.

Anterior Intercostal Arteries

There are nine intercostal spaces anteriorly. There are two anterior intercostal arteries in each space. In
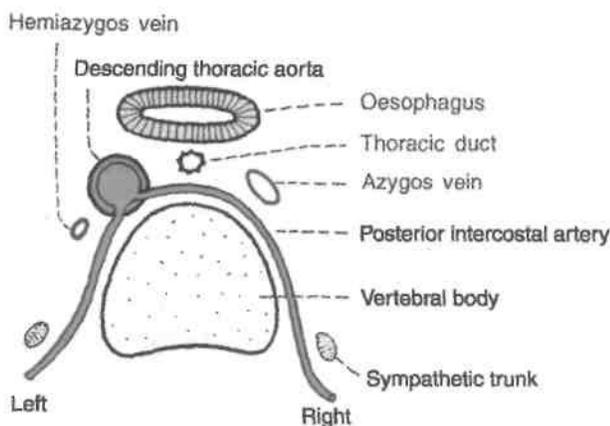
Fig. 14.7: *Diagram showing the origin of the right and left posterior intercostal arteries from the aorta. Note that the arteries are longer on the right side.*

the upper six spaces, they arise from the internal thoracic artery. In seventh to ninth spaces, the arteries are branches of musculophrenic artery. The
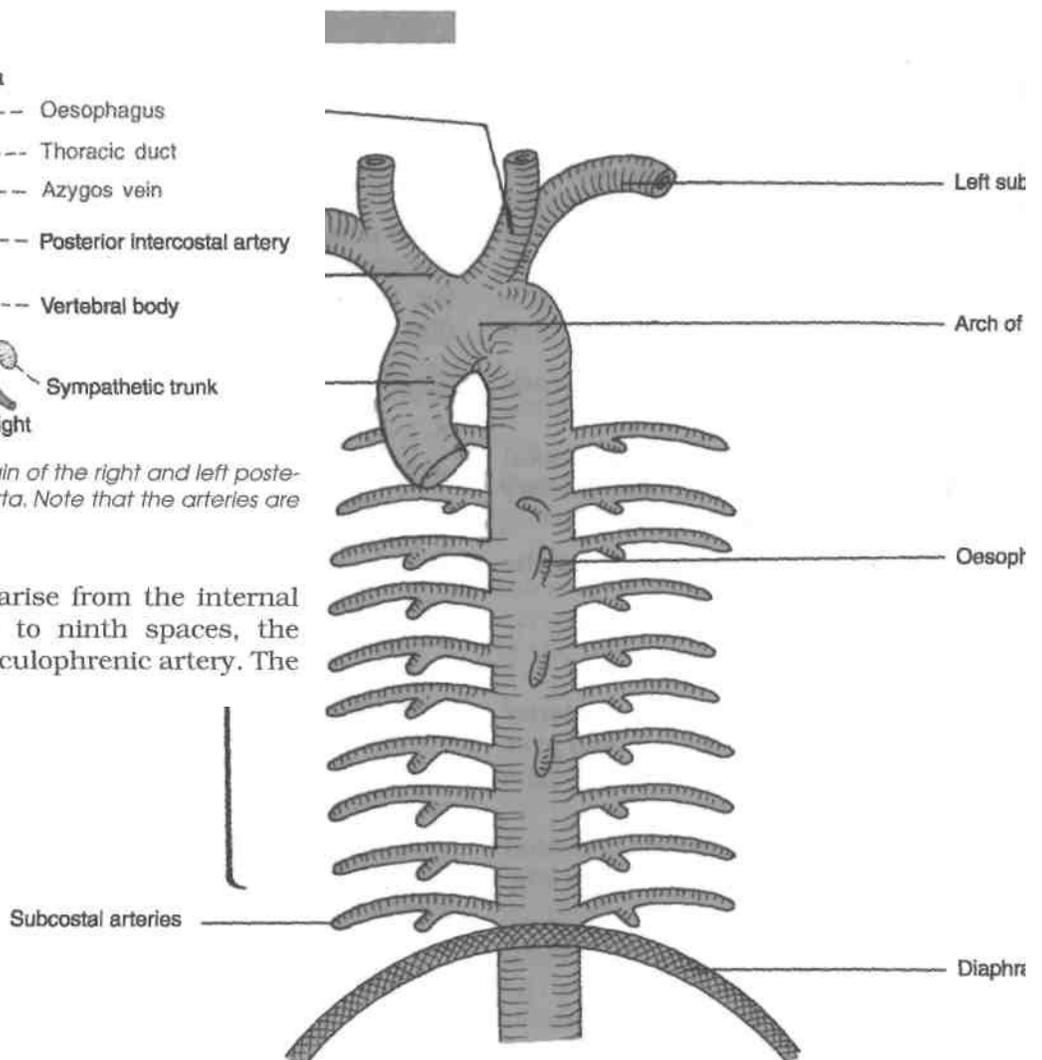
Fig. 14.6: *Branches of descending thoracic aorta.*

upper anterior intercostal arteries end at the costo-chondral junction by anastomosing with the posterior intercostal arteries. The lower arteries end by anastomosing with the collateral branches of the posterior intercostal arteries.

Intercostal Veins

There are two *anterior intercostal veins* in each of the upper nine spaces. They accompany the corresponding arteries. In the upper six spaces, the veins end in the internal thoracic vein. In the succeeding spaces, they end in the musculophrenic vein.

There is one *posterior intercostal vein* and one collateral vein in each intercostal space. Each vein accompanies the corresponding artery and lies superior to the artery. The tributaries of these veins correspond to the branches of the arteries. They include veins from the vertebral canal, the vertebral venous plexus, and the muscles and skin of the back

vein accommmpanying the collateral branch of the artery drains into the posterior intercostal vein.

The mode of termination of the posterior intercostal veins is different on the right and left sides as given in Table 14.2, and shown in Fig. 14.8.

Table 14.2: Termination of posterior intercostal veins

Veins	On right side they drain into	On left side they drain into
1st	Right brachiocephalic vein	Left brachiocephalic vein
2nd, 3rd, 4th	Join to form right superior intercostal vein which drains into the azygos vein	Join to form left superior intercostal vein which drains into the left brachio-cephalic vein
5th to 8th		Accessory hemiazygos vein
9th to 11th and subcostal	Azygos vein	Hemiazygos vein

The azygos and hemiazygos veins are described ater.

ymphatics of an Intercostal Space

ymphatics from the anterior part of the spaces pass o the anterior intercostal or internal mammary lodes which lie along the internal thoracic artery.

Their efferents unite with those of the tracheobronchial and brachiocephalic nodes to form the bronchomediastinal trunk, which joins the subclavian trunk on the right side and the thoracic duct on the left side.

Lymphatics from the posterior part of the space pass to the posterior intercostal nodes which lie on the heads and necks of the ribs. Their efferents in the lower four spaces unite to form a trunk which descends and opens into the cisterna chyli. The efferents from the upper spaces drain into the thoracic duct on the left side and into the right lymphatic duct on the right side.

INTERNAL THORACIC ARTERY

Origin

Internal thoracic artery arises from the inferior aspect of the first part of the subclavian artery opposite the thyrocervical trunk. The origin lies 2 cm above the sternal end of the clavicle (Fig. 14.9).

Surface Marking

Internal thoracic artery is marked by joining the following points.

1.A point 1 cm above the sternal end of the clavicle, 3.5 cm from the median plane (Fig. 14.10).

2.Points marked over the upper 6 costal cartilages at a distance of 1.25 cm half from the lateral sternal border.
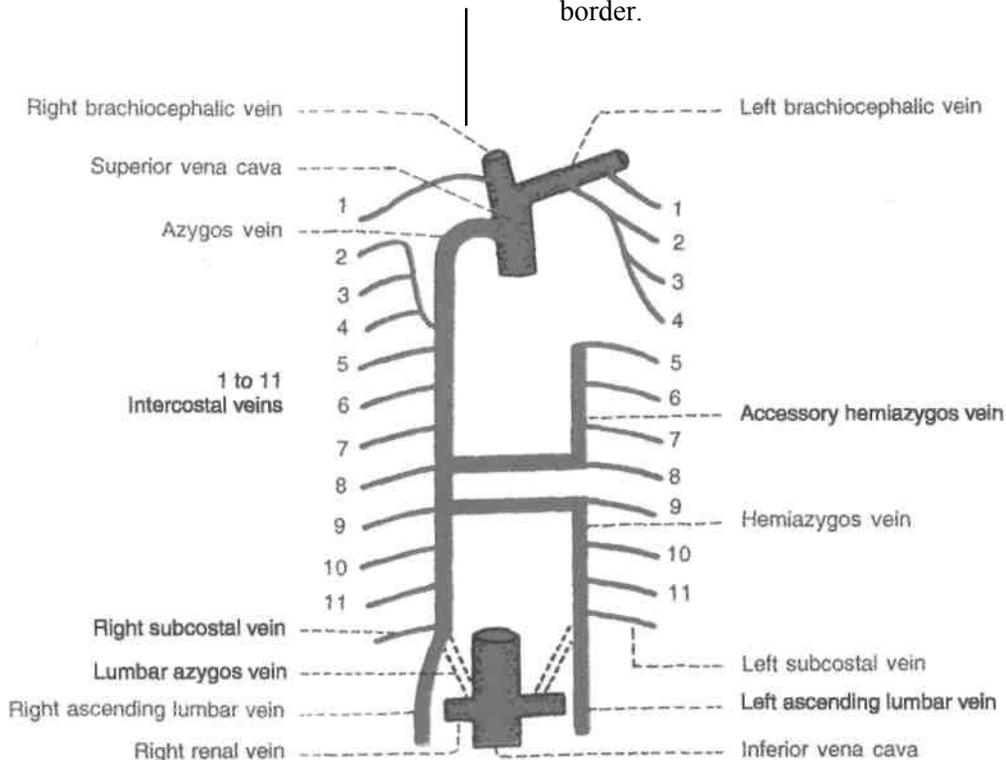
Fig. 14.8: The veins on the posterior thoracic wall. Note the drainage of the posterior intercostal veins.
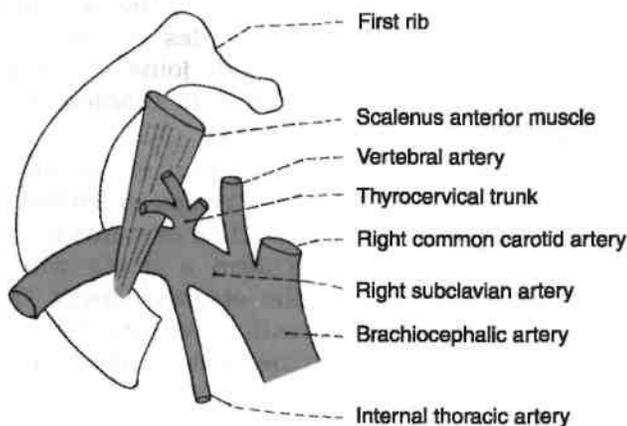
Fig. 14.9: *The origin of the internal thoracic artery from the first part of the subclavian artery.*

internal intercostal muscles, and (vi) the first six intercostal nerves.

Posteriorly: (i) The endothoracic fascia and pleura upto the second or third costal cartilage. Below this level the sternocostalis muscle separates the arteiy from the pleura (Fig. 14.11).

The artery terminates in the sixth intercostal space by dividing into the superior epigastric and musculophrenic arteries.

The artery is accompanied by two venae comitantes which unite at the level of the third costal cartilage to form the internal thoracic or internal mammary vein. The vein runs upwards along the medial side of the artery to end in the brachiocephalic vein at the inlet of the thorax.

A chain of lymph nodes lies along the artery.
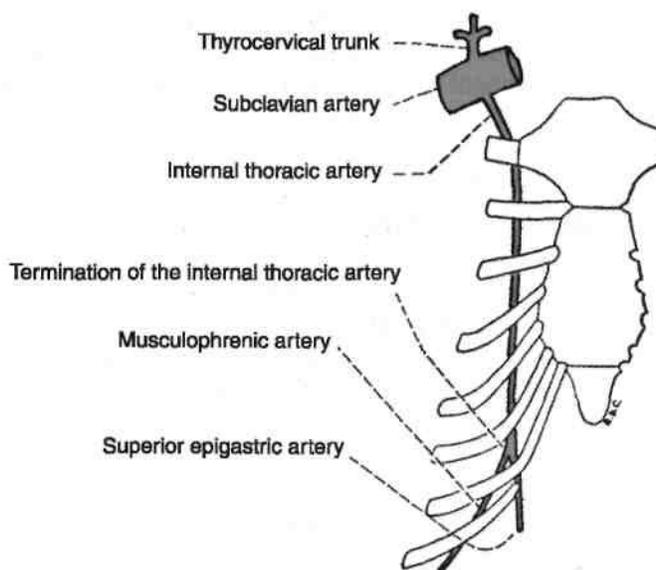
Fig. 14.10: *The origin, course and terminations of the internal thoracic artery.*

(v) the phrenic nerve. It descends in front of the cervical pleura.

Below the first costal cartilage the artery runs vertically downwards up to its termination in the 6th intercostal space. Its relations are as follows:

Anteriorly: (i) Pectoralis major, (ii) upper six costal cartilages, (iii) external intercostal membranes, (iv)

3. The last point is marked in the sixth space 1.25 cm half from the lateral sternal border.

Course and Relations

Above the first costal cartilage it runs downwards, forwards and medially, behind: (i) The sternal end of the clavicle, (ii) the internal jugular vein, (iii) the brachiocephalic vein, (iv) the first costal cartilage, and
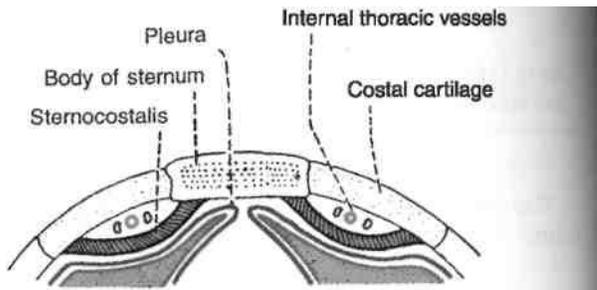
Fig. 14.11: *Transverse section through the anterior thoracic wall to show the relations of the internal thoracic vessels. In the lower part of their course the vessels are separated from the pleura by the sternocostalis muscle.*

Branches

1. The *pericardiophrenic artery* arises in the root of the neck and accompanies the phrenic nerve to reach the diaphragm. It supplies the pericardium and the pleura.

2. The *mediastinal arteries* are small irregular branches that supply the thymus, in front of the pericardium, and the fat in the mediastinum.

3. Two *anterior intercostal arteries* are given to each of the upper six intercostal spaces.

4. The *perforating branches* accompany the anterior cutaneous nerves. In the female, the perforating branches in the second, third and fourth spaces are large and supply the breast.

5. The *superior epigastric artery* runs downwards behind the seventh costal cartilage and enters the rectus sheath by passing between the sternal and costal slips of the diaphragm. Its further course is described in Vol. 2 of this book.

6. The *musculophrenic artery* runs downwards and laterally behind the seventh, eighth, and ninth

costal cartilages. It gives two anterior intercostal branches to each of these three spaces. It perforates the diaphragm near the 9th costal cartilage and terminates by anastomosing with other arteries on the undersurface of the diaphragm.

Note that through its various branches the internal thoracic artery supplies the anterior thoracic and abdominal walls from the clavicle to the umbilicus.

THE AZYGOS VEIN

The azygos vein drains the thoracic wall and the upper lumbar region (Figs 14.8, 20.6B, C). It forms an important channel connecting the superior and inferior venae cavae. The term 'azygos' means unpaired. The vein occupies the upper part of the posterior abdominal wall and the posterior mediastinum.

Formation

The azygos vein is formed by union of the lumbar azygos, right subcostal and right ascending lumbar veins.

1. The lumbar azygos vein may be regarded as the abdominal part of the azygos vein. It lies to the right of the lumbar vertebrae. Its lower end communicates with the inferior vena cava.

2. The right subcostal vein accompanies the corresponding artery.

3. The ascending lumbar vein is formed by vertical anastomoses that connect the lumbar veins. Usually, the right subcostal and ascending lumbar veins join to form a common channel that joins the lumbar azygos vein. Occasionally the lumbar azygos vein is absent. The azygos vein is then formed by union of the right subcostal and ascending lumbar veins.

Course

1. The azygos vein enters the thorax by passing through the aortic opening of the diaphragm.

2. The azygos vein then ascends up to fourth thoracic vertebra where it arches forwards over the root of the right lung and ends by joining the posterior aspect of the superior vena cava just before the latter pierces the pericardium (Fig. 15.1).

Relations

Anteriorly: Oesophagus.

Posteriorly: (i) Lower eight thoracic vertebrae, and (ii) right posterior intercostal arteries.

To the right: (i) Right lung and pleura, and (ii) greater splanchnic nerve.

To the left: (i) Thoracic duct and aorta in lower part, and (ii) oesophagus, trachea and vagus in the upper part.

Tributaries

1. Right superior intercostal vein formed by union of the second, third and fourth posterior intercostal veins.

2. Fifth to eleventh right posterior intercostal veins (Fig. 14.8).

3. Hemiazygos vein at the level of eight thoracic vertebra T8.

4. Accessory hemiazygos vein at the level of eight thoracic vertebra.

5. Right bronchial vein, near the terminal end of the azygos vein.

6. Several oesophageal, mediastinal, pericardial veins.

7. When the azygos vein begins as lumbar azygos vein the common trunk formed by the union of the right ascending lumbar vein and right subcostal vein is the largest tributary.

CLINICAL ANATOMY

In superior vena caval obstruction, the vein is the main channel which transmits the blood from the upper half of the body to either the unobstructed portion of the superior vena cava or to the inferior vena cava.

HEMIAZYGOS VEIN

Hemiazygos vein is also called the inferior hemiazygos vein. It is the mirror image of the lower part azygos vein. It may originate either from the surface of the left renal vein, or may be formed by the union of the left ascending lumbar and left subcostal veins.

Course

Hemiazygos vein pierces the left crus of the diaphragm, ascends on the left side of the vertebra overlapped by the aorta. At the level of eighth thoracic vertebra, it turns to the right, passes behind the oesophagus and the thoracic duct, and joins the azygos vein (Fig. 14.8).

Tributaries

(i) Left ascending lumbar vein, (ii) left subcostal vein, and (iii) ninth to eleventh left posterior intercostal veins.

ACCESSORY HEMIAZYGOS VEIN

Accessory hemiazygos vein is also called the superior hemiazygos vein. It is the mirror image of the upper part of the azygos vein.

Course

Accessory hemiazygos vein begins at the medial end of the fourth or fifth intercostal space, and descends on the left side of the vertebral column. At the level of eighth thoracic vertebra it turns to the right, passes behind the aorta and the thoracic duct, and joins the azygos vein.

Sometimes the hemiazygos and accessory hemiazygos veins join together to form a common trunk which opens into the azygos vein.

Tributaries

(i) Fifth to eighth left posterior intercostal veins, and (iij sometimes the left bronchial veins.

THE THORACIC SYMPATHETIC TRUNK   ~

The thoracic sympathetic trunk is a ganglionated chain situated one on each side of the thoracic vertebral column. Superiorly it is continuous with

the cervical part of the chain and inferiorly with **the!** lumbar part (Figs 14.12, 14.13).

Theoretically the chain bears 12 ganglia corresponding to the 12 thoracic nerves. However, the number of the ganglia is often reduced to 10 or J 11 due to fusion of adjacent ganglia with one another.
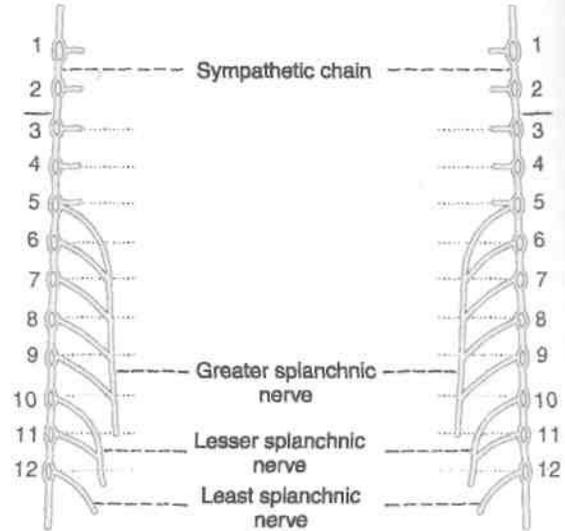
Fig. 14.12: The thoracic part of the sympathetic trunk, and its splanchnic branches.
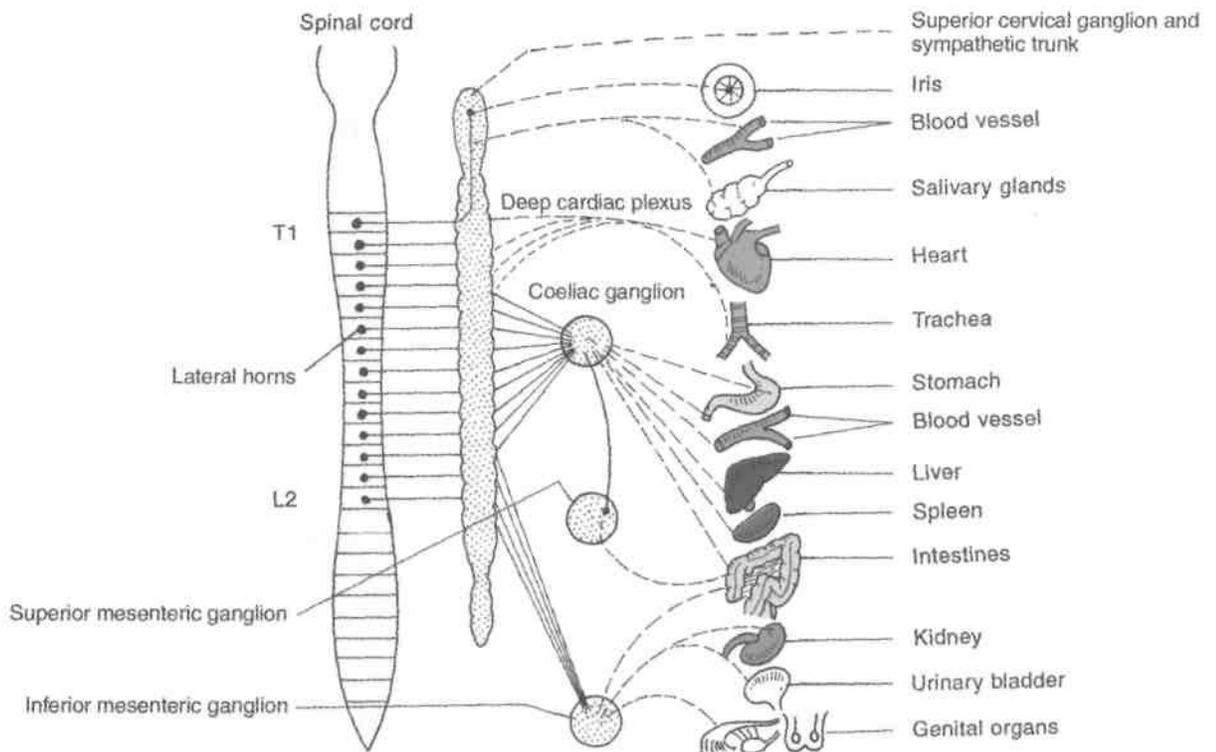
Fig. 14.13: The sympathetic outflow, black lines–preganglionic fibres; interrupted lines–postganglionic fibres.

The first thoracic ganglion is commonly fused with the inferior cervical ganglion to form the cervi-cothoracic, or stellate ganglion. The second thoracic ganglion is occasionally fused with the first. The remaining thoracic ganglia generally lie at the levels of the corresponding intervertebral discs and the intercostal nerves. The portion of the chain between two ganglia may be very slender; and at other times it may be double.

Course and Relations

The chain crosses the neck of the first rib, the heads of the second to tenth ribs, and bodies of the eleventh and twelfth thoracic vertebrae. The whole chain descends in front of the posterior intercostal vessels and the intercostal nerves, and passes deep to the medial arcuate ligament to become continuous with the lumbar part of the sympathetic chain.

Branches

Lateral Branches for the Limbs and Body Wall

Each ganglion is connected with its corresponding spinal nerve by two rami, the white (preganglionic) and grey (postganglionic) rami communicans. The white ramus is distal to the grey ramus, the two rami may fuse to form a single 'mixed' ramus.

Medial Branches for the Viscera

   (a) Medial branches from the upper 5 ganglia are postganglionic and get distributed to the heart, the

great vessels, the lungs and the oesophagus, through:

  (i) Pulmonary branches to the pulmonary plexuses.

  (ii) Cardiac branches to the deep cardiac plexus.

  (iii) Aortic branches to thoracic aortic plexus.

  (iv) Oesophageal branches which join the oesophageal plexus.

 (b) Medial branches from the lower 7 ganglia are preganglionic and form three splanchnic nerves.

  (i) *The greater splanchnic nerve* is formed by 5 roots from ganglia 5 to 9. It descends obliquely on the vertebral bodies, pierces the crus of the diaphragm, and ends (in the abdomen) mainly in the coeliac ganglion, and partly in the aorticorenal ganglion and the suprarenal gland.

  (ii) *The lesser splanchnic nerve* is formed by two roots from ganglia 10 and 11. Its course is similar to that of the greater splanchnic nerve. It pierces the crus of the diaphragm, and ends in the coeliac ganglion (Fig. 14.12).

  (iii) *The least (lowest) splanchnic nerve (renal nerve)* is tiny and often absent. It arises by one root from ganglion 12. It either pierces the corresponding crus of the diaphragm, or passes behind the medial arcuate ligament (with the main sympathetic chain) and ends in the renal plexus.

15

The Thoracic Cavity and Pleurae

T^he spongy lungs occupying a major portion of thoracic cavity are enveloped in a serous cavity — the pleural caviy. There is always slight negative pressure in this cavity. During inspiration the pressure becomes more negative, and air is drawn into the lungs covered with its visceral and parietal layers. Visceral layer is inseparable from the lung and is

supplied by the same arteries, veins and nerves as lungs. In a similar fashion, the parietal pleura sincerely follows the walls of the thoracic cavity with cervical, costal, diaphragmatic and mediastinal parts. Pleural cavity limits the expansion of the lungs.

THE PLEURA

Introduction

Like the peritoneum, the pleura is a serous membrane which is lined by mesothelium (flattened epithelum). There are two pleural sacs, one on either side of the mediastinum. Each pleural sac is invaginated from its medial side by the lung, so that it has an outer layer, the *parietal pleura,* and an inner layer, the *visceral or pulmonary pleura.* The two layers are continuous with each other around the hilum of the lung, and enclose between them a potential space, the pleural cavity (Fig. 15.3). In some diseases, the pleural cavity may get filled with air, fluid, blood, or pus. These conditions are called pneumothorax, pleural effusion, haemothorax or empyema respectively.

■■■■ DISSECTION (■■■■■

Divide the manubrium sterm transversely immediately inferior to its junction with the first costal cartilage. Cut through the parietal pleura in the first intercostal space on both sides as far back as possible. Carry the cut inferiorly through

the second and lower ribs or costal cartilages from the posterior end of pleural incision to the level of the xiphisternal joint.

Lift the inferior part of manubrium and body of sternum with ribs and costal cartilages and reflect it towards abdomen. Identify the pleura extending from the back of sternum on to the mediastinum to the level of lower border of heart. Note the smooth surface of pleura where it lines the thoracic wall and covers the lateral aspects of mediastinum. Trace the reflection of parietal pleura on the skeleton.

Remove the pleura and the endothoracic fascia from the back of sternum and costal cartilages which is reflected towards abdomen. Identify the transversus thoracis muscle and internal thoracic vessels. Note the origin of diaphragm from the xiphoid process and divide it. Identify the course and branches of intercostal nerve again. Trace the nerve medially superficial to the internal thoracic vessels.

Pull the lung laterally from the mediastinum and find its root with the pulmonary ligament extending downwards from it. Cut through the structures, i.e. bronchus/bronchi, pulmonary vessels, nerves, comprising its root from above downwards close to the lung. Remove the lung on each side. Be careful not to injure the lung or your hand from the cut ends of the ribs.

Identify the phrenic nerve with accompanying blood vessels anterior to the root of the lung. Give a longitudinal incision through the pleura only parallel to and on each side of the phrenic nerve. Strip the pleura posterior to the nerve backwards to the intercostal spaces. Pull the anterior flap forwards to reveal part of the pericardium with the heart. Identify the following structures seen through the pleura.

217

Right side

1. Bulge of the heart and pericardium anteroinferior to the root of the lung (Fig. 15.1).

2. A longitudinal ridge formed by right brachio-cephalic vein down to first costal cartilage and by superior vena cava up to the bulge of the heart.

3. A smaller longitudinal ridge formed by inferior vena cava formed between the heart and the diaphragm.

4. Phrenic nerve with accompanying vessels forming a vertical ridge on these two venae cavae passing anterior to root of the lung.

5. Vena azygos arching over root of the lung to enter the superior vena cava.

6. Trachea and oesophagus posterior to the phrenic nerve and superior vena cava.

7. Right vagus nerve descending postero-inferiorly across the trachea, behind the root of the lung.

8. Bodies of the thoracic vertebrae behind oesophagus with posterior intercostal vessels and azygos vein lying over them.

9. Sympathetic trunk on the heads of the upper ribs and on the sides of the vertebral bodies below this, anterior to the posterior intercostal vessels and intercostal nerves.

Left Side

1. Bulge of the heart (Fig. 15.2).

2. Root of lung posterosuperior to it.

3. Descending aorta between (1) and (2) in front and vertebral column behind.

4. Arch of aorta over the root of the lung.

5. Left common carotid and left subclavian arteries passing superiorly from the arch of aorta.

6. Phrenic and vagus nerves descending between these vessels and the lateral surface of the aortic arch.

7. Sympathetic trunk same as on right side.

Identify longitudinally running sympathetic trunk on the posterior part of thoracic cavity. Find delicate greater and lesser splanchnic nerves arising from the trunk on the medial side. Look carefully for grey and white rami communicans between the intercostal nerve and the ganglia on the sympathetic trunk. Trace the intercostal vessels above the intercostal nerve. The order being vein, artery and nerve (VAN). On the right side identify and follow one of the divisions of trachea to the lung root and the superior and inferior venae cavae till the pericardium.
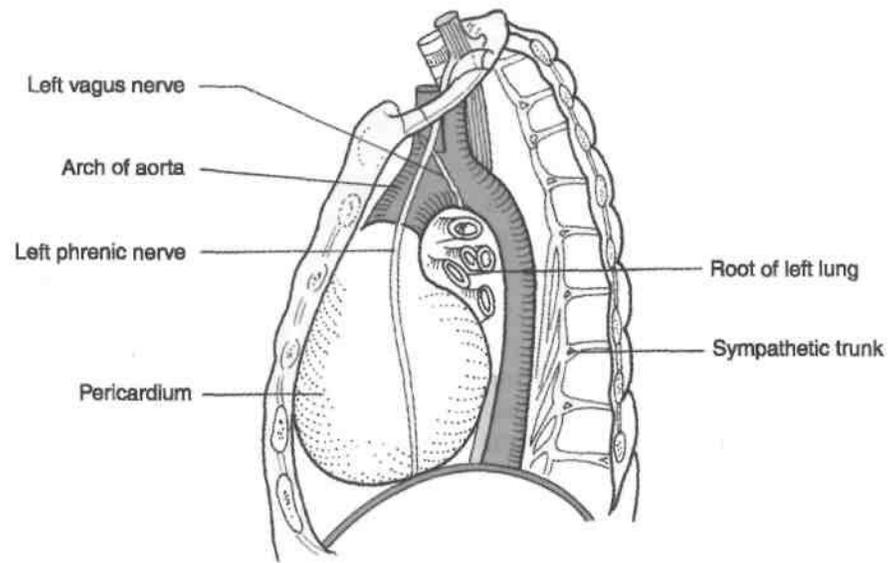
Fig. 15.2: *Mediastinum as seen from the left side.*

On the left side of thoracic cavity dissect the arch of aorta. Identify the superior cervical cardiac branch of the left sympathetic trunk and the inferior cervical cardiac branch of the left vagus on the arch of the aorta between the vagus nerve posteriorly and phrenic nerve anteriorly.

The cavity of the thorax contains the right and left pleural cavities which are completely invag-inated and occupied by the lungs. The right and left pleural cavities are separated by a thick median partition called the mediastinum. The heart lies in the mediastinum.

he Pulmonary Pleura

"he pulmonary pleura covers the surfaces and fis-lures of the lung, except at the hilum and along the ittachment of the pulmonary ligament where it is

continuous with the parietal pleura. It is firmly adherent to the lung and cannot be separated from it.

The Parietal Pleura

The parietal pleura is thicker than the pulmonary pleura, and is subdivided into four parts: (i) costal, (ii) diaphragmatic, (iii) mediastinal, and (iv) cervical (Figs 15.3, 15.4).

The *costal pleura* lines the thoracic wall comprises ribs and intercostal spaces to which it is loosely attached by a layer of areolar tissue called the endothoracic fascia. The *mediastinal pleura* lines the corresponding surface of the mediastinum. It is reflected over the root of the lung and becomes continuous with the pulmonary pleura around the hilum. The *cervical pleura* extends into the neck, nearly 5 cm above the first costal cartilage and 2.5 cm above the medial one-third of the clavicle, and covers the apex of the lung (Fig. 12.7). It is covered

Fig. 15.3: *The parietal pleura. The lung represented on the righ the earlier stage.*

Fig. 15.7: *Reflections of pleura as seen in a coronal section of the thorax.*
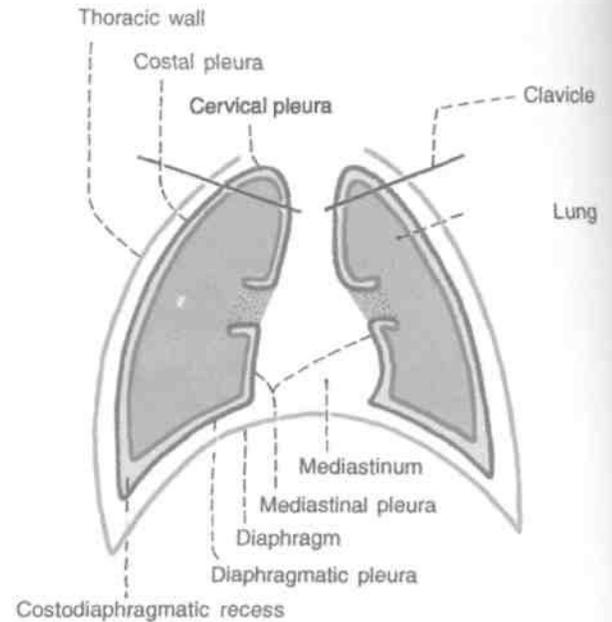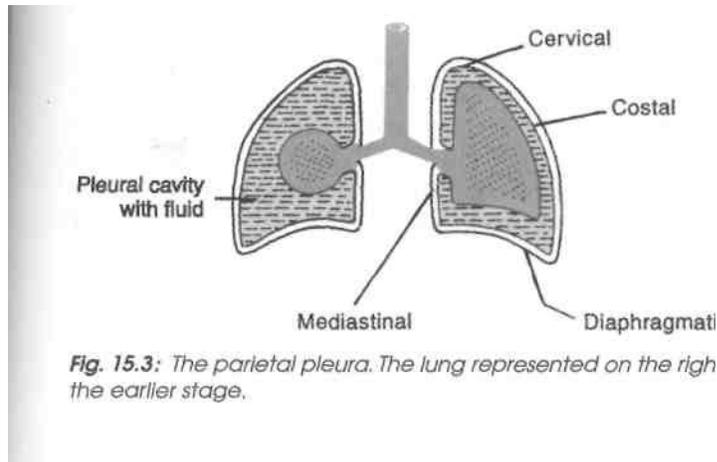
by the suprapleural membrane. It is related anteriorly to the subclavian artery and the scalenus anterior; posteriorly to the neck of the first rib and structures lying over it; laterally to the scalenus medius; and medially to the large vessels of the neck (Fig. 12.7).

Diaphragmatic pleura lines the superior aspect of diaphragm. It covers the base of the lung and gets continuous with mediastinal pleura medially and costal pleura laterally.

The Pulmonary Ligament

The parietal pleura surrounding the root of the lung extends downwards beyond the root as a fold called the pulmonary ligament. The fold contains a thin layer of loose areolar tissue with a few lymphatics. Actually it provides a dead space into which the pulmonary veins can expand during increased venous return as in exercise. The lung roots can also descend into it with the descent of the diaphragm (Fig. 15.5).
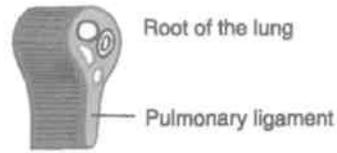
Fig. 15.5: *Diagram of pleura at root of lung.*

Recesses of Pleura

There are two folds or recesses of parietal pleura, which act as 'reserve spaces' for the lung to expand during deep inspiration (Figs 15.6–15.8).
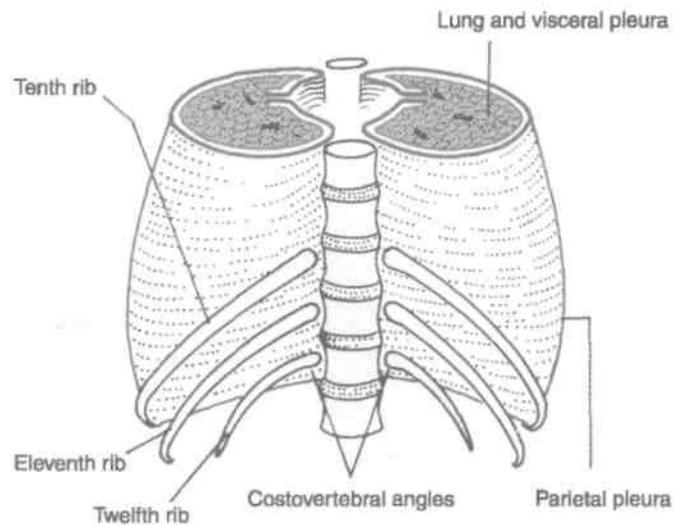
Fig. 15.6: *The pleural reflections, from behind.*
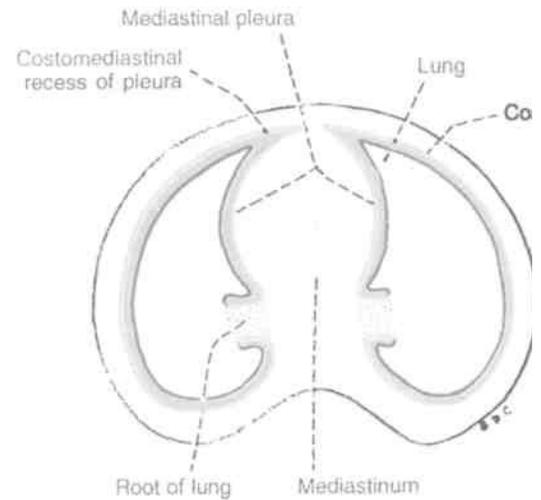
Fig. 15.8: *Reflections of the pleura as seen in a transv... through the thorax.*

The *costomediastinal recess* lies anterior the sternum and costal cartilages, between and mediastinal pleurae, particularly in the cardiac notch of the left lung. This rece up by the anterior margin of the lungs ev quiet breathing. It is only obvious in the the cardiac notch of the lung.

The *costodiaphragmatic recess* lies between the costal and diaphragmati Vertically it measures about 5 cm, and ext the eighth to tenth ribs along the midaxil

J Surface Marking of the Pleura

The *cervical pleura* is represented by a curved line forming a dome over the medial one-third of the clavicle with a height of about 2.5 cm above the bone (Fig. 15.9, 16.5).

The *anterior margin,* the costomediastinal line of pleural reflection is as follows: On the right side it extends from the sternoclavicular joint downwards and medially to the midpoint of the sternal angle. From here it continues vertically downwards to the midpoint of the xiphisternal joint. On the left side, the line follows the same course up to the level of the fourth costal cartilage. It then arches outwards and descends along the sternal margin up to the sixth costal cartilage.

The *inferior margin,* or the costodiaphragmatic line of pleural reflection passes laterally from the lower limit of its anterior margin, so that it crosses the eighth rib in the midclavicular line, *the* tenth rib in the midaxillary line, and the twelfth rib at the lateral border of the sacrospinalis muscle. Further it passes horizontally to the lower border of the twelfth thoracic vertebra, 2 cm lateral to the upper border of the twelfth thoracic spine.

Thus the pleurae descend below the costal margin at three places, at the right xiphicostal angle, and at the right and left costovertebral angles below the twelfth rib behind the upper poles of the kidneys. The latter fact is of surgical importance in exposure of the kidney. The pleura may be damaged at this site (Figs 15.6, 15.9).

The *posterior margins* of the pleura pass from a point 2 cm lateral to the twelfth thoracic spine to a point 2 cm lateral to the seventh cervical spine. The costal pleura becomes the mediastinal pleura along this line.

Nerve Supply of the Pleura

The parietal pleura develops from the somatopleuric layer of the lateral plate mesoderm, and is supplied by the somatic nerves. These are the intercostal and phrenic nerves. The parietal pleura is pain sensitive. The costal and peripheral parts of the diaphragmatic pleurae are supplied by the intercostal nerves, and the mediastinal pleura and central part of the diaphragmatic pleurae by the phrenic nerves. / The pulmonary pleura develops from the splanch-nopleuric layer of the lateral plate mesoderm, and is supplied by autonomic nerves. The sympathetic nerves are derived from second to fifth spinal segments while parasympathetic nerves are drawn from the vagus nerve. The nerves accompany the bronchial vessels. This part of the pleura is not sensitive to pain.^) *fcut I'Wo*

Blood Supply and Lymphatic Drainage of the Pleura

The parietal pleura is a part and parcel of the thoracic wall. Its blood supply and lymphatic drainage are, therefore, the same as that of the body wall. It is thus supplied by intercostal, internal thoracic and musculophrenic arteries.

The veins drain mostly into the azygos and internal thoracic veins. The lymphatics drain into the
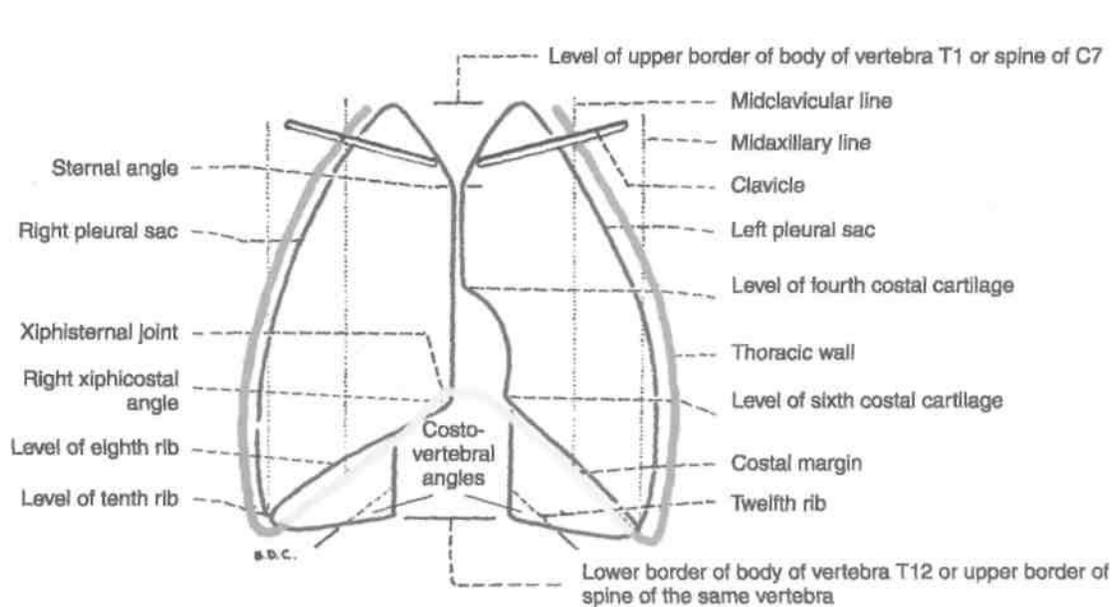
Fig. 15.9: Surface marking of the pleura.

intercostal, internal mammary, posterior mediastinal and diaphragmatic nodes.

The pulmonary pleura, like the lung, is supplied by the bronchial arteries while the veins drain intc

CLINICAL ANATOMY

Aspiration of any fluid from the pleural cavity is called *paracentesis thoracis*. It is usually done in the eighth intercostal space in the midaxillary line. The needle is passed through the lower part of the space to avoid injury to the principal neurovascular bundle.

Some clinical conditions associated with the pleura are as follows :

1. *Pleurisy.* This is inflammation of the pleura. It may be dry, but often it is accompanied by

bronchial veins. It is drained by the bronchopulmonary lymph nodes.

collection of fluid in the pleural cavity. The condition is called the pleural effusion.
1.*Pneumothorax.* Presence of air in the pleural cavity.
2.*Haemothorax.* Presence of blood in the pleural cavity.
3.*Hydropneumothorax.* Presence of both fluid and air in the pleural cavity.
4.*Empyema.* Presence of pus in the pleural cavity.

16

The Lungs

The lungs occupying major portions of the thoracic cavity leave little space for the heart, which excavates more of the left lung. The two lungs hold the heart tight between them, providing it the protection it rightly deserves. There are ten bronchopulmonary segments in both the lungs.
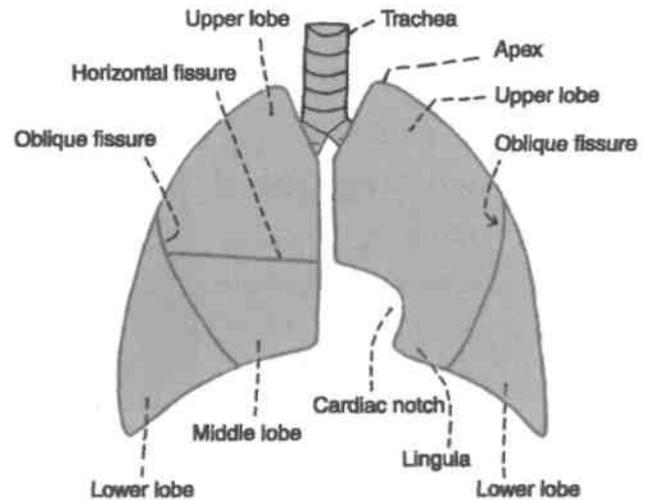
Fig. 16.1: *The trachea and lungs as seen from the front.*

[Introduction

The lungs are a pair of respiratory organs situated in the thoracic cavity. Each lung invaginates the corresponding pleural

cavity. The right and left lungs are separated by the mediastinum.

The lungs are spongy in texture. In the young, the lungs are brown or grey in colour. Gradually, they become mottled black because of the deposition of inhaled carbon particles. The right lung weighs about 700 g; it is about 50-100 g heavier than the left lung.

Identify the lungs by the thin anterior border, thick posterior border, conical apex, wider base, medial surface with hilum and costal surface with impressions of the ribs and intercostal spaces. In addition, the right lung is distinguished by the presence of three lobes whereas left lung comprises two lobes only. On the mediastinal part of the medial surface of right lung identify two bronchi—the eparterial and hyparterial bronchi, with bronchial vessels and posterior pulmonary plexus, the pulmonary artery between the two bronchi on an anterior plane. The upper pulmonary vein is situated still on an anterior plane while the lower pulmonary vein is identified below the bronchi. The impressions on the right lung are of superior vena cava, inferior vena cava, right ventricle. Behind the root of lung are the impressions of vena azygos and oesophagus.

Hilum of the left lung shows the single bronchus situated posteriorly, with bronchial vessels and posterior pulmonary plexus. The pulmonary artery lies above the bronchus. Anterior to the bronchus is the upper pulmonary vein, while the lower vein lies below the bronchus. The mediastinal surface of left lung has the impression of left ventricle, ascending aorta. Behind the root of the left lung are the impressions of descending thoracic aorta while oesophagus leaves an impression in the lower part only.

Features

Each lung is conical in shape (Fig. 16.1). It has: (1) an apex at the upper end; (2) a base resting on the diaphragm; (3) three borders, i.e. anterior, posterior and inferior; and (4) two surfaces, i.e. costal and medial. The medial surface is divided into vertebral and mediastinal parts.

The apex is blunt and lies above the level of the anterior end of the first rib. It reaches nearly 2.5 cm above the medial one-third of the clavicle, just medial to the supraclavicular fossa. It is covered by the cervical pleura and by the suprapleural membrane, and is grooved by the subclavian artery on the medial side and in front.

The base is semilunar and concave. It rests on the diaphragm which separates the right lung from the right lobe of the liver, and the left lung from the left lobe of the liver, the fundus of the stomach, and the spleen.

The *anterior border is* very thin (Figs 16.2, 16.3). It is shorter than the posterior border. On the right side it is vertical and corresponds to the anterior or costo-mediastinal line of pleural reflection. The anterior border of the left lung shows a wide cardiac notch below the level of the fourth costal cartilage. The heart and pericardium are uncovered by the lung in the region of this notch.

The *posterior border* is thick and ill defined. It corresponds to the medial margins of the heads of the ribs. It extends from the level of the seventh cervical spine to the tenth thoracic spine.

The *inferior border* separates the base from the costal and medial surfaces.

The *costal surface* is large and convex. It is in contact with the costal pleura and the overlying thoracic wall.

The *medial surface* is divided into a posterior c vertebral part, and an anterior or mediastinal par The vertebral part is related to the vertebral bodies intervertebral discs, the posterior intercostal vessel and the splanchnic nerves. The mediastinal part i related to the mediastinal septum, and shows cardiac impression, the hilum and a number of othe impressions which differ on the two sides. Varioui relations of the mediastinal surfaces of the two lung are listed in Table 16.1.

Table 16.1: Structures related to the mediastinal surfaces of the right and left lungs

Right side	Left side
1. Right atrium and Left ventricle, left auricle	1. Left ventricle, left auricle, infundibulum and adjoining part of the right ventricle auricle, infundibulum and adjoining part of
2. A small part of the right ventricle	2. Pulmonary trunk
3. Superior vena cava	3. Arch of aorta
4. Lower part of the right brachiocephalic vein	4. Descending thoracic aorta
5. Azygos vein	5. Left subclavian artery
6. Oesophagus	6. Thoracic duct
7. Inferior vena cava	7. Oesophagus
8. Trachea	8. Left brachiocephalic vein
9. Right vagus nerve	9. Left vagus nerve
10. Right phrenic nerve	10. Left phrenic nerve
	11. Left recurrent laryngeal nerve
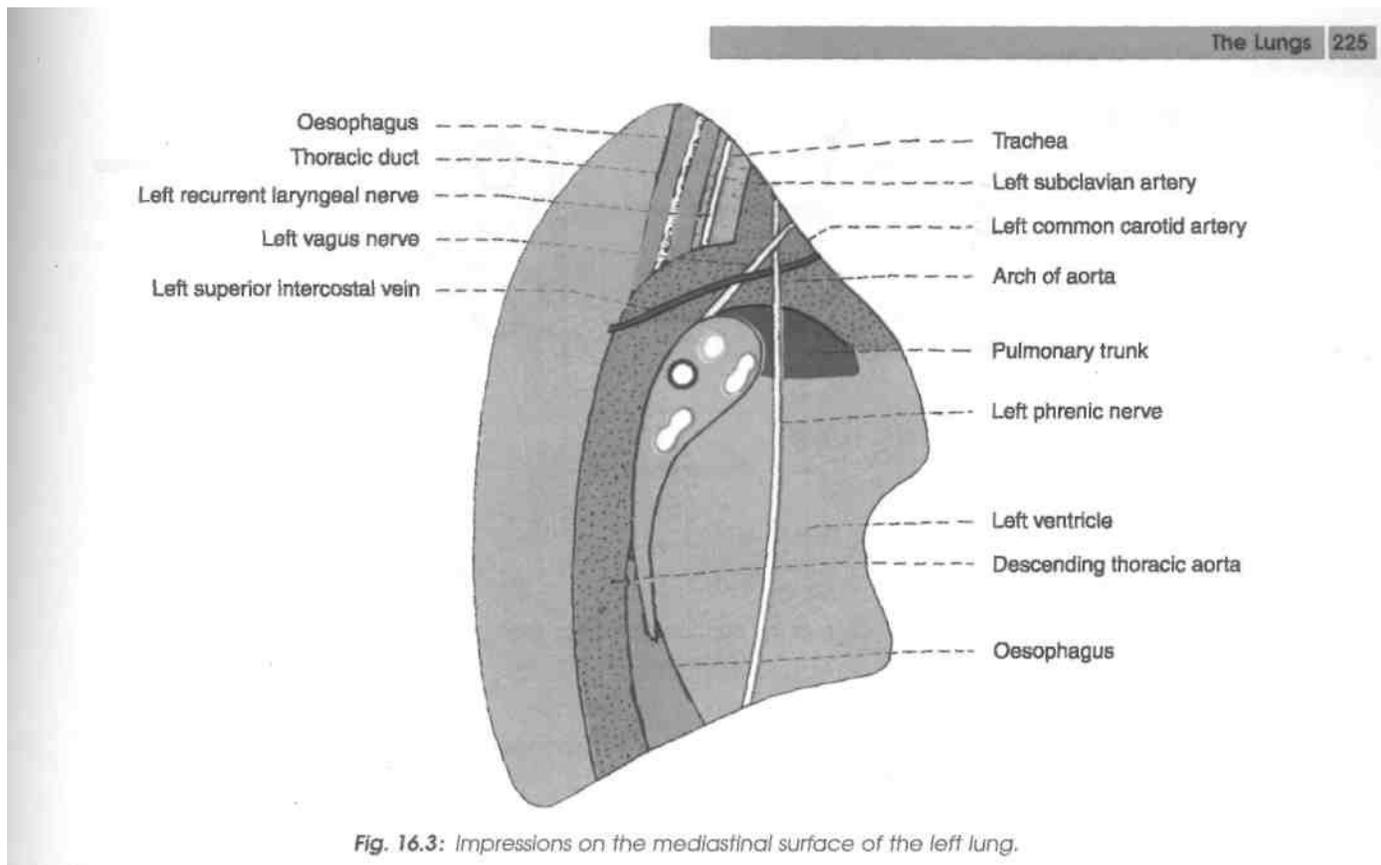
Fig. 16.3: Impressions on the mediastinal surface of the left lung.

Fissures and Lobes of the Lungs

The right lung is divided into 3 lobes (upper, middle and lower) by two fissures, oblique and horizontal. The left lung is divided into two lobes by the oblique fissure (Fig. 16.1).

The *oblique fissure* cuts into the whole thickness of the lung, except at the hilum. It passes obliquely downwards and forwards, crossing the posterior border about 6 cm below the apex and the inferior border about 5 cm from the median plane. Due to the oblique plane of the fissure the lower lobe is more posterior and the upper and middle lobe more anterior. In the right lung, the *horizontal fissure* passes from the anterior border up to the oblique fissure and separates a wedge-shaped middle lobe from the upper lobe. The fissure runs horizontally at the level of the fourth costal cartilage and meets the oblique fissure in the midaxillary line. The tongue-shaped projection of the left lung below the cardiac notch is called the *lingula*. It corresponds to the middle lobe of the right lung.   * °* ^ *

The number of lobes may vary in either lung. The right lung may have only two lobes, upper and lower and the left lung may have three lobes. Accessory lobes may also be present.

The lungs expand maximally in the inferior direction because movements of the thoracic wall and diaphragm are maximal towards the base of the lung. The presence of the oblique fissure of each lung allows a more uniform expansion of the whole lung.

Root of the Lung

Root of the lung is a short, broad pedicle which connects the medial surface of the lung to the mediastinum. It is formed by structures which either enter or come out of the lung at the hilum. The roots of the lungs lie opposite the bodies of the fifth, sixth and seventh thoracic vertebrae.

Contents

The root is made up of the following structures:
1. Principal bronchus on the left side, and epart-erial and hyparterial bronchi on right side.
2. One pulmonary artery.
3. Two pulmonary veins, superior and inferior.
4. Bronchial arteries, one on the right side and two on the left side.
5. Bronchial veins.
6. Anterior and posterior pulmonary plexuses of nerves.
7. Lymphatics of the lung.
8. Bronchopulmonary lymph nodes.
9. Areolar tissue.

Arrangement of Structures in the Root (Fig. 16.4)

A. From before backwards. It is similar on the two sides:
1. Superior pulmonary vein
2. Pulmonary artery
3. Bronchus
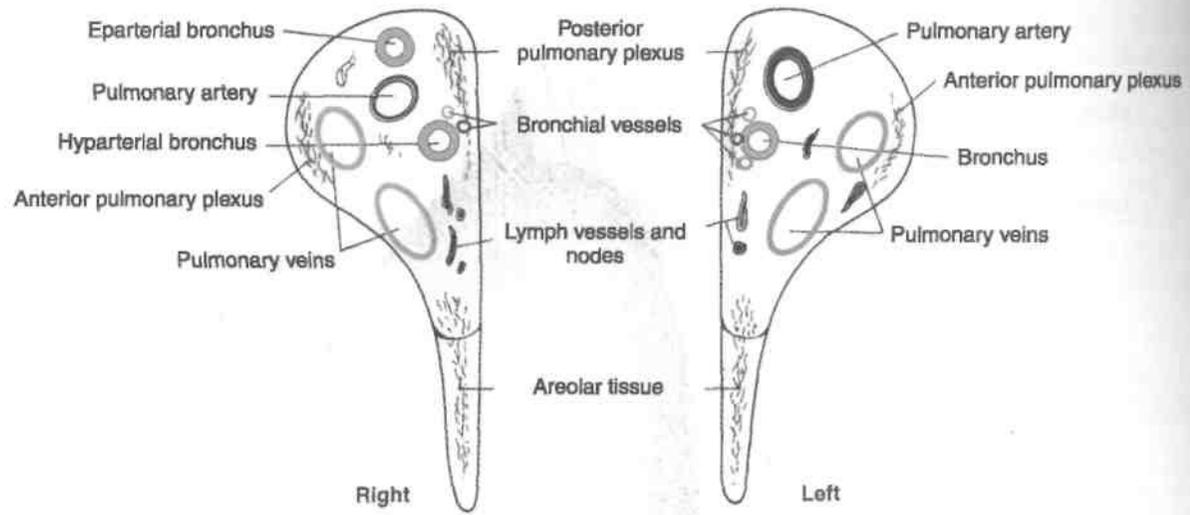
Fig. 16.4: Roots of the right and left lungs seen in section.

B. From above downwards. It is different on the two sides.

Right side

    1.Eparterial bronchus

    2.Pulmonary artery

    3.Hyparterial bronchus

    4.Inferior pulmonary vein *Left side*

    1.Pulmonary artery

    2.Bronchus

    3.Inferior pulmonary vein

Relations of the Root

Anterior

    a.   *Common on the two sides*

        1.Phrenic nerve

        2.Pericardiophrenic vessels

        3.Anterior pulmonary plexus

    b.   *On the right side*

        1.Superior vena cava

        2.A part of the right atrium. *Posterior*

    a.   *Common on the two sides*

        1.Vagus nerve

        2.Posterior pulmonary plexus

    b.   *On left side*

        1.   Descending thoracic aorta *Superior*

    a.   *On right side*

        Terminal part of azygos vein

    b.   *On left side*

        Arch of the aorta

D. *Inferior*

Pulmonary ligament.

Surface Marking of the Lung

The *apex* of the lung coincides with the cervical I pleura, and is represented by a line convex upwards I rising 2.5 cm above the medial one-third of the clavicle (Fig. 16.5).

The *anterior border of the right lung* corresponds very closely to the anterior margin or costomedia- j stinal line of the pleura and is obtained by joining: (i) a point at the sternoclavicular joint, (ii) another point in the median plane at the sternal angle, and (iii) a third point in the median plane just above the xiphisternal joint. The *anterior border of the left lung* corresponds to the anterior margin of the pleura upto the level of the fourth costal cartilage. In the lower part, it presents a cardiac notch of variable size. From the level of the fourth cartilage it passes laterally for 3.5 cm from the sternal margin, and then curves downwards and medially to reach the sixth costal cartilage 4 cm from the median plane. In the region of the cardiac notch, the pericardium is covered only by a double layer of pleura. The area of the cardiac notch is dull on percussion and is called the *area of superficial cardiac dullness.*

The *lower border* of each lung lies two ribs higher than the pleural reflection. It crosses the sixth rib in the midclavicular line, the eighth rib in the midaxillary line, the tenth rib at the lateral border of the erector spinae, and ends 2 cm lateral to the tenth thoracic spine.

The *posterior border* coincides with the posterior margin of the pleural reflection except that its lower end lies at the level of the tenth thoracic spine.
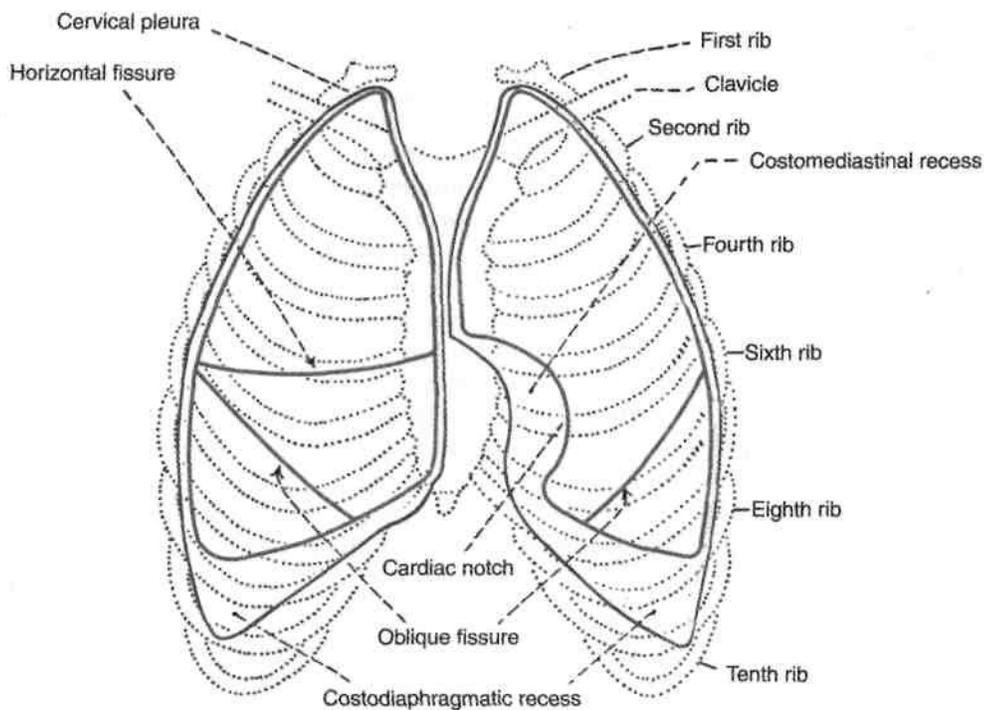
Fig. 16.5: *Surface projection of the pleurae and lungs on the front of the thorax.*

The *oblique fissure* can be drawn by joining: (i) a point 2 cm lateral to the third thoracic spine, (ii) another point on the fifth rib in the midaxillary line, and (iii) a third point on the sixth costal cartilage 7.5 cm from the median plane.

The *horizontal fissure* is represented by a line joining: (i) a point on the anterior border of the right lung at the level of the fourth costal cartilage, and (ii) a second point on the fifth rib in the midaxillary line.

Differences Between the Right and Left Lungs

These are given in Table 16.2.

Table 16.2: Differences between the left and right lungs

Right lung	Left lung	
1. It has 2 fissures and 3 lobes	1. It has only one fissure and 2 lobes	
2. Anterior border is straight	2. Anterior border is interrupted by the cardiac notch	
1. Larger and heavier	3. Smaller and lighter weighs about 700 g	weighs about 600 g
2. Shorter and broader	4. Longer and narrower	

Arterial Supply of the Lungs

The bronchial arteries supply nutrition to the bronchial tree and to the pulmonary tissue. These are

small arteries that vary in number, size and origin, but usually they are as follows.

(1)On the right side there is one bronchial artery which arises either from the third posterior intercostal artery or from the upper left bronchial artery.

(2)On the left side there are two bronchial arteries both of which arise from the descending thoracic aorta, the upper opposite fifth thoracic vertebra and the lower just below the left bronchus.

Deoxygenated blood is brought to the lungs by the pulmonary arteries and oxygenated blood is returned to the heart by the pulmonary veins.

There are precapillary anastomoses between bronchial and pulmonary arteries. These connections enlarge when any one of them is obstructed in disease.

Venous Drainage of the Lungs

The venous blood from the first one or two divisions of the bronchi is carried by bronchial veins. Usually there are two bronchial veins on each side. The right bronchial veins drain into the azygos vein. The left bronchial veins drain either into the left superior intercostal vein or into the hemiazygos vein.

The greater part of the venous blood from the lungs is drained by the pulmonary veins.

Lymphatic Drainage of the Lungs

There are two sets of lymphatics, both of which drain into the bronchopulmonary nodes.

1. Superficial vessels drain the peripheral lung tissue lying beneath the pulmonary pleura. The vessels pass round the borders of the lung and margins of the fissures to reach the hilum.

2. Deep lymphatics drain the bronchial tree, the pulmonary vessels and the connective tissue septa. They run towards the hilum where they drain into the bronchopulmonary nodes.

The superficial vessels have numerous valves: the deep vessels have only a few valves or no valves at all. Though there is no free anastomosis between the superficial and deep vessels some connections exist which can open up, so that lymph can flow from the deep to the superficial lymphatics when the deep vessels are obstructed in disease of the lungs or of the lymph nodes.

Nerve Supply

1. Parasympathetic nerves are derived from the vagus. These fibres are: (i) motor to the bronchial muscles, and on stimulation cause bronchospasm; (ii) secretomotor to the mucous glands of the bronchial tree; and (iii) sensory. The sensory fibres are responsible for the stretch reflex of the lungs, and for the cough reflex.

2. Sympathetic nerves are derived from second to fifth spinal segments. These are inhibitory to the smooth muscle and glands of the bronchial tree. That is how sympathomimetic drugs, like adrenalin, cause bronchodilatation and relieve symptom of bronchial asthma.

Both parasympathetic and sympathetic nerves first form anterior and posterior pulmonary plexuses situated in front of and behind the lung roots: from the plexuses nerves are distributed to the lungs along the blood vessels and bronchi.

Dissect the principal bronchus into the left lung. Remove the pulmonary tissue and follow the main bronchus till it is seen to divide into two lobar bronchi. Try to dissect till these divide into the segmental bronchi.

Bronchial Tree

The *trachea* divides at the level of the lower border of the fourth thoracic vertebra into two primary principal bronchi, one for each lung. The *right principal bronchus* is 2.5 cm long. It is shorter, wider and more

in line with the trachea than the left principal bronchus. Inhaled particles, therefore, tend to pass« more frequently to the right lung, with the result thatj infections are more common on the right side thanH on the left. The *left principal bronchus* is 5 cm. It is 1 longer, narrower and more oblique than the right bronchus.

Each principal bronchus enters the lung through the hilum, and divides into *secondary lobar bronchi,* 1 one for each lobe of the lungs. Thus there are three 1 lobar bronchi on the right side, and only two on the 1 left side. Each lobar bronchus divides into *tertiary or segmental bronchi,* one for each bronchopulmonary segment; which are 10 on the right side and 10 on the left side. The segmental bronchi divide repeatedly to form very small branches called *terminal bronchioles.* Still smaller branches are called *respiratory bronchioles.*

Each respiratory bronchiole aerates a small part of the lung known as a *pulmonary unit.* The respiratory bronchiole ends in microscopic passages which are termed: (i) alveolar ducts, (ii) atria, (iii) air saccules, and (iv) pulmonary alveoli. Gaseous exchanges take place in the alveoli (Fig. 16.6).
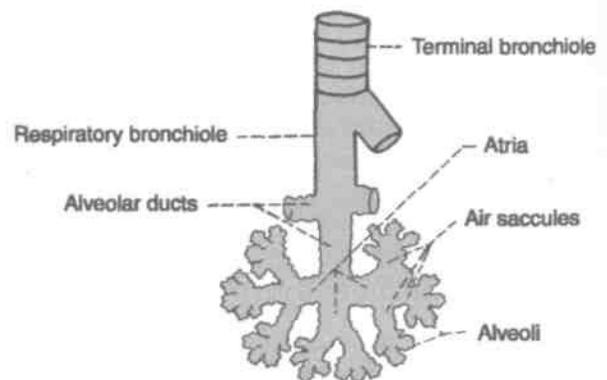
Fig. 16.6: *Diagram showing parts of a pulmonary unit.*

Bronchopulmonary Segments

Definition. These are well-defined sectors of the lung, each one of which is aerated by a tertiary or segmental bronchus. Each segment is pyramidal in shape with its apex directed towards the root of the lung (Fig. 16.7).

The most widely accepted classification of segments is given in Table 16.3. There are 10 segments on the right side and 10 on the left (Figs 16.8, 16.9).

Intersegmental planes. Each segment is surrounded by connective tissue which is continuous on the surface with pulmonary pleura. Thus the bronchopulmonary segments are independent respiratory units.

Table 16.3: The bronchopulmonary segments

Right lung		Left lung	
Lobes	*Segments*	*Lobes*	*Segments*
A. Upper	1. Apical	A. Upper	1. Apical
	1. Posterior	I. Upper division	2. Posterior
	2. Anterior		3. Anterior
			/ 4. Superior lingular
		II. Lower division	/ „ ,..;.,
			^ 5. Inferior lingular)
B. Middle	1. Lateral		
	2. Medial		
C. Lower	1. Superior	B. Lower	1. Superior
	2. Anterior basal		2. Anterior basal
	3. Medial basal		3. Medial basal
	4. Lateral basal		4. Lateral basal
	5. Posterior basal		5. Posterior basal
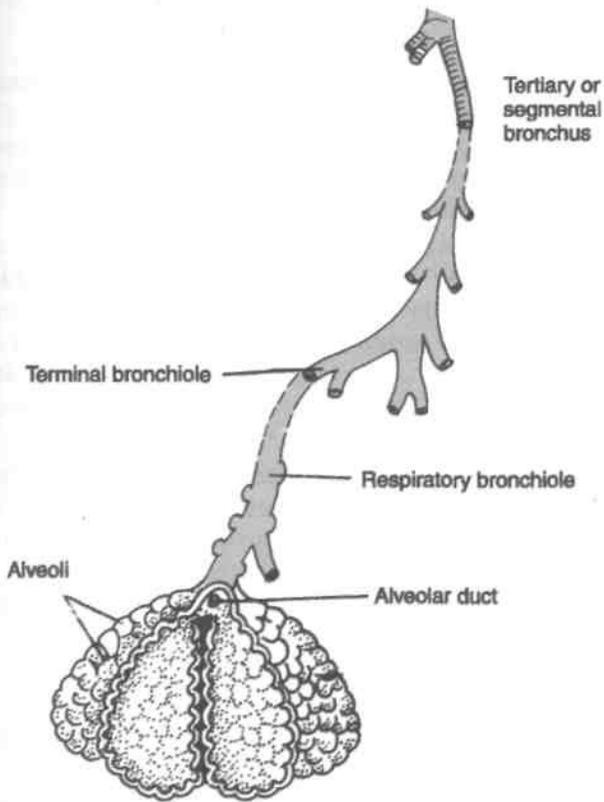
Fig. 16.7: Diagram of a bronchopulmonary segment.
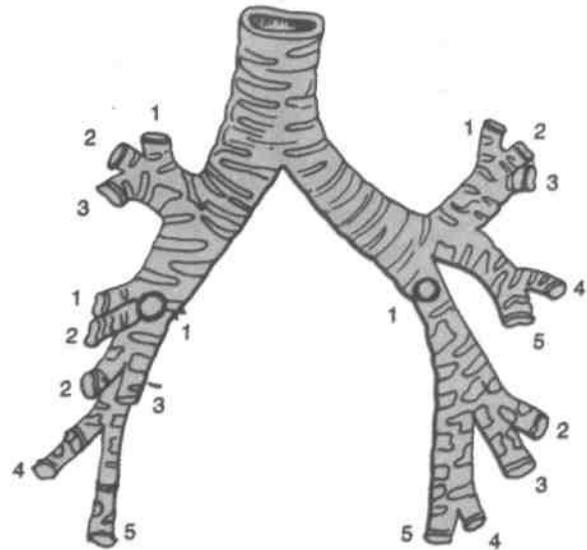
Fig. 16.8: Bronchopulmonary segments of the lungs.

The connective tissue septa between adjoining segments form intersegmental planes which are crossed by the pulmonary veins and occasionally by the pulmonary arteries. During removal of a segment or segmental resection, the surgeon works along the pulmonary veins to isolate a particular segment.

Relation to pulmonary artery. The branches of the pulmonary artery accompany the bronchi. The artery

lies dorsolateral to the bronchus. Thus each segment has its own separate artery (Fig. 16.10).

Relation to pulmonary vein. The pulmonary veins do not accompany the bronchi or pulmonary arteries. They run in the intersegmental planes. Thus each segment has more than one vein and each vein drains more than one segment. Near the hilum the veins are ventromedial to the bronchus.
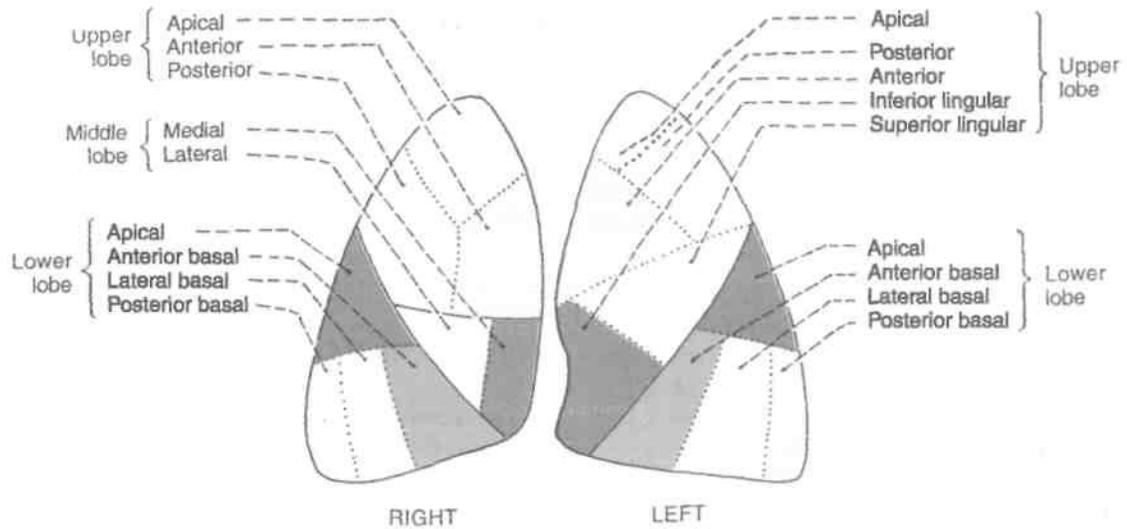
Fig. 16.9: The bronchopulmonary segments as seen on the lateral aspects of the right and left lungs. Medial basal segments are not seen.
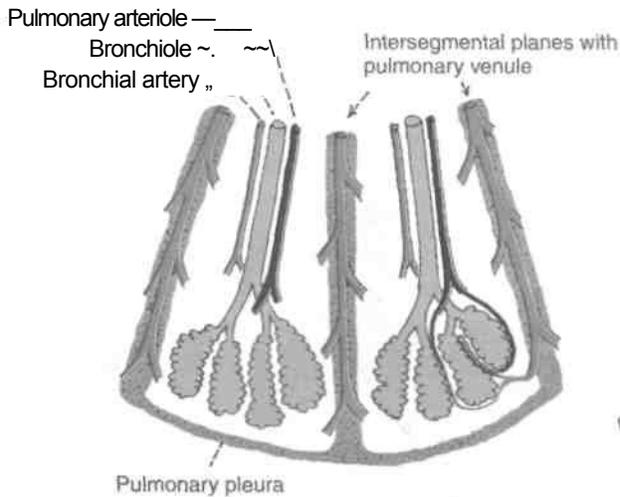
Fig. 16.10: Distal portions of adjacent bronchopulmonary segments.

jjc ^ It should be noted that the bronchopulmonary segment is not a bronchovascular segment because it does not have its own vein.

There is considerable variation in the above pattern of bronchi, arteries and veins: the veins being more variable than arteries, and the arteries more variable than the bronchi.

Histology of Trachea and Lung

/Trachea and extrapulmonary bronchi have pseudo-" stratified ciliated columnar epithelium with goblet V--?4.   cells. Lamina propria contains connective tissue and V^s ducts of glands present in submucosa.) No muscularis mucosae is present

Submucosa contains mucous and serous acini, Outermost is musculocartilaginous layer with 'C-shaped hyaline cartilage and smooth muscle fibres joining the two ends of 'C'-shaped cartilage. Outermost is connective tissue.

Intrapulmonary bronchus: Epithelium is same as in trachea. The epithelium is thrown into folds. Lamina propria is same as in trachea. The lamina propria is surrounded on all sides by thin sheet of smooth muscle fibres. Outside the muscle layer are small pieces of cartilage with glands in between these pieces. Outermost is the connective tissue. ^Terminal bronchiole is lined by columnar epithelium with no cilia or goblet cells. Smooth muscles surround it all around. No cartilage or glands are seen. Connective tissue is seen outside.*)* /Respiratory bronchiole is lined by cuboidal cells. There are outpocketing of alveoli. Smooth muscle' fibres and connective tissue surround it. No glands, or cartilage is seen. Alveoli are lined by squamous cells. Few cuboidal cells producing surfactant are seen. No muscle, no gland, no cartilage seen. Interalveolar connective tissue contains capillaries.

Development of Respiratory System

During fourth week of embryonic life the tracheobronchial or lung bud appears as a diverticulum from the ventral wall of the foregut. As this bud descends downwards it gets separated from oesophagus by oesophagotracheal septum. The two, however, maintain communication at the level of laryngeal inlet.

The lung bud forms trachea and two bronchial buds one on each side of trachea. Each bud forms

right and left principal bronchi. The right one divides into three and the left one into two lobar bronchi.

The developing lung buds invaginate and expand into pericardioperitoneal canals, the primitive pleural cavities and get covered by visceral and parietal pleura.

The bronchi divide into 18 generations before birth and six generations after birth to reach the final stage.

Maturation of lung occurs through pseudo-glandular period (5-16 weeks), canalicular period (16-26 weeks), terminal sac period (26 weeks to birth) and alveolar period (eighth month to childhood).

Epithelial lining of trachea, bronchi till alveoli including the glands are endodermal in origin. The cartilages, muscles, connective tissue develop from splanchnic mesoderm around the foregut.

CLINICAL ANATOMY

1. Usually the infection of a segment remains restricted to it, although some infections like tuberculosis may spread from one segment to another.

2. Segments are no barriers to the spread of bronchogenic carcinoma.

3. Knowledge of the detailed anatomy of the bronchial tree helps considerably in:

(i) Surgical removal of a segment or segmental resection).

(ii) Drainage of lung abscess or bronchiectasis by making the patient adopt a particular posture called postural drainage.

(iii) Visualizing the interior of the bronchi through an instrument passed through the mouth and trachea. The instrument is called a bronchoscope and the procedure is called bronchoscopy.

(iv) In understanding why abscesses are more common in some segments like the posterior segment of the right upper lobe, and the apical segment of the right lower lobe.

17

Mediastinum

Mediastinum is the middle space left in the thoracic cavity in between the lungs. Its most important content is the heart enclosed in the pericardium in the middle part of the inferior mediastinum or the middle mediastinum. Above it, lies superior mediastinum. Anterior and posterior to the heart are anterior mediastinum and posterior medistinum respectively.

Introduction
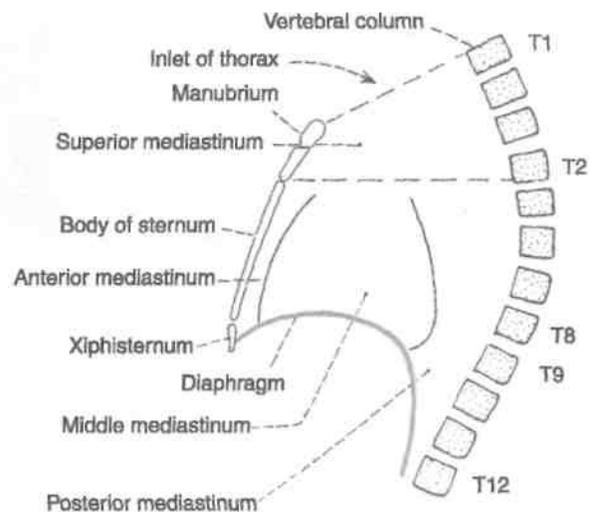
Fig. 17.1: Subdivisions of the mediastinum.

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The mediastinum is the median septum of the thorax between the two lungs. It includes the mediastinal pleurae (Figs 15.7, 15.8).

Reflect the upper half of manubrium sterni upwards and study the boundaries and contents of superior and three divisions of *the* inferior mediastinum.

Boundaries

Anteriorly	:	Sternum
Posteriorly	:	Vertebral column
Superiorly	:	Thoracic inlet
Interiorly	:	Diaphragm
On each side	:	Mediastinal pleura.

Divisions

For descriptive purposes the mediastinum is dividei into the *superior mediastinum* and the *inferior medi astinum.* The inferior mediastinum is further dividei into the *anterior, middle and posterior* mediastinur (Fig. 17.1).

The superior mediastinum is separated from th inferior by an imaginary plane passing through th sternal angle (anteriorly) and the lower border of th body of the fourth thoracic vertebra posteriorly. Th

inferior mediastinum is subdivided into three parts by the pericardium. The area in front of the pericardium is the anterior mediastinum. The area behind the pericardium is the posterior mediastinum. The pericardium and its contents form the middle mediastinum.

SUPERIOR MEDIASTINUM.

Boundaries

Anteriorly : Manubrium sterni Posteriorly : Upper four thoracic vertebrae Superiorly : Plane of the thoracic inlet Interiorly : An imaginary plane passing through the sternal angle in front, and the lower border of the body of the fourth thoracic vertebra behind. *On each side* : Mediastinal pleura.

Contents

1. Trachea and oesophagus.
2. *Muscles:* Origins of: (i) sternohyoid and (ii) sternothyroid, and (iii) lower ends of longus colli.
3. *Arteries:* (i) Arch of aorta, (ii) brachiocephalic artery, (iii) left common carotid artery, and (iv) left subclavian artery (Fig. 17.2).
4. *Veins:* (i) Right and left brachiocephalic veins, (ii) upper half of the superior vena cava, and (iii) left superior intercostal vein.
5. *Nerves:* (i) Vagus, (ii) phrenic, (iii) cardiac nerves, of both sides, and (iv) left recurrent laryngeal nerve.
6. Thymus.
7. Thoracic duct.   )

1. The prevertebral layer of the deep cervical fascia extends to the superior mediastinum, and is attached to the fourth thoracic vertebra. An infection present in the neck behind this fascia can pass down into the superior mediastinum but not lower down.

The pretracheal fascia of the neck also extends to the superior mediastinum, where it blends with the arch of the aorta. Neck infections between the pretracheal and prevertebral fasciae can spread into the superior mediastinum, and through it into the posterior mediastinum. Thus mediastinitis can result from infections in the neck.

1. There is very little loose connective tissue between the mobile organs of the mediastinum. Therefore, the space can be readily dilated by inflammatory fluids, neoplasms, etc.
2. In the superior mediastinum, all large veins are on the right side and the arteries on the left side. During increased blood flow veins expand enormously, while the large arteries do not expand at all. Thus there is much 'dead space' on the right side and it is into this space that tumours or fluids of the mediastinum tend to project.

8. *Lymph nodes:* Paratracheal, brachiocephalic, and tracheobronchial.

INFERIOR MEDIASTINUM   ~

The inferior mediastinum is divided into anterior, middle and posterior mediastina. These are as under:

Anterior Mediastinum

Anterior mediastinum is a very narrow space in front of the pericardium, overlapped by the thin anterior borders of both lungs. It is continuous through the superior mediastinum with the pretracheal space of the neck.

Boundaries

Anteriorly :   Body of sternum.
Posteriorly: Pericardium.
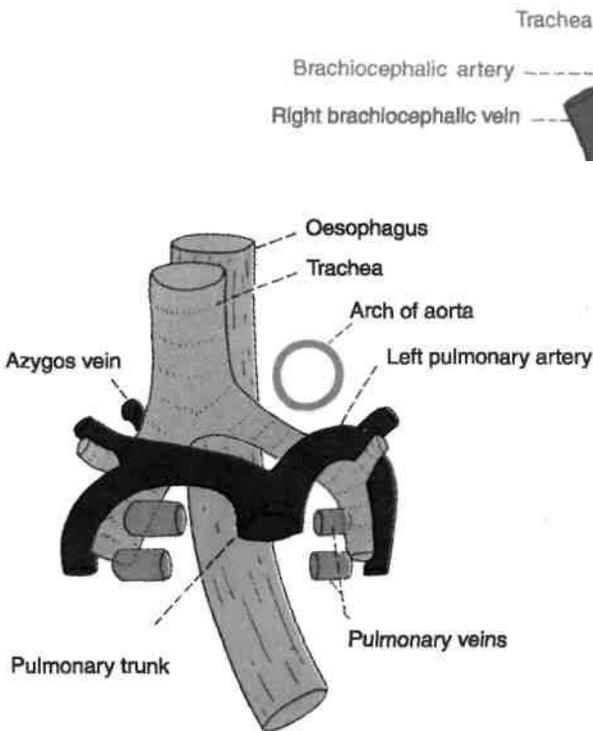
Fig. 17.3: *Some structures present in superior, middle and posterior mediastinum.*
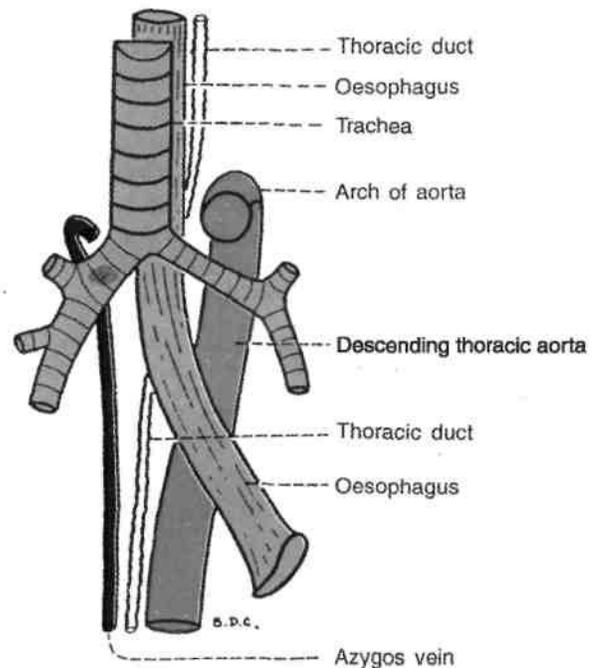
Fig. 17.4: *Structures in the posterior part of the superior mediastinum, and their continuation into the posterior mediastinum. Note the relationship of the arch of the aorta to the left bronchus, and that of the azygos vein to the right bronchus.*

Superiorly :   Imaginary plane separating the superior mediastinum from the inferior mediastinum. *Inferiorly*: Superior surface of diaphragm. *On each side :* Mediastinal pleura.

Contents

   (i) Sternopericardial ligaments, (ii) lymph nodes with lymphatics, (iii) small mediastinal branches of the internal thoracic artery, (iv) the lowest part of the thymus, and (v) areolar tissue.

Middle Mediastinum

Middle mediastinum is occupied by the pericardium and its contents, along with the phrenic nerves and the pericardiophrenic vessels.

Boundaries

Anteriorly : Posterior surface of sternum *Posteriorly :* Oesophagus, descending thoracic aorta, azygos vein On each side - Mediastinal pleura.

Contents

   1.*Heart* enclosed in pericardium.
   2.*Arteries:* (i) Ascending aorta, (ii) pulmonary trunk, and (iii) two pulmonary arteries.
   3.Veins: (i) Lower half of the superior vena cava, (ii) terminal part of the azygos vein, and (iii) right and left pulmonary veins (Fig. 17.3).
   4.*Nerves:* (i) Phrenic, and (ii) deep cardiac plexus.
   5.*Lymph nodes:* Tracheobronchial nodes.

6. *Tubes:* (i) Bifurcation of trachea, and (ii) the right and left principal bronchi.

Posterior Mediastinum

Boundaries

Anteriorly: (i) Pericardium, (ii) bifurcation of trachea, (iii) pulmonary vessels, and (iv) posterior part of the upper surface of the diaphragm.

Posteriorly: Lower eight thoracic vertebrae and intervening discs.

On each side: Mediastinal pleura.

Contents

1. Oesophagus (Fig. 17.4).

2. *Arteries:* Descending thoracic aorta and its branches.

3. Veins: (i) Azygos vein, (ii) hemiazygos vein, and (iii) accessory hemiazygos vein.

4. *Nerves:* (i) Vagi, and (ii) splanchnic nerves, greater, lesser and least, arising from the lower eight thoracic ganglia of the sympathetic chain.

5. *Lymph nodes and lymphatics:* (i) Posterior mediastinal lymph nodes lying alongside the aorta, and (ii) the thoracic duct (Fig. 17.4).

1. The posterior mediastinum is continuous through the superior mediastinum with the neck between the pretracheal and prevertebral layers of the cervical fascia. This region of the neck includes the retropharyngeal space, spaces on each side of the trachea and oesophagus, the space between these tubes and the carotid sheaths. Infections leading to fluid collections from these spaces can spread to the superior and posterior mediastina.

2. Compression of mediastinal structures by any tumour gives rise to a group of symptoms known as *'mediastinal syndrome'*. The common symptoms are as follows.

  (i) Obstruction of the superior vena cava gives rise to engorgement of veins in the upper half of the body.

  (ii) Pressure over the trachea causes dyspnoea

  (iii) Pressure on the oesophagus causes dysphagia.

  (iv) Pressure or the left recurrent laryngeal nerve gives rise to hoarseness of voice.

  (v) Pressure on the phrenic nerve causes paralysis of the diaphragm on that side,

  (vi) Pressure on the intercostal nerves gives rise to pain in the area supplied by them. It is called intercostal neuralgia.

  (vii) Pressure on the vertebral column may cause erosion of the vertebral bodies.

The common causes of mediastinal syndrome are bronchogenic carcinoma, Hodgkin's disease causing enlargement of the mediastinal lymph nodes, aneurysm or dilatation of the aorta, etc.

18
Pericardium and Heart

Pericardium, comprising fibrous and serous layers, encloses the heart pulsating from 'womb to tomb'. It limits its movements.

Heart is a vital organ, pumping blood to the entire body. Its pulsations are governed by the brain through various nerves. Since heart beat is felt or seen against the chest wall, it appears to be more active than the quiet brain controlling it. That is why there are so many songs on the heart and none on the brain. Meditation, *yoga* and exercise help in regulating the heart beat through the brain.

THE PERICARDIUM

The pericardium is a fibroserous sac which encloses the heart and the roots of the great vessels. It is situated in the middle mediastinum. It consists of the *fibrous pericardium* and the *serous pericardium* (Figs 18.1, 18.2).

Fibrous pericardium encloses the heart and fuses with the vessels which enter/leave the heart. Heart is situated within the fibrous and serous pericardial
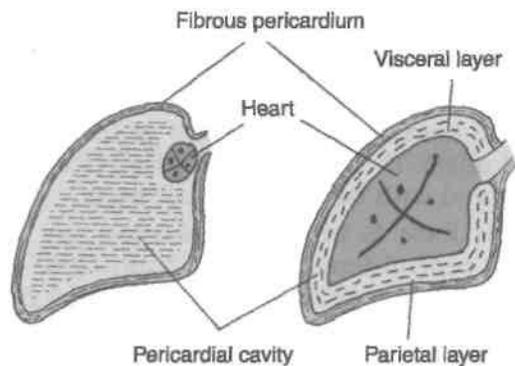
Fig. 18.2: Diagram showing the development of the layers of serous pericardium.

sacs. As heart develops, it invaginates itself into the serous sac, without causing any breach in its continuity, the last part to enter is the region of atria, from where the visceral pericardium is reflected as the parietal pericardium. Thus parietal layer of serous pericardium gets adherent to the inner surface of fibrous pericardium, while the visceral layer of serous pericardium gets adherent to the outer layer of heart and forms its epicardium.

Fig. 18.1: Diagram showing the layers of the pericardium.

DISSECTION

Make a vertical cut through each side of the pericardium immediately anterior to the line of the phrenic nerve. Join the lower ends of these two incisions hy a transverse cut approximately 1 cm above the diaphragm. Turn the flap of pericardium upwards and, examine the pericardial cavity. See that the turned flap comprises fibrous and parietal layer of visceral pericardium. The pericardium enclosing the heart is its visceral layer.

Pass a probe from (lie right side behind ihe ascending aorta and pulmonary trunk till il appears on the left just to the right of left atrium. This probe is in the transverse sinus of the pericardium. Lift the apex of the heart upwards. Put a finger behind the left atrium into a cul-de-sac, bounded to the right and below by inferior vena cava and above and to left by lower left pulmonary vein. This is the oblique sinus of pericardium.

Define the borders, surfaces, grooves, apex and base of the heart.

FIBROUS PERICARDIUM

Pibrous pericardium is a conical sac made up o ibrous tissue. The parietal layer of serous pericardium is attached to its deep surface. The following features of the fibrous pericardium are noteworthy

1. The apex is blunt and lies at the level of the sternal angle. It is fused with the roots of the greai vessels and with the pretracheal fascia.

2. The base is broad and inseparably blendec ivith the central tendon of the diaphragm. In lowei nammals or quadrupeds it is separated from the diaphragm by the infracardiac bursa.

3. Anteriorly, it is connected to the upper anc ;ower ends of body of the sternum by weak superioi and inferior *sternopericardial ligaments* (Fig. 18.3).

4. Posteriorly, it is related to the principal bronchi Lhe oesophagus with the nerve plexus around it anc :he descending thoracic aorta.

1. On each side it is related to the mediastinal pleura, the mediastinal surface of the lung, the phrenic nerve, and the pericardiophrenic vessels.

2. It protects the heart against sudden overfilling.

SEROUS PERICARDIUM

Serous pericardium is thin, double-layered serous membrane lined by mesothelium. The outer layer of parietal pericardium is fused with the fibrous pericardium. The inner layer or the visceral pericardium, or epicardium is fused to the heart, except along the cardiac gooves, where it is separated from the heart by blood vessels. The two layers are continuous with each other at the roots of the great vessels, i.e. ascending aorta, pulmonary trunk, two venae cavae, and four pulmonary veins.

The *pericardial cavity* is a potential space between the parietal pericardium and the visceral pericardium. It contains only a thin film of serous fluid which lubricates the apposed surfaces and allows the heart to move smoothly.

Contents of the Pericardium

(i) Heart with cardiac vessels and nerves, (ii) ascending aorta, (iii) pulmonary trunk, (iv) lower half of the superior vena cava, (v) terminal part of the inferior vena cava, and (vi) the terminal parts of the pulmonary veins.

Fig. 18.3: *The relations of the fibrous pericardium to the roots of the great vessels, to the diaphragm and sternum.*

Fig. 18.5: *Transverse secton through the upper part of the heart. Note the reflections of pericardium, and the mode of formation of the transverse and oblique sinuses.*

Fig. 18.4: *The pericardial cavity seen after removal of the heart. Note the reflections of pericardium and the mode of formation of the transverse and oblique sinuses.*

Sinuses of Pericardium

The epicardium at the roots of the great vessels is arranged in form of two tubes. The arterial tube encloses the ascending aorta and the pulmonary trunk at the arterial end of the heart tube, and the venous tube encloses the venae cavae and pulmonary veins at the venous end of the heart tube. The passage between the two tubes is known as the *transverse sinus* of pericardium. During development, to begin with the veins of the heart are crowded together. As the heart increases in size and these veins separate out, a pericardial reflection surrounds all of them and forms the oblique pericardial sinus. This cul-de-sac is posterior to the left atrium (Fig. 18.4).

The *transverse sinus* is a horizontal gap between fee arterial and venous ends of the heart tube. It is bounded anteriorly by the ascending aorta and pulmonary trunk, and posteriorly by the superior vena cava and inferiorly by the left atrium: on each side it opens into the general pericardial cavity) (Fig. 18.5). The *oblique sinus* is a narrow gap behind the heart. It is bounded anteriorly by the left atrium, and posteriorly by the parietal pericardium. On the right and left sides it is bounded by reflections of pericardium as shown in Fig. 18.5. Below, and to the left it opens into the rest of the pericardial cavity. The oblique sinus permits pulsations of the left atrium to take place freely (Figs 18.4, 18.5).

Arterial Supply

The fibrous and parietal pericardia are supplied by branches from: (i) internal thoracic, and (ii) muscu-

lophrenic arteries, and (iii) the descending thoracic aorta.

Nerve Supply

The fibrous and parietal pericardia are supplied by the phrenic nerve. They are sensitive to pain. The epicardium is supplied by autonomic nerves of the heart, and is not sensitive to pain. Pain of pericarditis originates in the parietal pericardium alone. On the other hand cardiac pain or angina originates in the cardiac muscle or in the vessels of the heart.

<div align="center">CLINICAL ANATOMY</div>

Collection of fluid in the pericardial cavity is referred to as pericardial effusion. Pericardial effusion can be drained by puncturing the left fifth or sixth intercostal space just lateral to the sternum, or in the angle between the xiphoid process and left costal margin, with the needle directed upwards, backwards and to the left.

THE HEART

Introduction

The heart is a conical hollow muscular organ situated in the middle mediastinum. It is enclosed within the pericardium. It pumps blood to various parts of the body to meet their nutritive requirements. The Greek name for the heart is *cardia* from which we have the adjective *cardia*. The Latin name for the heart is *cor* from which we have the adjective *coronary*.

The heart is placed obliquely behind the body of the sternum and adjoining parts of the costal cartilages, so that one-third of it lies to the right and two-thirds to the left of the median plane. The direction of blood flow, from atria to the ventricles is downwards forwards and to the left. The heart measures about 12 x 9 cm and weighs about 300 g in males and 250 g in females.

~ EXTERNAL FEATURES ~

The human heart has four chambers. These are the right and left atria and the right and left ventricles. The atria lie above and behind the ventricles. On the surface of the heart they are separated from the ventricles by an atrioventricular groove. The atria are separated from each other by an interatrial groove. The ventricles are separated from each other by an interventricular groove, which is subdivided into anterior and posterior parts (Fig. 18.6).

The heart has an apex directed downwards forwards and to the left, a base (or posterior surface) directed backwards; and anterior, inferior and left surfaces. The surfaces are demarcated by upper, lower, right and left borders.

Grooves or Sulci

The atria are separated from the ventricles by a circular a *trioven tricular or coronary sulcus.* It is overlapped anteriorly by the ascending aorta and the pulmonary trunk. The *interatrial groove* is faintly visible posteriorly. While anteriorly it is hidden by the aorta and pulmonary trunk. The *anterior interventricular groove* is nearer to the left margin of the heart. It runs downwards and to the left. The lower end of the groove separates the apex from the rest of the inferior border of the heart. The *posterior interventricular groove* is situated on the diaphragmatic or inferior surface of the heart. It is nearer to the right margin of this surface. The two interventricular grooves meet at the inferior border near the apex (Fig. 18.6).

Apex of the Heart

Apex of the heart is formed entirely by the left ventricle. It is directed downwards forwards and to the left and is overlapped by the anterior border of the left lung. It is situated in the left fifth intercostal space 9 cm lateral to the midsternal line just medial to the midclavicular line. In the living subject, pulsations may be seen and felt over this region.
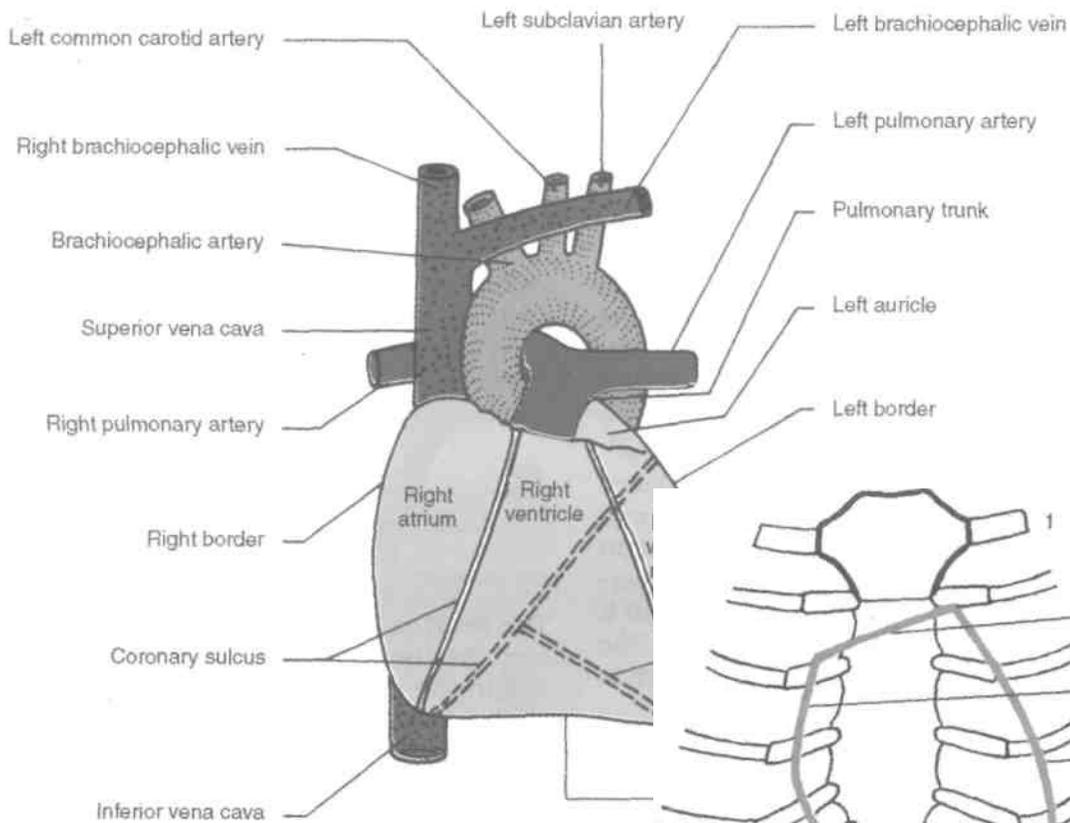
Fig. 18.6: Gross features: Sternocos
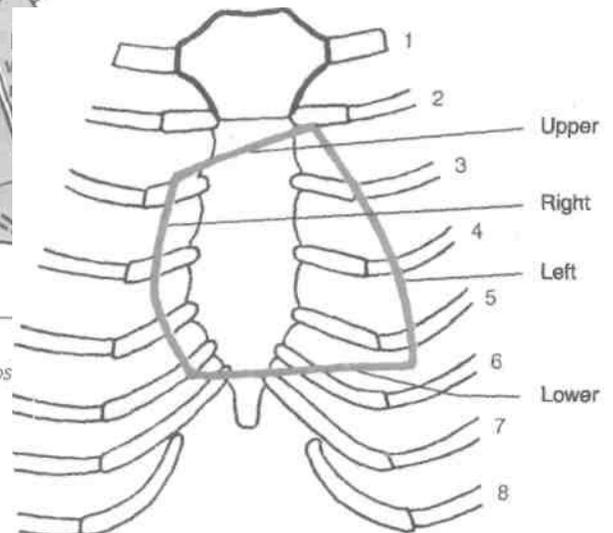
Fig. 18.8: Surface projection of the borders of the heart.

Base of the Heart

The base of the heart is also called its posterior surface. It is formed mainly by the left atrium and by a small part of the right atrium. In relation to the base we see the openings of four pulmonary veins which open into the left atrium; and of the superior and inferior venae cavae which open into the right atrium. It is related to thoracic five to thoracic eight vertebrae in the lying posture, and descends by one vertebra in the erect posture. It is separated from the vertebral column by the pericardium, the right pulmonary veins, the oesophagus and the aorta (Fig. 18.7).
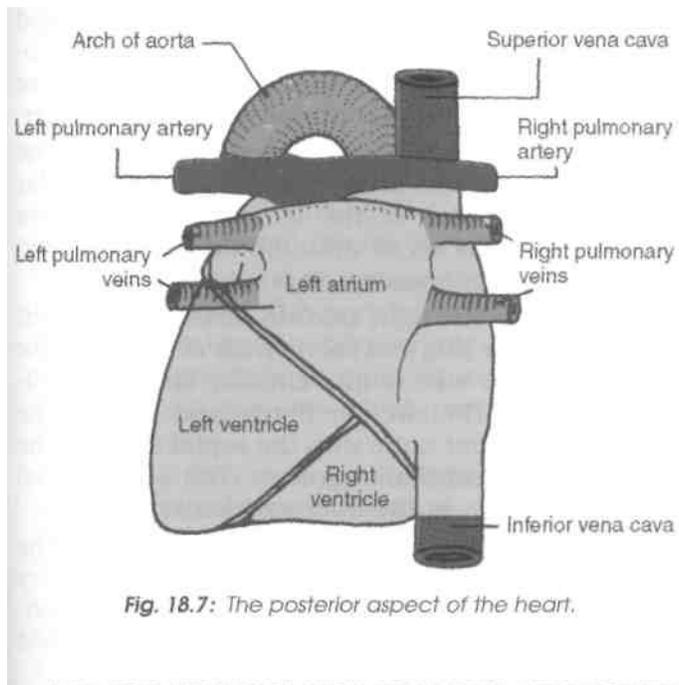
Fig. 18.7: *The posterior aspect of the heart.*

Note that clinicians often refer to the upper border of the heart as the base.

Borders of the Heart

The *upper border is* slightly oblique, and is formed by the two atria, chiefly the left atrium. The *right border* is more or less vertical and is formed by the right atrium. The *inferior border is* nearly horizontal and is formed mainly by the right ventricle. A small part of it near the apex is formed by left ventricle. The *left border* is oblique and curved. It is formed mainly by the left ventricle, and partly by the left auricle. It separates the anterior and left surfaces of the heart (Fig. 18.6).

Surfaces of the Heart

The *anterior or sternocostal surface* is formed mainly by the right atrium and right ventricle: and partly by the left ventricle and left auricle. The left atrium is not seen on the anterior surface as it is covered by

the aorta and pulmonary trunk. Most of the sternocostal surface is covered by the lungs, but a part of it that lies behind the cardiac notch of the left lung is uncovered. The uncovered area is dull on percussion. Clinically it is referred to as the area *of superficial cardiac dullness.*

The *inferior or diaphragmatic surface* rests on the central tendon of the diaphragm. It is formed in its left two-thirds by the left ventricle, and in its right one-third by the right ventricle. It is traversed by the posterior interventricular groove, and is directed downwards and slightly backwards: The *left surface* is formed mostly by the left ventricle, and at the upper end by the left auricle. In its upper part, the surface is crossed by the coronary sulcus. It is related to the left phrenic nerve, the left pericardiophrenic vessels, and the pericardium.

Surface Marking of the Borders of the Heart

The *upper border is* marked by a straight line joining: (i) a point at the lower border of the second left costal cartilage about 1.3 cm from the sternal margin to, (ii) a point at the upper border of the third right costal cartilage 0.8 cm from the sternal margin (Fig. 18.8)

The *lower border* is marked by a straight line joining: (i) a point at the lower border of the sixth right costal cartilage 2 cm from the sternal margin to, (ii) a point at the apex of the heart in the left fifth intercostal space 9 cm from the midsternal line.

The *right border* is marked by a line, slightly convex to the right, joining the right ends of the upper and lower borders. The maximum convexity is about 3.8 cm from the median plane in the fourth space.

The *left border is* marked by a line, fairly convex to the left, joining the left ends of the upper and lower borders.

The area of the chest wall overlying the heart is called the *precardium.*

Fibrous Skeleton

The fibrous rings surrounding *the* atrioventricular and arterial orifices, along with some adjoining masses of fibrous tissue, constitute the fibrous skeleton of the heart. It provides attachment to the cardiac muscle and keeps the cardiac valve competent (Fig. 18.9).

The *atrioventricular fibrous rings* are in the form of
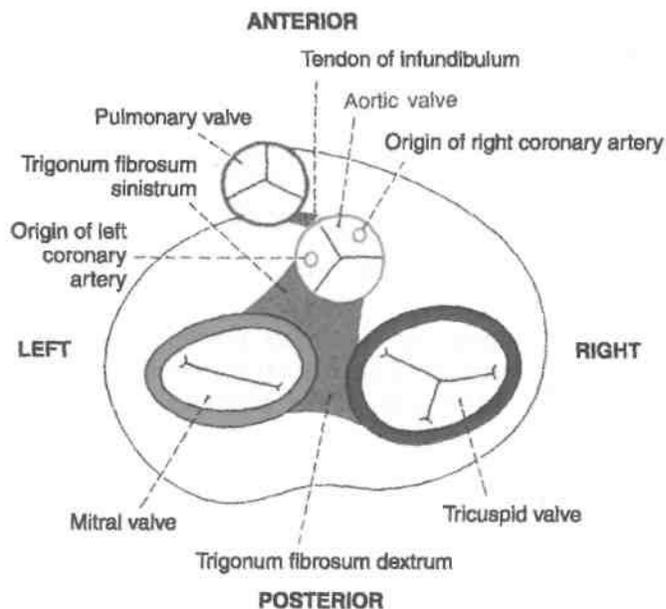
Fig. 18.9: *Heart seen from above after removing the atria. The mitral, tricuspid, aortic and pulmonary orifices and their valves are seen. The fibrous skeleton of the heart is also shown.*

the figure of 8. The atria, the ventricles and the membranous part of the interventricular septum are attached to them. There is no muscular continuity between the atria and ventricles across the rings except for the atrioventricular bundle or bundle of His.

There is large mass of fibrous tissue between the atrioventricular rings behind and the aortic ring in front. It is known as the *trigonum fibrosum dextrum.* In some mammals like sheep, a small bone the os *cordis* is present in this mass of fibrous tissue.

Another smaller mass of fibrous tissue is present between the aortic and mitral rings. It is known as the *trigonum fibrosum sinistrum. The tendon of the*

infundibulum binds the posterior surface of thi infundibulum to the aortic ring.

Musculature of the Heart

Cardiac muscle fibres form long loops which an attached to the fibrous skeleton. Upon contraction o the muscular loops the blood from the cardiac chambers is wrung out like water from a wet cloth. The atrial fibres are arranged in a superficial transverse layer and a deep anteroposterior (vertical) layer.

The ventricular fibres are arranged in superficial, middle and deep layers. The superficial fibres arise from skeleton of the heart to undergo a spiral course. First these pass across the inferior surface, wind round the lower border and then across the sternocostal surface to reach the apex of heart: where these fibres form a vortex and continue with the deep layer.

The middle layer of fibres of heart are thickest. The fibres of the left side arise from left atrioventricular ring, pass in front of the left ventricle and are inserted into tendon of infundibulum and around the aortic and pulmonary rings.

The fibres of the right side also arise from the left atrioventricular ring and soon divide at the posterior interventricular sulcus into circular and longitudinal branches. The circular fibres pass around the right ventricle and unite with the septal fibres of the anterior interventricular groove. The longitudinal fibres pass down in the interventricular septum.

The deep layer of fibres pass at right angles to the superficial layer to get continuous with the papillary muscles of both the ventricles. Lastly they get continuous with the chordae tendinae and are attached back to the skeleton of the heart.

Histology of Cardiac Muscle

Cardiac muscle is specialised type of muscle found in the myocardium. The cell is a short cylinder, with striations and a single central nucleus surrounded by a light perinuclear space. These cells branch, and at regular intervals, the cytoplasm reveals a transverse dark line called the 'intercalated disc'. It has partial properties both of the skeletal and the smooth muscles of fibres.

THE RIGHT ATRIUM ~

The right atrium is the right upper chamber of the heart. It receives venous blood from the whole body, pumps it to the right ventricle through the right atrioventricular or tricuspid opening. It forms the right border, part of the upper border, the sternocostal surface and the base of the heart.

Cut along the upper edge of the right auricle by an incision from the anterior end of the superior vena caval opening to the left side. Similarly cut along its lower edge by an incision extending from the anterior end of the inferior vena caval opening to the left side. Incise the anterior wall of the right auricle near its left margin and reflect the flap to the right (Fig. 18.10). On its internal surface, see the vertical crista terminalis and horizontal pectinate muscles. The fossa ovalis is on the interatrial septum and the opening of the coronary sinus is to the left of the inferior vena caval opening. Define the three cusps of tricuspid valve.

External Features

1. The chamber is elongated vertically, receiving the superior vena cava at the upper end and the inferior vena cava at the lower end (Fig. 18.6).

2. The upper end is prolonged to the left to form the right *auricle*. The auricle covers the root of the ascending aorta and partly overlaps the infundibulum of the right ventricle. Its margins are notched and the interior is sponge-like, which prevents free flow of blood.

3. Along the right border of the atrium there is a shallow vertical groove which passes from the superior vena cava above to the inferior vena cava below. This groove is called the *sulcus terminalis*. It is produced by an internal muscular ridge called the *crista terminalis* (Fig. 18.10). The upper part of the sulcus contains the *sinuatrial or SA node* which acts as the pacemaker of the heart.

Inferior vena cava   Septal cusp of tricuspid valve
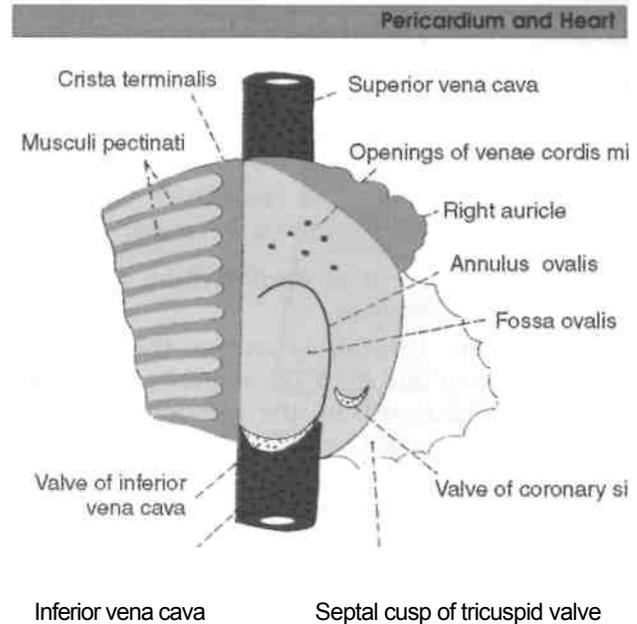
Fig. 18.10: Interior of the right atrium.

4. The right atrioventricular groove separates the right atrium from the right ventricle. It is more or less vertical and lodges the right coronary artery and the small cardiac vein.

Tributaries or Inlets of the Right Atrium

(i) Superior vena cava, (ii) inferior vena cava, (iii) coronary sinus, (iv) anterior cardiac veins, (v) venae cordis minimi (Thebesian veins), (vi) and sometimes the right marginal vein.

Right Atrioventricular Orifice

Blood passes out of the right atrium through the right atrioventricular or tricuspid orifice and goes to the right ventricle. The tricuspid orifice is guarded by the tricuspid valve which maintains unidirectional flow of blood (Fig. 18.11).
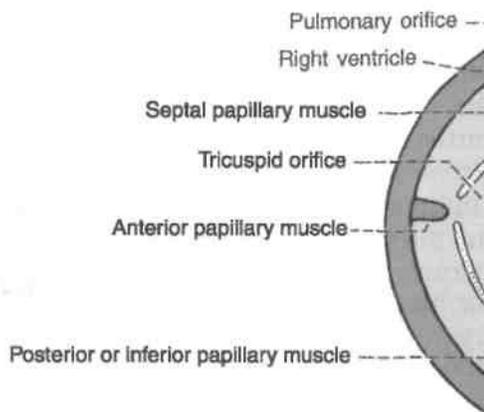
Fig. 18.11: Schematic transverse section through the ven the pulmonary and aortic orifices.

between the upper part of the fossa and the limbus It is normally occluded after birth, but may some times persist.

THE RIGHT VENTRICLE

The right ventricle is a triangular chamber which receives blood from the right atrium and pumps it tc the lungs through the pulmonary trunk and pulmonary arteries. It forms the inferior border and a large part of the sternocostal surface of the heart (Fig. 18.6).

DISSECTION

Incise along the ventricular aspect of right AV groove, till you reach the inferior border. Continue to incise along the inferior border till the inferior end of anterior interventricular groove. Next cut along the infundibulum. Now the anterior wall of right ventricle is reflected to the left to study its interior.

Internal Features

The interior of the right atrium can be broadly divided into the following three parts.

The Smooth Posterior Part or Sinus Venarum

1. Developmentally it is derived from the right horn of the sinus venosus.

2. Most of the tributaries except the anterior cardiac veins open into it. (ij The *superior vena cava* opens at the upper end. (ii) the *inferior vena cava* opens at the lower end. The opening is guarded by a rudimentary valve of the inferior vena cava or Eus tachian valve. During embryonic life the valve guides the inferior vena caval blood to the   left atrium through the foramen ovale, (iii) The *coronary sinus* opens between the opening of the inferior vena cava and the right atrioventricular orifice. The opening is guarded by the *valve of the coronary sinus,* (iv) The venae cordis minimae are numerous small veins present in the walls of all the four chambers. They open into the right atrium through small foramina.

3. The *intervenous tubercle* of'Lower is a very small projection, scarcely visible, on the posterior wall of the atrium just below the opening of the superior vena cava. During embryonic life it directs the superior caval blood to the right ventricle.

Ihd'&ug(\Ante-not'Petri'otPecUe Pari, ihcfuaihg the.Auricle

Features

1. Externally, the right ventricle has two surfaces: *anterior or sternocostal and inferior diaphragmatic.*

2. The interior has two parts, (i) The *inflowing part* is rough due to the presence of muscular ridges called *trabeculae carneae.* It develops from the proxi mal part of bulbus cordis of the heart tube, (ii) The *outflowing part or infundibulum* is smooth and forms the upper conical part of the right ventricle which gives rise to the pulmonary trunk. It develops from the mid portion of the bulbus cordis.

The two parts are separated by a muscular ridge called the *supraventricular crest* or infundi-buloventricular crest situated between the tricuspid and pulmonary orifices.

1.The interior shows two orifices: (i) the right atrioventricular or tricuspid orifice, guarded by the tricuspid valve, and (ii) the pulmonary orifice guarded by the pulmonary valve (Fig. 18.11).

2.The interior of the inflowing part shows *trabeculae carneae or* muscular ridges of three types: (i) *ridges* or fixed elevations, (ii) *bridges, (iii) pillars* or papillary muscles with one end attached to the ventricular wall, and the other end connected to the cusps of the tricuspid valve by chordae tendinae. There are three papillary muscles in the right ven-tricle, anterior, posterior and septal. The anterior muscle is the largest (Fig. 18.12). The posterior or inferior muscle is small and irregular. The septal muscle is divided into a number of little nipples.

1. Developmentally it is derived from the primitive atrial chamber.
2. It presents a series of transverse muscular ridges called *musculi pectinati.* They arise from the crista terminalis and run forwards and downwards towards the atrioventricular orifice, giving the appearance of the teeth of a comb. In the auricle, the muscles are interconnected to form a reticular network.

Interatrial Septum

1. Developmentally it is derived from the septum, primum and septum secundum.
2. It presents the fossa *ovalis,* a shallow saucer-shaped depression, in the lower part. The fossa represents the site of the embryonic septum primum.
3. The *annulus ovalis or limbus fossa ovalis* is the prominent margin of the fossa ovalis. It represents the lower free edge of the septum secundum. It is , distinct above and at the sides of the fossa ovalis, but is deficient inferiorly. Its anterior edge is continuous with the left end of the valve of the inferior vena cava.
4. The remains of the *foramen ovale* are occasionally present. This is a small slit-like valvular opening
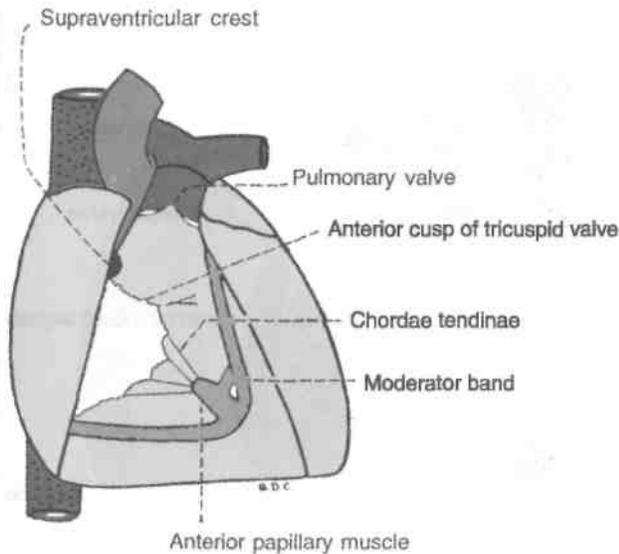
Fig. 18.12: *Interior of the right ventricle. Note the moderator band and the supraventricular crest.*

Fig. 18.14: *The conducting system of the heart.*

ventricle. The lower part is thick muscular separates the two ventricles. Its position is indic: by the anterior and posterior interventricular groc

Each papillary muscle is attached by chordae to the contiguous sides of two cusps (Fig. 18.13)

1. The septomarginal trabecula or moderator band is a muscular ridge extending from the ventricular septum to the base of the anterior papillary muscle. It contains the right branch of the AV bundle (Figs 18.12, 18.14).

2. The cavity of the right ventricle is cresentic in section because of the forward bulge of the interventricular septum (Fig. 18.11).

3. The wall of the right ventricle is thinner than that of the left ventricle in a ratio of 1:3.

Interventricular Septum

The septum is placed obliquely. Its one surface faces forwards and to the right and the other faces backwards and to the left. The upper part of the septum is thin and membranous and separates not only the two ventricles but also the right atrium and left

Fig. 18.13: *Structure of an atrioventricular valve.*

THE LEFT ATRIUM

The left atrium is a quadrangular chamber situated posteriorly. Its appendage, the left auricle projects anteriorly to overlap the infundibulum of the right ventricle. The left atrium forms the left two-thirds of the base of the heart, the greater part of the upper border, parts of the sternocostal and left surfaces and of the left border. It receives oxygenated blood from the lungs through four pulmonary veins, and pumps it to the left ventricle through the left atrioventricular or bicuspid or mitral orifice which is guarded by the valve of the same name.

Features

1. The posterior surface of the atrium forms the anterior wall of the oblique sinus of pericardium (Fig. 18.5).

2. The anterior wall of the atrium is formed by the interatrial septum.

3. Two pulmonary veins open into the atrium on each side of the posterior wall (Fig. 18.7).

4. The greater part of the interior of the atrium is smooth walled. It is derived embryologically from the absorbed pulmonary veins which open into it. Musculi pectinati are present only in the auricle where they form a reticulum. This part develops from the original primitive atrial chamber of the heart tube. The septal wall shows the fossa lunata corresponding to the fossa ovalis of the right atrium. In addition to the four pulmonary veins, the tributaries of the atrium include a few venae cordis minimi.

The left ventricle receives oxygenated blood from the left atrium and pumps it into the aorta. It forms the apex of the heart, a part of the sternocostal surface, most of the left border and left surface, and the left two-thirds of the diaphragmatic surface (Figs 18.6, 18.13).

Features

1. Externally, the left ventricle has three surfaces: anterior or sternocostal, inferior or diaphragmatic, and left.

2. The interior is divisible into two parts: (i) the lower rough part with or trabeculae carneae develops from the primitive ventricle of the heart tube, (ii) the upper smooth part or aortic vestibule gives origin to the ascending aorta: it develops from the mid portion of the bulbus cordis. The vestibule lies between the membranous part of the interventricu-lar septum and the anterior or aortic cusp of the mitral valve.

3. The interior of the ventricle shows two orifices: (i) The left atrioventricular or bicuspid or mitral orifice, guarded by the bicuspid or mitral valve, and (ii) the aortic orifice, guarded by the aortic valve (Fig. 18.15).

4. There are two well-developed papillary muscles, anterior and posterior. Chordae tendinae from both
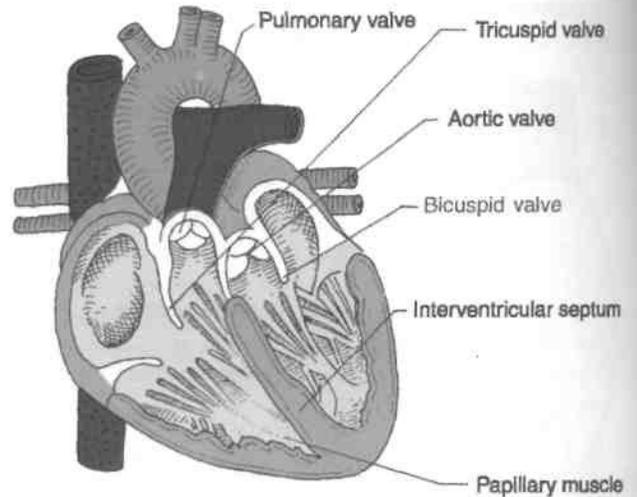
Fig. 18.15: Interior of heart.

muscles are attached to both the cusps of the mitral valve.

5. The cavity of the left ventricle is circular in cross-section (Fig.18.9).

6. The walls of the left ventricle are three times thicker than those of the right ventricle.

The valves of the heart maintain unidirectional flow of the blood and prevent its regurgitation in the opposite direction. There are two pairs of valves in the heart, a pair of atrioventricular valves and a pair of semilunar valves. The right atrioventricular valve is known as the tricuspid valve because it has three cusps. The left atrioventricular valve is known as the bicuspid valve because it has two cusps. It is also called the mitral valve. The semilunar valves include the aortic and pulmonary valves, each having three semilunar cusps. The cusps are folds of endocardium, strengthened by an intervening layer of fibrous tissue (Fig. 18.9).

Atrioventricular Valves

1. Both valves are made up of the following components: (i) a *fibrous ring to* which the cusps are attached (Fig. 18.13). (ii) The cusps are flat and project into the ventricular cavity. Each cusp has an attached and a free margin, and an atrial and a ventricular surface. The atrial surface is smooth (Fig. 18.16). The free margins and ventricular surfaces are rough and irregular due to the attachment of chordae tendinae. *The valves are closed during ventricular systole* by apposition of the atrial surfaces
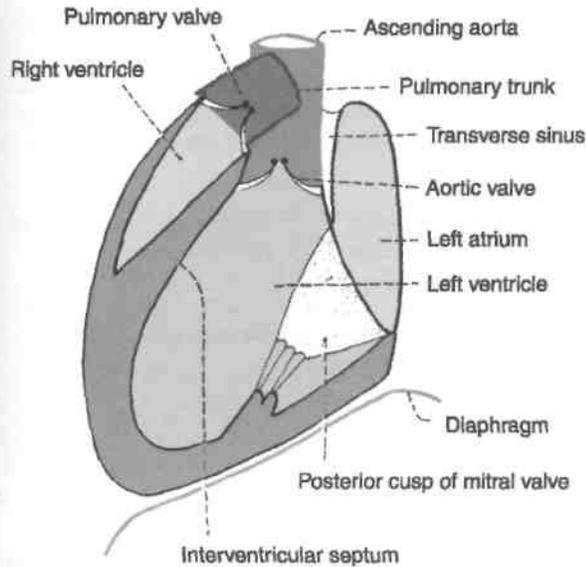
Fig. 18.16: *Sagittal section of the heart. Note that the left atrium lies posterosuperior to the left ventricle, and that the mitral valve is placed almost vertically.*

near the serrated margins, (iii) The *chordae tendinae* connect the free margins and ventricular surfaces of the cusps to the apices of the papillary muscles. They prevent eversion of the free margins and limit the amount of ballooning of the cusps towards the cavity of the atrium, (iv) The atrioventricular valves are kept competent by active contraction of the *papillary muscles,* which pull on the chordae tendinae during ventricular systole. Each papillary muscle is connected to the contiguous halves of two cusps (Figs 18.11, 18.13).

1. Blood vessels are present only in the fibrous ring and in the basal one-third of the cusps. Nutrition to the central two-thirds of the cusps is derived directly from the blood in the cavity of the heart.

2. The tricuspid valve has three cusps and can admit the tips of three fingers. The three cusps, the anterior, posterior or inferior, and septal lie against the three walls of the ventricle. Of the three papillary muscles, the anterior is the largest, the inferior is smaller and irregular, and the septal is represented by a number of small muscular elevations.

3. The mitral or bicuspid valve has two cusps, a large anterior or aortic cusp, and a small posterior cusp. It admits the tips of two fingers. The anterior cusp lies between the mitral and aortic orifices. The mitral cusps are smaller and thicker than those of the tricuspid valve.

Semilunar Valves

1. The aortic and pulmonary valves are called semilunar valves because their cusps are semilunar in shape. Both valves are similar to each other (Fig. 18.17).

1. Each valve has three cusps which are attached directly to the vessel wall, there being no fibrous ring. The cusps form small pockets with their mouths directed away from the ventricular cavity. The free margin of each cusp contains a central fibrous *nodule* from each side of which a thin smooth margin the *lunule* extends up to the base of the cusp. These *valves are closed during ventricular diastole* when each cusp bulges towards the ventricular cavity (Fig. 18.17).

2. Opposite the cusps the vessel walls are slightly dilated to form the aortic and pulmonary sinuses. The coronary arteries arise from the anterior and the left posterior aortic sinuses (Fig. 18.19).
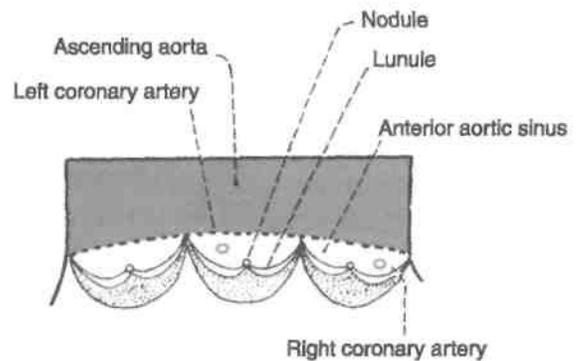
Fig. 18.17: *Structure of the aortic valve.*

Surface Marking of the Cardiac Valves and the Auscultatory Areas

Sound produced by closure of the valves of the heart can be heard using a stethoscope. The sound arising in relation to a particular valve are best heard not directly over the valve, but at areas situated some distance away from the valve in the direction of blood flow through it. These are called auscultatory areas. The position of the valves in relation to the surface of the body, and of the auscultatory areas is given in Table 18.1 and Fig. 18.18.

Conducting System

The conducting system is made up of myocardium that is specialized for initiation and conduction of the cardiac impulse. Its fibres are finer than other myocardial fibres, and are completely cross-striated. The conducting system has the following parts:

1. **Sinuatrial Node or SA node.** It is known as the 'pacemaker' of the heart. It generates an impulse at the rate of about 70/ min and initiates the heart beat. It is horseshoe-shaped and is situated at the

Table 18.1: Surface marking of the cardiac valves and the sites of the ausculatory areas

Valve	Diameter of orifice	Surface marking	Auscultatory area
1. Pulmonary	2.5 cm	A horizontal line, 2.5 cm long, behind the upper border of the third left costal cartilage and adjoining part of the sternum	Second left intercostal space near the sternum
2. Aortic	2.5 cm	A slightly oblique line, 2.5 cm long, behind the left half of the sternum at the level of the lower border of the left third costal cartilage	Second right costal cartilage near the sternum
3. Mitral	3 cm	An oblique line, 3 cm long; behind the left half of the sternum opposite the left fourth costal cartilage	Cardiac apex
4. Tricuspid	4 cm	Most oblique of all valves, being nearly vertical, 4 cm long; behind the right half of the sternum opposite the fourth and fifth spaces	Lower end of the sternum
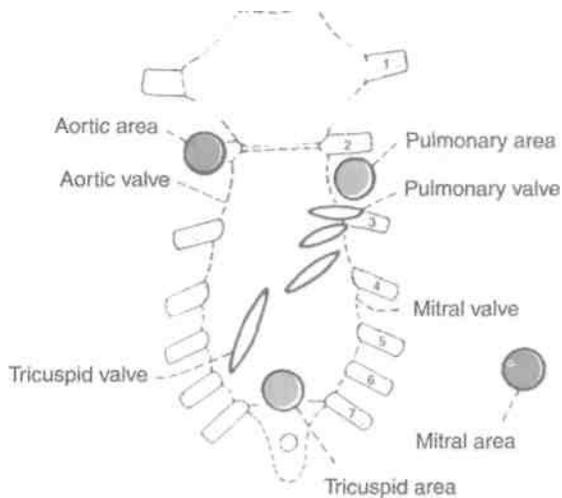
Fig. 18.18: Surface projection of the cardiac valves. The position of the auscultatory areas is also shown.

CLINICAL ANATOMY

1. The first heart sound is produced by closure of the atrioventricular valves. The second heart sound is produced by closure of the semilunar valves.

2. Narrowing of the valve orifice due to fusion of the cusps is known as 'stenosis', viz. mitral stenosis, aortic stenosis, etc.

3. Dilatation of the valve orifice, or stiffening of the cusps causes imperfect closure of the valve leading to back-flow of blood. This is known as incompetence or regurgitation, e.g. aortic incompetence or aortic regurgitation.

atriocaval junction in the upper part of the sulcus terminals. The impulse travels through the atrial wall to reach the AV node (Fig. 18.14).

2. **Atrioventricular node or AV node.** It i smaller than the SA node and is situated in the lowe and dorsal part of the atrial septum just above th opening of the coronary sinus. It is capable of genei ating impulses at a rate of about 60/ min.

1. **Atrioventricular bundle or AV bundle** o **bundle of His.** It is the only muscular connectio between the atrial and ventricular musculatures.] begins as the atrioventricular (AV) node crosses A ring and descends along the posteroinferior borde of the membranous part of the ventricular septurr At the upper border of the muscular part of th septum it divides into right and left branches.

2. **The right branch** of the AV bundle passe down the right side of the interventricular septum., large part enters the moderator band to reach th anterior wall of the right ventricle where it divide into Purkinje fibres.

3. **The left branch** of the AV bundle descends o; the left side of the interventricular septum and i distributed to the left ventricle after dividing int Purkinje fibres.

4. **The Purkinje fibres** form a subendocardi£ plexus. They are large pale fibres striated only a their margins. They usually possess double nucle:

Defects of or damage to this system results ii cardiac arrhythmias, i.e. defects in the normal rhythr of contraction. Except for a part of the left branch c the AV bundle supplied by the left coronary arter the whole of the conducting system is usually sup plied by the right coronary artery. Vascular lesions c the heart can cause a variety of arrhythmias.

ARTERIES SUPRY1N® THE HEART

The heart is supplied by two coronary arteries arising from the ascending aorta. Both arteries rui in the coronary sulcus.

Carfully remove the fat from the coronary sulcus. Identify the right coronary artery in the depth of the right part of the atrioventricular sulcus. Trace the right coronary artery superiorly to its origin from the right aortic sinus and inferiorly till it turns on to the posterior surface of the heart to lie in its atrioventricular sulcus. It gives off the posterior interventricular branch which is seen in posterior interventricular groove. The right coronary ends by anastomosing with the circumflex branch of left coronary artery or by dipping itself deep in the myocardium there.

Right Coronary Artery

Right coronary artery is smaller than the left coronary artery. It arises from the anterior aortic sinus (Fig. 18.19).

Course

1. It first passes forwards and to the right to emerge on the surface of the heart between the root of the pulmonary trunk and the right auricle.

2. It then runs downwards in the right anterior coronary sulcus to the junction of the right and inferior borders of the heart.

3. It winds round the inferior border to reach the diaphragmatic surface of the heart. Here it runs

backwards and to the left in the right posterior coronary sulcus to reach the posterior interventricular groove.

4. It terminates by anastomosing with the left coronary artery.

Branches

(A)Large branches: (1) Marginal, and (2) posterior interventricular.

(B)Small branches: (1) Nodal in 60% cases, (2) right atrial, (3) infundibular, and (4) terminal.

Area ofDistribution

1. Right atrium

2. Ventricles

(i) Greater part of the right ventricle, except the area adjoining the anterior interventricular groove.

(ii) A small part of the left ventricle adjoining the posterior interventricular groove.

3. Posterior part of the interventricular septum.[1]

/ 4. Whole of the conducting system of the heart except a part of the left branch of the AV bundle. The SA node is U / supplied by the left coronary artery in about 40% of cases.

Left Coronary Artery

Left coronary artery is larger than the right coronary artery. It arises from the left posterior aortic sinus.
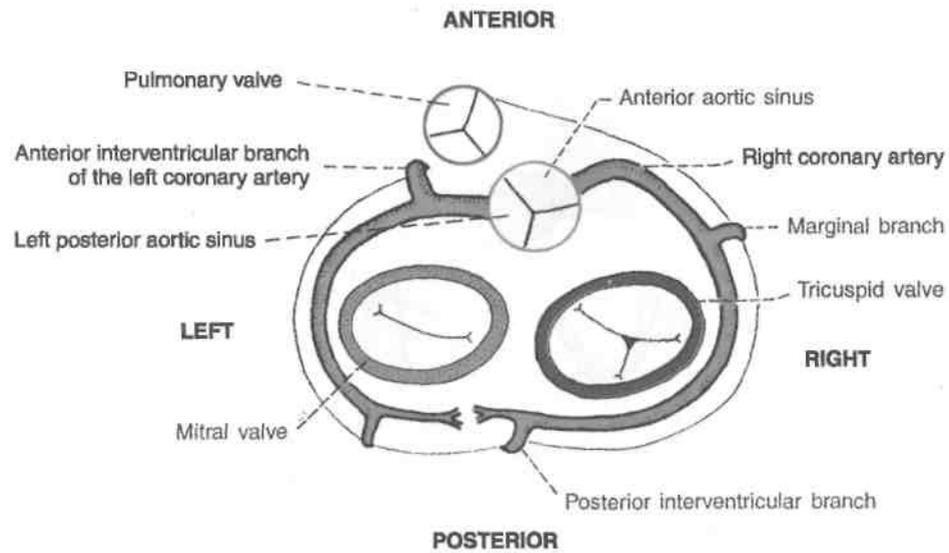
Fig. 18.19: *Origin of the coronary arteries from the aortic sinuses and their course in the coronary sulcus, as seen after removal of the atria.*

surlace of the *heart. Expose the anterior* interventricular branch of the left coronary artery and the great cardiac vein by carefully removing the fat from the anterior interventricular sulcus. Note the branches of the artery to both ventricles and to the interventricular septum which lies deep to it. Trace the artery inferiorly to the diaphragmatic surface and superiorly to the left of the pulmonary trunk. Trace the circumflex branch of left coronary artery on the left border of heart into the posterior part of the sulcus, where it may end by anastomosing with the right coronary artery or by dipping into the myocardium.

Course

1.The artery first runs forwards and to the left and emerges between the pulmonary trunk and the left auricle. Here it gives the anterior interventricular branch which runs downwards in the groove of the same name. The further continuation of the left coronary artery is called the circumflex artery (Fig. 18.20).

2.After giving off the anterior interventricular branch the artery runs to the left in the left anterior coronary sulcus.

3.It winds round the left border of the heart and continues in the left posterior coronary sulcus. Near the posterior interventricular groove it terminates by anastomosing with the right coronary artery.

Branches

A. *Large branches:* (1) Anterior interventricular, (2) branches to the diaphragmatic surface of the *left* ventricle, including a large diagonal branch.

B. *Small branches:* (1) Left atrial, (2) pulmonary, and (3) terminal.

Area of Distribution

1. Left artium
2. Ventricles

(i) Greater part of the left ventricle, except the area adjoining the posterior interventricular groove.

(ii) A small part of the right ventricle adjoining the anterior interventricular groove.

1. Anterior part of the interventricular septum (Fig 18.21).
2. A part of the left branch of the AV bundled

Cardiac Dominance

In about 10% of hearts, the right coronary is rather small and is not able to give the postrior interventricular branch. In these cases the circumflex artery, the continuation of left coronary provides the posterior interventricular branch as well as to the AV node. Such cases are called as left dominant.

Mostly the right coronary gives posterior interventricular artery. Such hearts are right dominant. Thus *ihe* artery giving the posterior interventricular branch is the dominant artery.

Superier vena cava
Ascending aorta
Left coronary artery
Circumflex branch
Diagonal branch
Pulmonary trunk
Right coronary artery
Marginal branch

POSTERIOR

Area supplied by the right coronary artery
Posterior interventricular groove
Left ventricle
RIGHT
LEFT
Right ventricle
Anterior interventricular groove
Area supplied by the left coronary artery

Pulmonary trunk
Vein of left ventricle
Great cardiac vein (Anterior inter ventricular gr)
Right atrium
Anterior cardiac vein
Middle cardiac vein (Posterior interventri groove)
Small cardiac vein
Coronary sinus (coronary sulus)

Fig. 18.22: Veins of the heart.

fig. 18.21: Transverse section through the ventricles showing the areas supplied by the two coronary arteries.

Collateral Circulation

Cardiac anastomosis: The two coronary arteries anastomose with each other in myocardium.

Extracardiac anastomoses: The coronary arteries anastomose with the: (i) vasa vasorum of the aorta: (ii) vasa vasorum of the pulmonary arteries: (iii) the internal thoracic arteries, (iv) the bronchial arteries, and (v) the phrenic arteries. The last three anastomose through the pericardium. These channels may open up in emergencies when both coronary arteries are obstructed.

Retrograde flow of blood in the veins may irrigate the myocardium.

These anastomoses are of little practical value. They are not able to provide an alternative source of blood in case of blockage of a branch of a coronary. Blockage of arteries or coronary thrombosis usually leads to death of myocardium. The condition is called myocardial infarction.

CLINICAL ANATOMY

1. Thombosis of a coronary artery is a common cause of sudden death in persons past middle age. This is due to myocardial infarction and ventricular fibrillation.
2. Incomplete obstruction, usually due to spasm of the coronary artery causes angina pectoris, which is associated with agonising pain in the precordial region and down the medial side of the left arm and forearm.
3. Coronary angiography determines the site(s) of narrowing or occlusion of the coronary arteries or their branches.

1.Angioplasty helps in removal of small blockage. It is done using small stent or small inflated balloon.

2.If there are large segments or multiple sites of blockage, coronary bypass is done using either great saphenous vein or internal thoracic artery as graft(s).

THE VEINS OF THE HEART   ~

These are the great cardiac vein, the middle cardiac vein, the right marginal vein, the posterior vein of the left ventricle, the oblique vein of the left atrium, the right marginal vein, the anterior cardiac veins, and the venae cordis minimi (Fig. 18.22). All veins except the last two drain into the coronary sinus which opens into the right atrium. The anterior cardiac veins and the venae cordis minimae open directly into the right atrium.

A. Coronary sinus: The coronary sinus is the largest vein of the heart. It is situated in the left posterior coronary sulcus. It is about 3 cm long. It ends by opening into the posterior wall of the right atrium. It receives the following tributaries.

1.The *great cardiac vein* accompanies first the anterior interventricular artery and then the left coronary artery to enter the left end of the coronary sinus (Fig. 18.22).

2.The *middle cardiac vein* accompanies the posterior interventricular artery, and joins the middle part of the coronary sinus.

3. The *small cardiac vein* accompanies the right coronary artery in the right posterior coronary sulcus and joins the right end of the coronary sinus. The right marginal vein may drain into the small cardiac vein.

4. The *posteriorvein ofthe left ventricle runs* on the diaphragmatic surface of the left ventricle and ends in the middle of the coronary sinus.

5. The *oblique vein of the left atrium ofMarshallis* a small vein running on the posterior surface of the left atrium. It terminates in the left end of the coronary sinus. It develops from the left common cardinal vein or duct of Cuvier which may sometimes form a large left superior vena cava.

6. The *right marginal vein* accompanies the marginal branch ofthe right coronary artery. It may either drain into the small cardiac vein, or may open directly into the right atrium.

B. Anterior cardiac veins: The *anterior cardiac veins* are three or four small veins which run parallel to one another on the anterior wall of the right ventricle and usually open directly into the right atrium through its anterior wall.

C. Venae cordis minimi: The *venae cordis minimi or Thebesian veins or smallest cardiac veins* are numerous small veins present in all four chambers of the heart which open directly into the cavity. These are more numerous on the right side of the heart than on the left. This may be one reason why left sided infarcts are more common.

LYMPHATICS OF THE HEART

Lymphatics of the heart accompany the coronary arteries and form two trunks. The right trunk ends in the brachiocephalic nodes, and the left trunk ends in the tracheobronchial lymph nodes at the bifurcation of the trachea.

NERVE SUPPLY OF THE HEART

Parasympathetic nerves reach the heart via the vagus. These are cardioinhibitory; on stimulation they slow down the heart rate. Sympathetic nerves' are derived from the upper two to five thoracic segments of the spinal cord. These are cardio-, acceleratory, and on stimulation they increase the heart rate, and also dilate the coronary arteries. Both parasympathetic and sympathetic nerves form. the superficial and deep cardiac plexuses, the branches of which run along the coronary arteries to reach the myocardium (Figs 14.13).

The *superficial cardiac plexus* is situated below the arch of the aorta in front of the right pulmonary artery. It is formed by: (i) the superior cervical cardiac branch of the left sympathetic chain; and (ii) the inferior cervical cardiac branch of the left vagus nerve. It gives branches to the deep cardiac plexus, the right coronary artery, and to the left anterior pulmonary plexus.

The *deep cardiac plexus* is situated in front ofthe bifurcation ofthe trachea, and behind the arch ofthe aorta. It is formed by all the cardiac branches derived from all the cervical and upper thoracic ganglia ofthe sympathetic chain, and the cardiac branches of the vagus and recurrent laryngeal nerves, except those which form the superficial plexus. The right and left halves of the plexus distribute branches to the corresponding coronary and pulmonary plexuses. I Separate branches are given to the atria.

DEVELOPMENT OF HEART

The central part of intraembryonic coelom forms the pericardial cavity. The cavity has a parietal wall lined by mesothelium derived from somatic mesoderm and a visceral wall derived from splanchnic mesoderm. The two together form the serous pericardium. The pleuropericardial membrane which partitions off the pleural and pericardial cavities form the fibrous pericardium of the heart.

The heart tube with its venous and arterial ends gets invaginated into the pericardial cavity. The site of invagination is the dorsal mesocardium. Soon the dorsal mesocardium gets absorbed, resulting in the formation of transverse sinus of the pericardium. Reflection of pericardium along the veins entering the heart gives rise to oblique sinus of the pericardium (Figs 18.4, 18.5).

The splanchnic mesenchymal cells in the cardiogenic area ventral to developing pericardial cavity form two endocardial heart tubes which soon fuse to form a single tube. The heart tube shows two ends — arterial and venous and shows alternate constrictions and dilatations. The dilatations are bulbus cordis, the ventricle, common atria and sinus veno-sus. The straight tube forms a loop due to paucity of space, so that cranial portion lies ventrocaudally and caudal atrial portion shifts dorsocranially.

Bulbus cordis gets divided into a distal cranial part the truncus arteriosus, a middle part the conus cordis and a proximal dilated part which forms the trabeculated part of the right ventricle (RV). The conus cordis part of bulbus cordis forms part of ventricles, e.g. infundibulum of RVand the vestibule of left ventricle (LV). The right and left bulbar ridges with the endocardial cushion form the membranous part of interventricular septum.

Simultaneously the common atrium gets divided into right and left atria by the interatrial septum. From the roof of the common atrial chamber first septum to arise is *septum primum[SP). Ostiumprtmum* is the foramen between the lower end of septum and the endocardial cushion. Soon this septum joins the cushion and ostium primum gets obliterated. SP degenerates in upper part and is called *ostium secundum.* A cresentic septum, the *septum secundum* appears on the right side of SP. Now the passage, between the two atria is valvular and is called *foramen ovale.* After birth the two septae fuse to form interatrial septum.

The sinus venosus modifies and can be divided into three parts: right and left horns and body. The right horn gets incorporated into the right atrium while the left horn and body give rise to the coronary sinus.

Developmental Components of Heart

1. Right atrium (Fig. 18.10)
    a. Rough anterior part — atrial chamber proper.
    b. Smooth posterior past
    i.   absorption of right horn of sinus venosus ii. interatrial septum Dermarcating part — crista terminals.
2. Left atrium (Fig. 18.7)
    a. Rough part — atrial chamber proper
    b. Smooth part —
        i.   absorption of pulmonary veins ii. interatrial septum

Fig. 18.23: Foetal circulation.

1. One umbilical vein
2. Ductus venosus
3. Foramen ovale
4. Ductus arteriosus

5. Two umbilical arteries

At the time of birth ^^ the start of breathing process, these structures (1-5) retrogress and gradually the adult form of circulation takes over.

1. The area of the chest wall overlying the heart is called the *precordium.*

2. Rapid pulse or increased heart rate is called *tachycardia.*

3. Slow pulse or decreased heart rate is called *bradycardia.*

4. Irregular pulse or irregular heart rate Is called *arrhythmia.*

5. Consciousness of one's heart beat is called *palpitation.*

6. Inflammation of the heart can involve more than one layer of the heart. Inflammation of the pericardium is called *pericarditis;* of the myocardium is *myocarditis;* and of the endocardium is *endocarditis.*

7. Normally the diastolic pressure in ventricles is zero. A positive diastolic pressure in the ventricle is evidence of its failure. Any one of the four chambers of the heart can fail separately, but ultimately the rising back pressure causes right sided failure (congestive cardiac failure or CCF) which is associated with increased venous pressure, oedema on feet, and breathlessness on exertion. Heart failure (right sided) due to lung disease is known as *cor pulmonale.*

8. Normally the cardiac apex or apex beat is on the left side. In the condition called dextrocardia, the apex is on the right side. Dextrocardia may be part of a condition called *situs inversus* in which all thoracic and abdominal viscera are a mirror image of normal.

/ 9. Cardiac pain is an ischaemic pain caused by incomplete obstruction of a coronary artery.

mmmmmmmmmmsmmmm m

Axons of pain fibres conveyed by the sensory sympathetic cardiac nerves reach thoracic one to thoracic five segments of spinal cord mostly through the dorsal root ganglia of the left side. Since these dorsal root ganglia also receive sensory impulses from the medial side of arm, forearm and upper part of front of chest, the pain gets referred to these areas as depicted in Fig. 18.24.

Though the pain is usually referred to the left side, it may even be referred to right arm, jaw, epigastrium or back?)

Usual distribution and referral of pain in angina pectoris

Fig. 18.24: *Usual distribution and referral of pain in angina pectoris.*

Superior Vena Cava, Aorta and Pulmonary Trunk

19

Superior vena cava brings deoxygenated blood from the head and neck, upper limbs and thorax to the heart. Aorta and pulmonary trunk are the only two exit channels from the heart, developing from a single truncus arteriosus. The two are intimately related to each other.

SUPERIOR VENA CAVA

Superior vena cava is a large venous channel which collects blood from the upper half of the body and drains it into the right atrium. It is formed by the union of the right and left brachiocephalic or innominate veins behind the lower border of the first right costal cartilage close to the sternum. Each brachiocephalic vein is formed behind the corresponding sternoclavicular joint by the union of the internal jugular and subclavian veins (Fig. 19.1).

The superior vena cava is about 7 cm long. It begins behind the lower border of the sternal end of the first right costal cartilage, pierces the pericardium opposite the second right costal cartilage, and terminates by opening into the upper part of the right atrium behind the third right costal cartilage (Fig. 19.2). It has no valves.

Surface Marking

7. *Superior Vena Cava*

It is marked by two parallel lines 2 cm apart, drawn from the lower border of the right first costal cartilage to the upper border of the third right costal cartilage, overlapping the right margin of the sternum (Fig. 19.1).

2. Right Brachiocephalic Vein

It is marked by two parallel lines 1.5 cm apart, drawn from the medial end of the right clavicle to the lower

border of the right first costal cartilage close to the sternum (Fig. 19.1).

3. Left Brachiocephalic Vein

It is marked by two parallel lines 1.5 cm apart, drawn from the medial end of the left clavicle to the lower border of the first right costal cartilage. It crosses the left sternoclavicular joint and the upper half of the manubrium (Fig. 19.1).

Trace superior vena cava from level of first right costal cartilage where it is formed by union of left and right brachiocephalic veins till the third costal cartilage where it opens into right atrium. Trace the ascending aorta from the vestibule of left ventricle upwards between superior vena cava and pulmonary trunk. Arch of aorta is seen above the bifurcation of pulmonary trunk. Cut liga-mentum arteriosum as it connects the left pulmonary artery to the arch of aorta. Trace the left recurrent laryngeal nerve to the medial aspect of arch of aorta. Lift the side of oesophagus forwards to expose the anterior surface of the descending aorta. Lift the diaphragm forwards and expose the aorta in the inferior part of the posterior mediastinum.

Relations of Superior Vena Cava

A. *Anterior:* (i) Chest wall, (ii) internal thoracic vessels, (iii) anterior margin of the right lung and pleura, (iv) the vessel is covered by pericardium in its lower half (Fig. 19.3).

B. *Posterior:* (i) Trachea and right vagus (postero medial to the upper part of the vena cava), (ii) root of right lung posterior to the lower part.

C. *Medial:* (i) Ascending aorta, (ii) brachiocephalic artery.
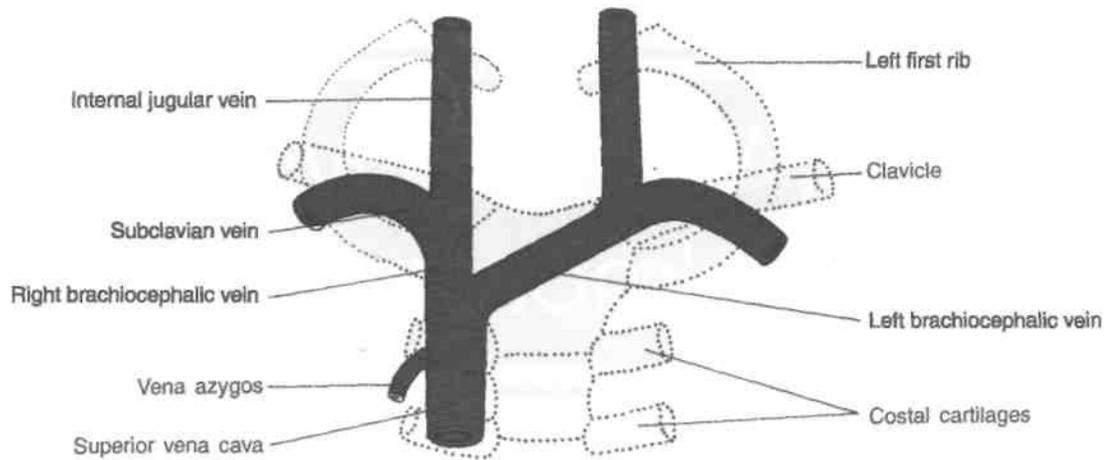
Fig. 19.1: Surface marking of veins of thorax.
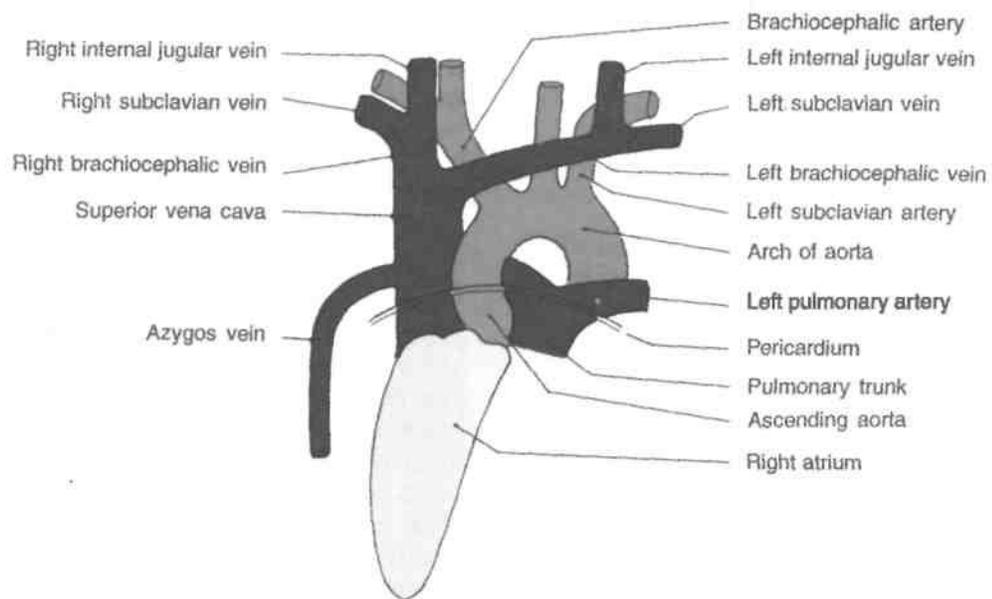
Fig. 19.2: The superior vena cava and its relations.

D. *Lateral:* (i) Phrenic nerve with accompanying vessels, (ii) right pleura and lung.

Tributaries

1. The azygos vein arches over the root of the right lung and opens into the superior vena cava at the level of the second costal cartilage, just before the latter enters the pericardium.

2. Several small mediastinal and pericardial veins drain into the vena cava.

Development

1. The upper half of the superior vena cava up to the opening of the azygos vein, develops from the right anterior cardinal vein.

2. The lower half, below the opening of the azygos vein develops from the right common cardinal vein.

CLINICAL ANATOMY

When the superior vena cava is obstructed above the opening of the azygos vein, the venous blood of the upper half of the body is returned through the azygos vein: and the superficial veins are dilated on the chest up to the costal margin.

When the superior vena cava is obstructed below the opening of the azygos veins, the blood is returned through the inferior vena cava via the femoral vein; and the superior veins are dilated on both the chest and abdomen up to the saphenous

Muscles of second intercostal space

Ascending aorta

Pulmonary trunk

Left phrenic nerve

Internal thoracic vessels

Right pleura

Right lung

Right phrenic nerve

Superior vena cava

Trachea

Right pulmonary artery

Right bronchus

Left vagus nerve

Descending aorta

Right vagus nerve

Oesophagus

Azygos vein

Thoracic duct

Fifth thoracic vertebra
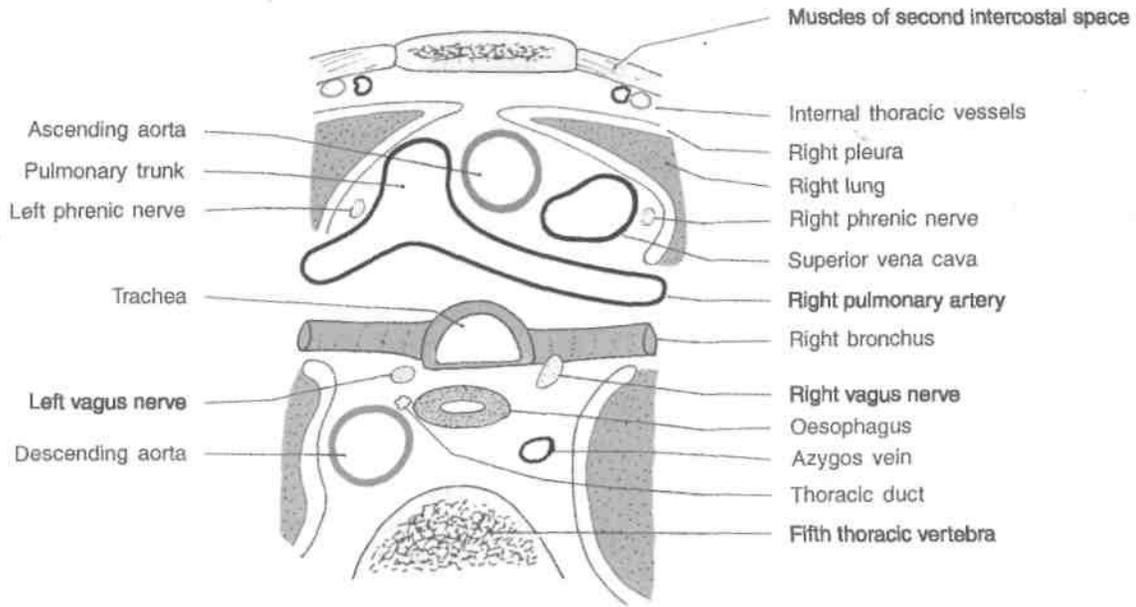
Fig. 19.3: *Transverse section of the thorax passing through the fifth thoracic vertebra.*

opening in the thigh. The superficial vein connecting the lateral thoracic vein with the superficial vein is known as the *thoracoepigastric* vein.

In cases of mediastinal syndrome, the signs of superior vena caval obstruction are the first to
PP '

THE AORTA

rhe aorta is the great arterial trunk which receives axygenated blood from the left ventricle and distrib-parts of the body. It is studied in three

parts: (i) the ascending aorta, (ii) the arch of the aorta, and (iii) the descending aorta, epigastric

Surface Marking

Ascending Aorta

1. First mark the aortic valve by a slightly oblique line 2.5 cm long running downwards and to the right over the left half of the sternum beginning at the level of the lower border of the left third costal cartilage

2. Then mark the ascending aorta (Fig. 19.4) by two parallel lines 2.5 cm apart from the aortic orifice jtes it to all upwards to the right half of the sternal angle.

Brachiocephalic trunk

Sternoclavicular joint

Sternal angle

Right nipple

Seventh right costal cartilage

Left common carotid

Left subclavian

Second intercostal space

Left nipple

Descending thoracic aorta
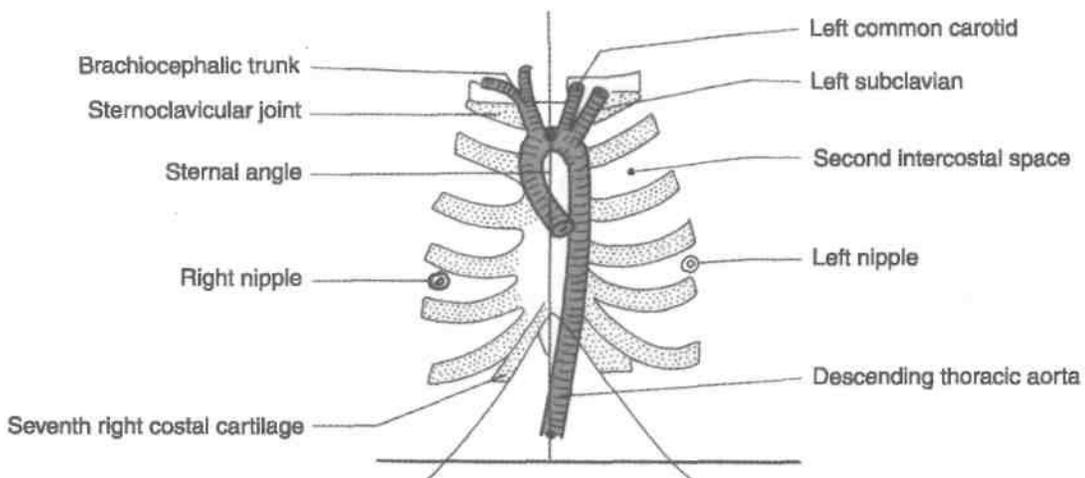
Fig. 19.4: *Surface marking of some arteries of thorax.*

Arch of the Aorta

Arch of the aorta lies behind the lower half of the manubrium sterni. Its upper convex border is marked by a line which begins at the right end of the sternal angle, arches upwards and to the left through the centre of the manubrium, and ends at the sternal end of the left second costal cartilage. Note that the beginning and the end of the arch lie at the same level. When marked on the surface as described above the arch looks much smaller than it actually is because of foreshortening.

Descending Thoracic Aorta

Descending thoracic aorta is marked by two parallel lines 2.5 cm apart, which begin at the sternal end of the left second costal cartilage, pass downwards and medially, and end in the median plane 2.5 cm above the transpyloric plane.

Brachiocephalic Artery

Brachiocephalic artery is marked by a broad line extending from the centre of the manubrium to the right sternoclavicular joint.

Left Common Carotid Artery

The thoracic part of this artery is marked by a broad line extending from a point a little to the left of the centre of the manubrium to the left sternoclavicular joint.

Left Subclavian Artery

The thoracic part of the left subclavian artery is marked by a broad vertical line along the left border of the manubrium a little to the left of the left common carotid artery.

| **THE ASCENDING AORTA**

Origin and Course

The ascending aorta arises from the upper end of the left ventricle. It is about 5 cm long and is enclosed in the pericardium (Fig. 19.2).

It begins behind the left half of the sternum at the level of the lower border of the third costal cartilage. It runs upwards, forwards and to the right and becomes continuous with the arch of the aorta at the sternal end of the upper border of the second right costal cartilage.

At the root of the aorta there are three dilatations of the vessel wall called the aortic sinuses. The sinuses are anterior, left posterior and right posterior.

Relations

Anterior: (i) Sternum, (ii) left lung and pleura, infundibulum of the right ventricle, (iv) root of pulmonary trunk, and (v) right auricle (Fig. 19.;

Posterior: (i) Transverse sinus of pericardium, left atrium, (iiij right pulmonary artery, and (iv) ri principal bronchus (Fig. 19.3).

To the right: (i) Superior vena cava, and (ii) ri, atrium.

To the left: (i) Pulmonary trunk above, and (ii) i atrium below.

Branches

1.The right coronary artery arises from anteri aortic sinus, while the left coronary emerges from tl left posterior aortic sinus (Fig. 18.19).

2.Left coronary artery arises from the left post rior aortic sinus.

| **ARCH OF THE AORTA**

Arch of the aorta is the continuation of the ascendin aorta. It is situated in the superior mediastinur behind the lower half of the manubrium sterni.

Course

1.It begins behind the upper border of the secon right sternochondral joint (Figs 17.2-17.4).

2.It runs upwards, backwards and to the le across the left side of the bifurcation of trachea. The it passes downwards behind the left bronchus an on the left side of the body of the fourth thorati vertebra. It thus arches over the root of the left lun;

3.It ends at the lower border of the body of th fourth thoracic vertebra by becoming continuor with the descending aorta.

Thus the beginning and the end of the aorta are i the same level although it begins anteriorly and enc posteriorly.

Relations

A. Anteriorly and to the Left

1. Four nerves including from before backward:
(i) left phrenic, (ii) lower cervical cardiac branch i the left vagus, (iii) upper cervical cardiac branch < left sympathetic chain, and (iv) left vagus (Fig. 19.5

1.Left superior intercostal vein, deeptothephren nerve and superficial to the vagus nerve.

2.Left pleura and lung.

3.Remains of thymus.
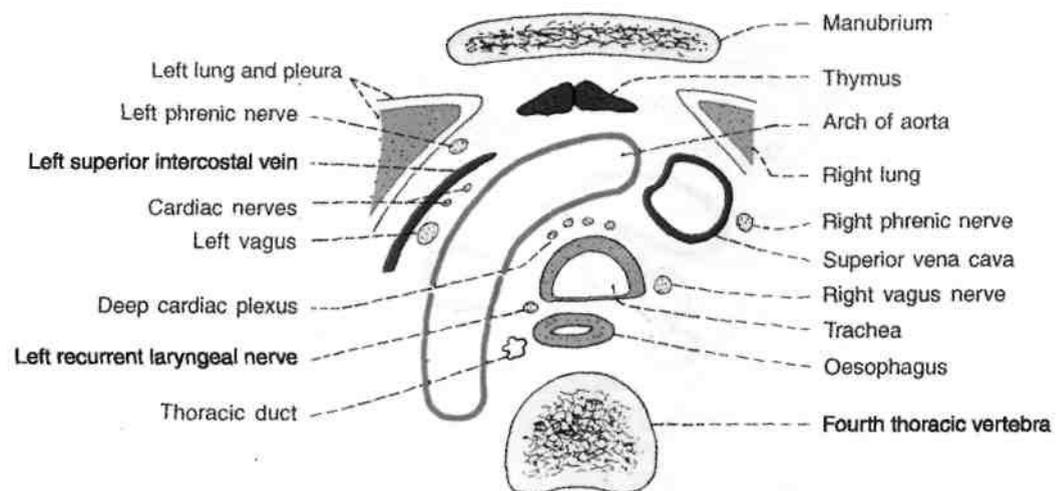
Fig. 19.5: Transverse section of the thorax passing through the fourth thoracic vertebra.

B. Posteriorly and to the Right

1. Trachea, with the deep cardiac plexus and the tracheobronchial lymph nodes.
2. Oesophagus.
3. Left recurrent laryngeal nerve.
4. Thoracic duct.
5. Vertebral column.

C. Superior

1. Three branches of the arch of the aorta: (i) brachiocephalic, (ii) left common carotid, and (iii) left subclavian arteries (Fig. 19.6) .
2. All three arteries are crossed close to their origin by the left brachiocephalic vein.

D. Inferior

1. Bifurcation of the pulmonary trunk.
2. Left bronchus.
3. Ligamentum arteriosum with superficial cardiac plexus on it.

4.Left recurrent laryngeal nerve.

Branches

1.Brachiocephalic artery which divides into the right common carotid and right subclavian arteries (Fig. 19.2).
2.Left common carotid artery.
3.Left subclavian artery.
4.Occasionally: (i) the thyroidea ima, (iii) or vertebral artery may arise from it.

1.*Aortic knuckle.* In PA view of radiographs of the chest, the arch of the aorta is seen a projection beyond the left margin of the mediastinal shadow. The projection is called the aortic knuckle. It becomes prominent in old age.

2.*Coarctation of the aorta* is a localized narrowing of the aorta opposite to or just beyond the attachment of the ductus arteriosus. An extensive collateral circulation develops between the branches of the subclavian arteries and those of the descending aorta. These include the anastomoses between the anterior and posterior intercostal arteries. These arteries enlarge greatly and produce a characteristic notching on the ribs.

3.*Ductus arteriosus, ligamentum arteriosum and patent ductus arteriosus,* muring fetal life, the *ductus arteriosus* is a short wide channel connecting the beginning of the left pulmonary artery with the arch of the aorta immediately distal to the origin of the left subclavian artery. It conducts most of the v blood from the right ventricle into the aorta, thus shortcircuiting the lungs. After birth it is closed functionally within about a week and anatomically within about 8 weeks. The remnants of the ductus form a fibrous band called the *ligamentum arteriosum.* The left recurrent laryngeal nerve hooks around the ligamentum arteriosum.

The ductus may remain patent after birth. The condition is called *patent ductus arteriosus/and* may cause serious problems. The condition can be surgically treated.

4. *Aortic aneurysm* is a localized dilatation of the aorta which may press upon the surrounding structures and cause the mediastinal syndrome.

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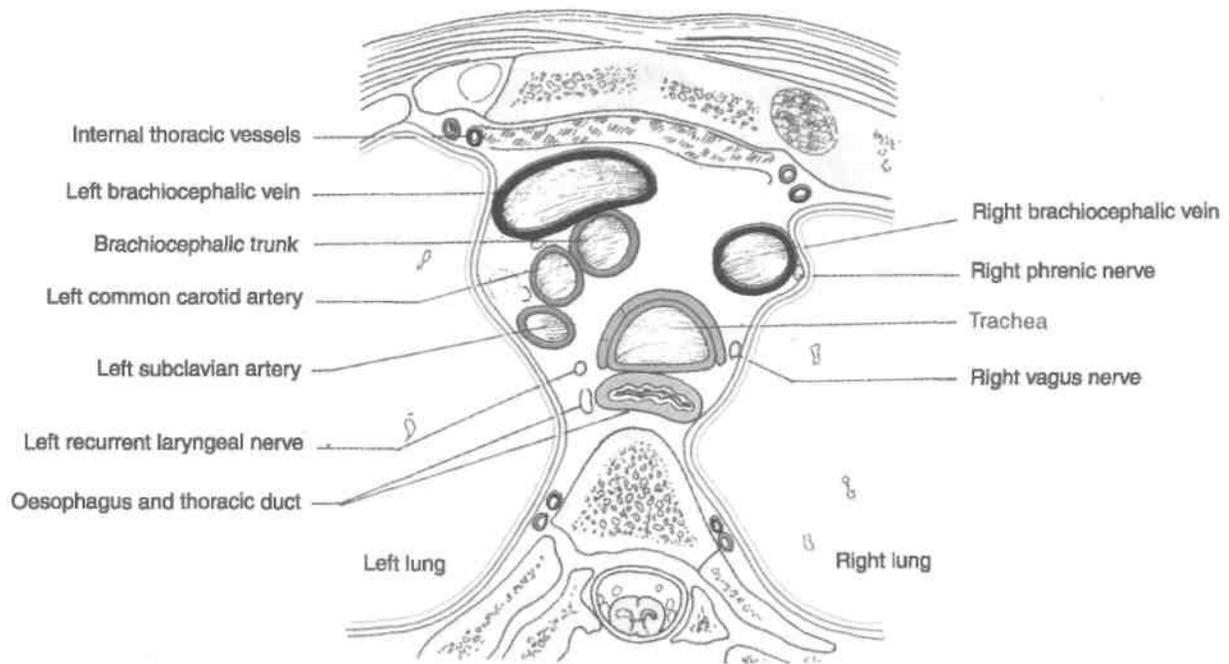
Fig. 19.6: *Transverse section of thorax passing through the third thoracic vertebra.*

Internal thoracic vessels

Left brachiocephalic vein

Brachiocephalic trunk

Left common carotid artery

Left subclavian artery

Left recurrent laryngeal nerve

Oesophagus and thoracic duct

Left lung

Right brachiocephalic vein

Right phrenic nerve

Trachea

Right vagus nerve

Right lung

DESCENDING THORACIC AORTA

Descending thoracic aorta is the continuation of the arch of the aorta. It lies in the posterior mediastinum (Fig. 17.4).

Course

1. It begins on the left side of the lower border of the body of the fourth thoracic vertebra.
2. It descends with an inclination to the right and terminates at the lower border of the twelfth thoracic vertebra.

Relations

Anterior: (i) Root of left lung, (ii) pericardium and heart, (iii) oesophagus in the lower part, and (iv) diaphragm.

   Posterior: (i) Vertebral column, and (ii) hemiazygos veins.

   To the right side: (i) Oesophagus in the upper part, (ii) azygos vein, (iii) thoracic duct, and (iv) right lung and pleura (Fig. 19.3).

   To the left side: Left lung and pleura.

Branches

   1.Nine posterior intercostal arteries on each side for the third to eleventh intercostal spaces.

   2.The subcostal artery on each side.

1.Two left bronchial arteries. The upper left artery may give rise to the right bronchial artery which usually arises from the third right posterior intercostal artery.

2.Oesophageal branches, supplying the middle one-third of the oesophagus.

3.Pericardial branches, to the posterior surface of the pericardium.

4.Mediastinal branches, to lymph nodes and areolar tissue of the posterior mediastinum.

5.Superior phrenic arteries to the posterior part of the superior surface of the diaphragm. Branches of these arteries anastomose with those of the musculophrenic and pericardiophrenic arteries.

PULMONARY TRUNK

Surface Marking

1.First mark the pulmonary valve by a horizontal line 2.5 cm long, mainly along the upper border of the left third costal cartilage and partly over the adjoining part of the sternum (Fig. 18.18).

2.Then mark the pulmonary trunk by two parallel lines 2.5 cm apart from the pulmonary orifice upwards to the left second costal cartilage (Fig. 18.6).

The wide pulmonary trunk starts from the summit of infundibulum of right ventricle. Both the ascending aorta and pulmonary trunk are enclosed in a

common sleeve of serous pericardium, in front of transverse sinus of pericardium. Pulmonary trunk carrying deoxygenated blood overlies the beginning of ascending aorta. It courses to the left and divides into right and left pulmonary arteries under the concavity of aortic arch at the level of sternal angle (Figs 19.2, 19.3). The right pulmonary artery courses to the right behind ascending aorta, and superior vena cava and anterior to oesophagus to become part of the root of the lung. It gives off its first branch to the upper lobe before entering the hilum. Within the lung the artery descends posterolateral to the main bronchus and divides like the bronchi into lobar and segmental arteries. The left pulmonary artery passes to the left anterior to descending thoracic aorta to become part of the root of the left lung. At its beginning, it is connected to the inferior aspect of arch of aorta by ligamentum arteriosus, a remnant of ductus arteriosus. Rest of the course is same as of the right branch.

DEVELOPMENT OF ARTERIES

Fused heart tubes form ventral aorta, which forms the aortic sac. Aortic sac gets divided by spiral septum into ventral part, the aorta and dorsal part the pulmonary trunk. The aorta forms right and left horns which get connected to respective dorsal aor-tae by six arch arteries. Below this level the two dorsal aortae fuse to form single aorta (Fig. 19.7).

Neural crest cells get intermingled in the spiral septum as well as in the processes forming the face. So defects of heart and face may appear together.

1. Arch of aorta is formed from ventral part of aortic sac, left fourth arch artery and left dorsal aorta upto seventh cervical intersegmental artery.
2. Descending aorta is formed by left dorsal aorta below the fourth arch artery and by fused dorsal aortae.
3. Brachiocephalic artery is formed from right horn of aortic sac wherein third and fourth arch arteries open.
4. Common carotid is formed from proximal half of third arch artery.
5. External carotid artery is new branch from third arch.
6. Right subclavian artery is formed by proximal part of right fourth arch artery, part of right dorsal aorta and distal part of right seventh cervical intersegmental artery.
7. Left subclavian artery is formed only by seventh left intersegmental artery.

DEVELOPMENT OF VEINS

To begin with the veins draining the embryo are the cardinal veins. These are anterior cardinal vein from the cephalic part of the embryo, the posterior cardinal vein from caudal part.

Right fourth arch forms part of the right subclavian artery

Dorsal aorta
Third aortic arches
Left fourth arch
Dorsal aorta
Dorsal 1/2 of left sixth arch forms ductus arteriosus
Seventh cervical intersegmental artery forms left subclavian artery
Left horn of aortic sac
Ventral 1/2 of right sexth arch forms the right pulmonary artery
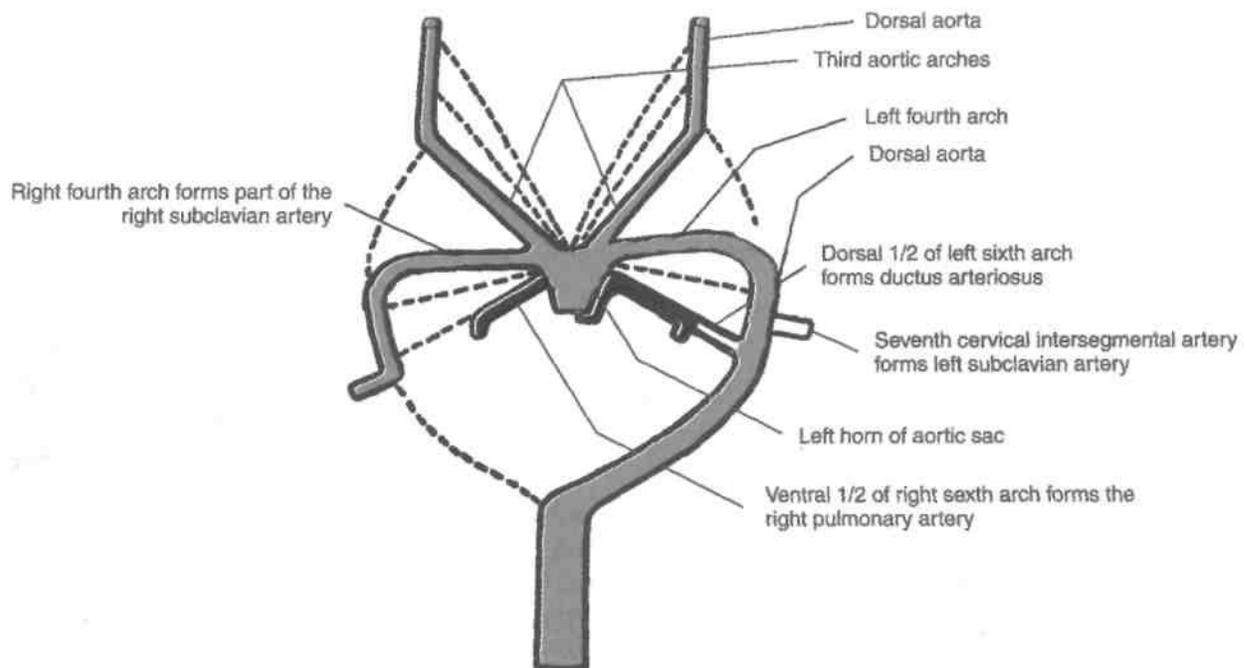
Fig. 19.7: Development of arch arteries.

Anterior and posterior cardinal veins join to form short common cardinal veins which in turn drain

The oblique anastomosis between two anterior cardinal veins develops into the left brachiocephalic

into the sinus venosus.

Veins though appear symmetrically, retrogress from the left side with the result, the main veins get formed on the right side. The reverse is true for the arteries.

vein. The terminal portion of left posterior cardinal vein opening into the left brachiocephalic vein forms the left superior intercostal vein. Proximal portion of right anterior cardinal vein with the right common cardinal vein forms the superior vena cava.

20

The Trachea, Oesophagus and Thoracic Duct

Cricoid cartilage

Trachea

Brachiocephalic trunk

Right principal bronchus

Oesophagus

Thyroid cartilage

Thyroid gland

Left common carotid artery

Left subclavian artery

Arch of aorta

Left principal bronchus
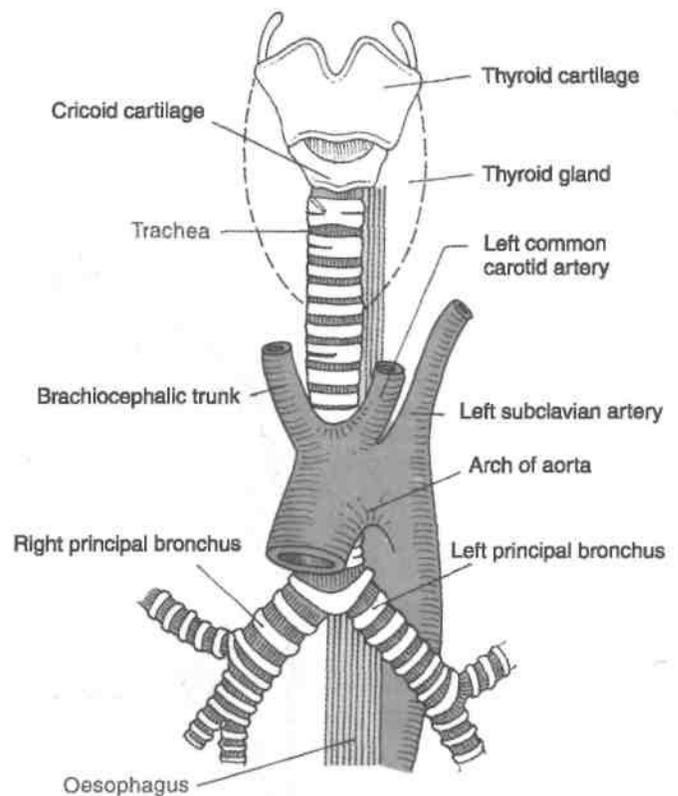
Fig. 20.1: *Trachea and its relations.*

Trachea or windpipe is the patent tube for passage of air to and from the lungs. In contrast, oesophagus lying behind the trachea opens only while drinking or eating. Thoracic duct brings the lymph from major part of the body to the root of the neck.

Remove the posterior surface of the parietal pericardium between the right and left pulmonary veins. This uncovers the anterior surface of the oesophagus in the posterior mediastinum.

Find the azygos vein and its tributaries on the vertebral column to the right of the oesophagus. Find and follow the thoracic duct on the left of azygos vein.

Identify the sternal, sternocostal, interchondral and costochondral joints in the anterior aspect of chest wall which was reflected downwards.

Expose the ligaments which unite the heads of the ribs to the vertebral bodies and intervertebral discs.

THE TRACHEA

The trachea is a wide tube lying more or less in the midline, in the lower part of the neck and in the superior mediastinum. Its upper end is continuous with the lower end of the larynx. At its lower end the trachea ends by dividing into the right and left principal bronchi (Fig. 20.1).

The trachea is 10 to 15 cm in length. Its external diameter measures about 2 cm in males and about 1.5 cm in females. The lumen is smaller in the living than in the cadaver. It is about 3 mm at one year of age. During childhood it corresponds to the age in vears, with a maximum of about 12 mm in adults.

The upper end of the trachea lies at the lower border of the cricoid cartilage, opposite the sixth cervical vertebra. In the cadaver its bifurcated lower end lies at the lower border of the fourth thoracic vertebra, corresponding in front to the sternal angle. However, in living subjects, in the erect posture, the bifurcation lies at the lower border of the sixth thoracic vertebra and descends still further during inspiration.

Over most of its length the trachea lies in the median plane, but near the lower end it deviates

slightly to the right. As it runs downwards, the trachea passes slightly backwards following the curvature of the spine.

Surface Marking

7. Thoracic Part of Trachea

It is marked by two parallel lines 2 cm apart, drawn from the lower border of the cricoid cartilage to the sternal angle, inclining slightly to the right (Fig. 20.1).

2. Right Bronchus

It is marked by a broad line running downwards and to the right for 2.5 cm from the lower end of the trachea to the sternal end of the right third costal cartilage.

3. Left Bronchus

It is marked by a broad line running downwards and to the left for 5 cm from the lower end of the trachea to the left third costal cartilage 4 cm from the median plane.

Relations of the Thoracic Part

A. *Anteriorly:* (i) Manubrium sterni, (ii) sternothyroid muscles, (iii) remains of the thymus, (iv) the left brachiocephalic and inferior thyroid veins, (v) aortic arch, brachiocephalic and left common carotid arteries, (vi) deep cardiac plexus, and (vii) some lymph nodes (Fig. 19.5).

B. *Posteriorly:* (i) Oesophagus, and (ii) vertebral column.

C. *On the right side:* (i) Right lung and pleura, (ii) right vagus, and (iii) azygos vein (Fig. 20.2).

D. *On the left side:* (i) Arch of aorta, left common carotid and left subclavian arteries, and (ii) left recurrent laryngeal nerve (Fig. 20.3).

For relations of cervical part see Vol. 3 of this book.

Structure

The trachea has a fibroelastic wall supported by a cartilaginous skeleton formed by C-shaped rings. The rings are about 16-20 in number and make the tube convex anterolaterally. Posteriorly there is a gap which is closed by a fibroelastic membrane and contains transversely arranged smooth muscle known as the trachealis. The lumen is lined by ciliated columnar epithelium and contains many mucous and serous glands.

Arterial supply: Inferior thyroid arteries.

Venous drainage: Into the left brachiocephalic vein.

Lymphatic drainage: To the pretracheal and paratracheal nodes.

Nerve supply

1. *Parasympathetic:* Nerves through vagi and recurrent laryngeal nerves. It is: (i) sensory and secretomotor to the mucous membrane, and (ii) motor to the trachealis muscle.

Left recurrent laryngeal nerve
Left subclavian artery
Left common carotid artery
Left superior intercostal vein
Left vagus
Left phrenic nerve
Pericardium

Trachea
Oesophagus
Thoracic duct
Arch of aorta
Thoracic aorta
Oesophagus
Diaphragm
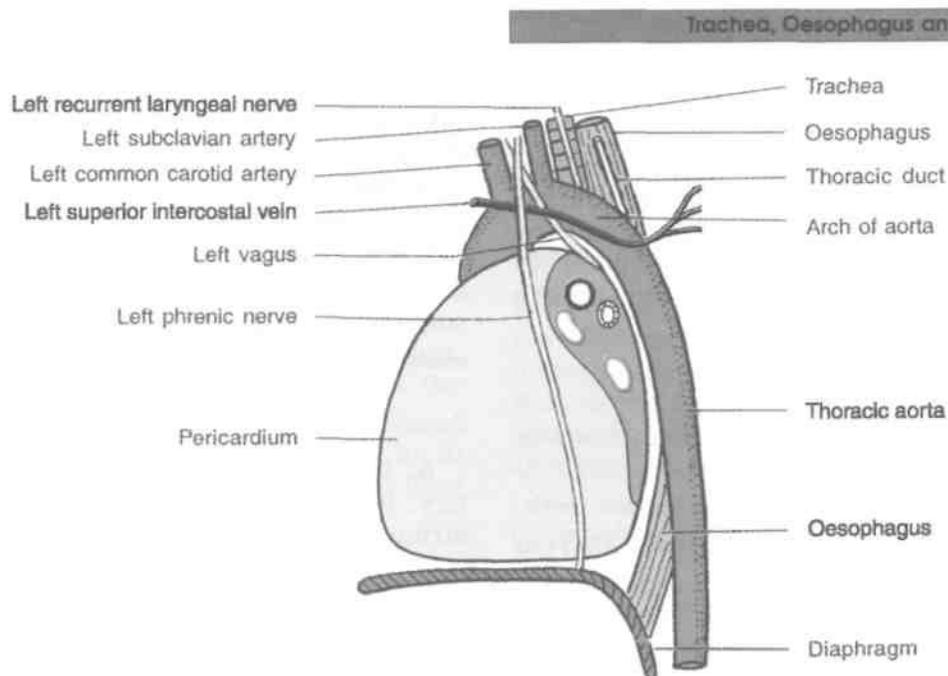
Fig. 20.3: *Mediastinum as seen from the right side.*

2. *Sympathetic:* Fibres from the middle cervical ganglion reach it along the inferior thyroid arteries and are vasomotor.

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CLINICAL ANATOMY

</div>

1.In radiographs, the trachea is seen as a vertical translucent shadow due to the contained air in front of the cervicothoracic spine.

2.Clinically the trachea is palpated in the suprasternal notch. Normally it is median in position. Shift of the trachea to any side indicates a mediastinal shift.

3.During swallowing when the larynx is elevated, the trachea elongates by stretching because the tracheal bifurcation is not permitted to move by the aortic arch. Any downward pull due to sudden and forced inspiration, or aortic aneurysm will produce the physical sign known as 'tracheal tug".

4.Tracheostomy: See Chapter 8 of volume 3 of this book.

5.As the tracheal rings are incomplete posteriorly the oesophagus can dilate during swallowing. This also allows the diameter of the trachea to be controlled by the trachealis muscle. This muscle narrows the calibre of the tube, compressing the contained air if the vocal cords are closed. This increases the explosive force of the blast of compressed air, as occurs in coughing and sneezing.

6.Mucous secretions help in trapping inhaled foreign particles, and the soiled mucus is then

expelled by coughing. The cilia of the mucous membrane beat upwards, pushing the mucus towards the pharynx.

7. The trachea may get compressed by pathological enlargements of the thyroid, the thymus, lymph nodes and the aortic arch. This causes dyspnoea, irritative cough, and often a husky voice.

THE OESOPHAGUS

The oesophagus is a narrow muscular tube, forming the food passage between the pharynx and stomach. It extends from the lower part of the neck to the upper part of the abdomen (Fig. 20.4). The oesophagus is about 25 cm long. The tube is flattened anteroposteriorly and the lumen is kept collapsed; it dilates only during the passage of the food bolus. The pharyngo-oesophageal junction is the narrowest part of the alimentary canal except for the vermiform appendix (Fig. 17.3).

The oesophagus begins in the neck at the lower border of the cricoid cartilage where it is continuous with the lower end of the pharynx.

It descends in front of the vertebral column through the superior and posterior parts of the mediastinum, and pierces the diaphragm at the level of tenth thoracic vertebra. It ends by opening into the stomach at its cardiac end at the level of eleventh thoracic vertebra.

Curvatures

In general, the oesophagus is vertical, but shows slight curvatures in the following directions. There are two side to side curvatures, both towards the left (Fig. 17.4). One is at the root of the neck and the other near the lower end. It also has anteroposterior curvatures that correspond to the curvatures of the cervicothoracic spine.

/Constrictions

Normally the oesophagus shows 4 constrictions at the following levels.

1. At its beginning, 15 cm from the incisor teeth.
2. Where it is crossed by the aortic arch, 22.5 cm from the incisor teeth.
3. Where it is crossed by the left bronchus, 27.5 cm from the incisor teeth.
4. Where it pierces the diaphragm 37.5 cm from the incisor teeth.*J*

The distances from the incisor teeth are important in passing instruments into the oesophagus.

For sake of convenience the relations of the oesophagus may be studied in three parts: cervical, thoracic and abdominal. The relations of the cervical part are described in Vol. 3, and those of the abdominal part in Vol. 2 of this book.

Surface Marking

The oesophagus is marked by two parallel lines 2.5 cm apart by joining the following points.

1. Two points 2.5 cm apart at the lower border of the cricoid cartilage across the median plane (Fig. 20.5).
2. Two points 2.5 cm apart at the root of the neck a little to the left of the median plane.
3. Two points 2.5 cm apart at the sternal angle across the median plane.
4. Two points 2.5 cm apart at the left seventh costal cartilage 2.5 cm from the median plane.

Relations of the Thoracic Part of the Oesophagus

A. *Anterior:* (i) Trachea, (ii) right pulmonary artery, (iii) left bronchus, (iv) pericardium with left atrium, and (v) the diaphragm (Figs 20.2, 20.3).
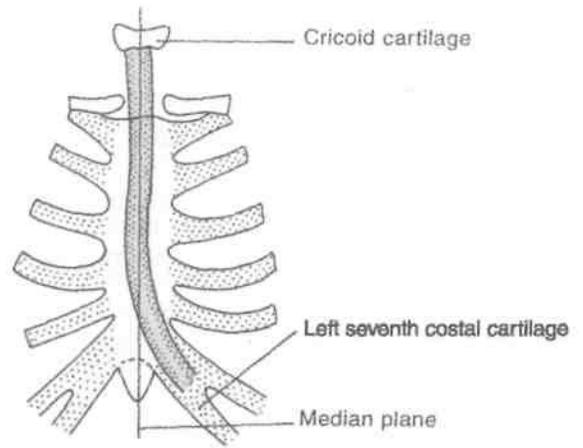
Fig. 20.5: Surface marking of oesophagus.
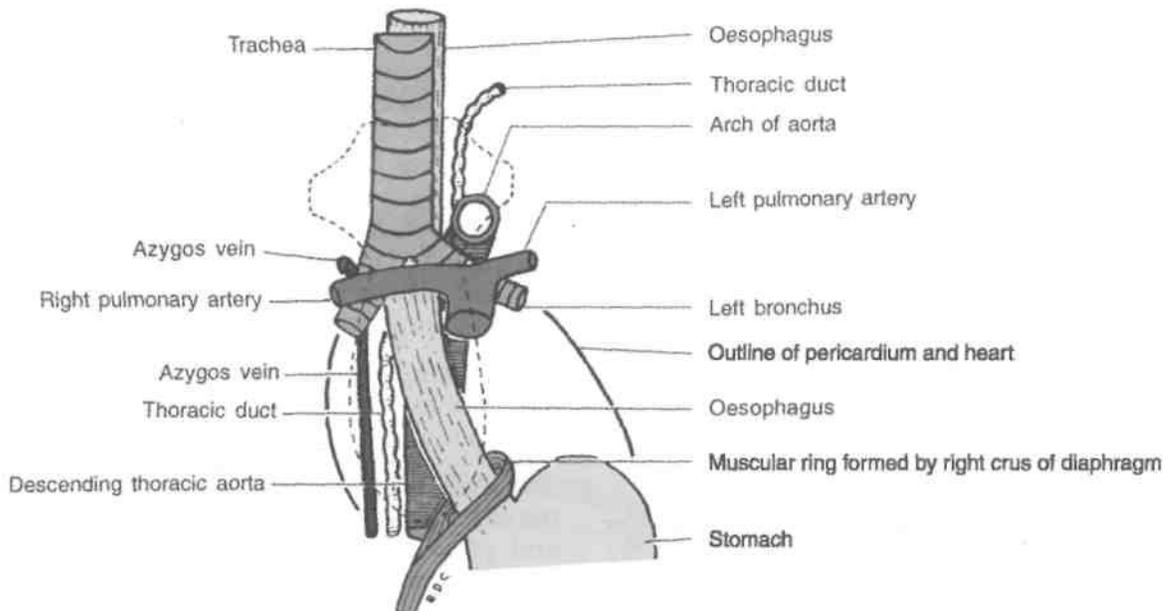
Fig. 20.4: Structures in the posterior mediastinum seen after removal of the heart and pericardium.

Left common carotid artery

Left vagus

Left subclavian artery

Trachea and left recurrent laryngeal nerve

Brachiocephalic trunk

Right vagus

Oesophagus and thoracic duct

Third thoracic vertebra

A

Oesophagus and vagi nerves

Descending thoracic aorta

Right principal bronchus

Vena azygos

Thoracic duct

Fifth thoracic vertebra

B

Oesophagus and its plexus

Descending thoracic aorta

Diaphragm

Vena azygos

Thoracic duct

Eighth thoracic vertebra

C

Fig. 20.6: Outline drawings of three sections through the oesophagus at different levels of thoracic vertebrae.

B. *Posteriorly:* (i) Vertebral column, (ii) right posterior intercostal arteries, (iii) thoracic duct, (iv) azygos vein with the terminal parts of the hemiazygos veins

(v) thoracic aorta, (vi) right pleural recess, and (vii) diaphragm (Fig. 20.4).

C. *To the right:* (i) Right lung and pleura, (ii) azygos vein, and (iii) the right vagus (Fig. 20.6).

D. *To the left:* (i) Aortic arch, (ii) left subclavian artery, (iii) thoracic duct, (iv) left lung and pleura, and (v) left recurrent laryngeal nerve, all in the superior mediastinum (Figs 19.3, 20.8).

In the posterior mediastinum, it is related to: (i) the descending thoracic aorta, and (ii) the left lung and mediastinal pleura (Figs 17.4, 20.6).

Arterial Supply

1. The cervical part including the segment up to the arch of aorta is supplied by the inferior thyroid arteries.

1. The thoracic part is supplied by the oesophageal branches of the aorta.
2. The abdominal part is supplied by the oesophageal branches of the left gastric artery.

Venous *Drainage*

Blood from the upper part of the oesophagus drains into the brachiocephalic veins; from the middle part it goes to the azygos veins; and from the lower end it goes to the left gastric vein. The lower end of the oesophagus is one of the sites of portosystemic anastomoses.

Lymphatic Drainage

The cervical part drains into the deep cervical nodes: the thoracic part to the posterior mediastinal nodes; and the abdominal part to the left gastric nodes.

Nerve Supply

A. *Parasympathetic nerves.* The upper half of the oesophagus is supplied by the recurrent laryngeal nerves, and the lower half by the oesophageal plexus formed mainly by the two vagi. Parasympathetic nerves are sensory, motor and secretomotor to the oesophagus.

B. *Sympathetic nerves.* For the upper half of the oesophagus, the fibres come from the middle cervical ganglion and run on the inferior thyroid arteries. For the lower half, the fibres come directly from the upper four thoracic ganglia, and take part in forming the oesophageal plexus before supplying the oesophagus. Sympathetic nerves are vasomotor.

The *oesophageal plexus* is formed mainly by the parasympathetic through vagi but sympathetic fibres are also present. Towards the lower end of the oesophagus the vagal fibres form the anterior and posterior gastric nerves which enter the abdomen through the oesophageal opening of the diaphragm.

HISTOLOGY

Mucous membrane—Epithelial lining is stratified squamous non-keratinised in nature. Lamina propria consists of loose connective tissue with papillae.

Muscularis mucosae is distinct in lower part and formed by longitudinal muscle fibres.

Submucosa contains mucus-secreting oesophageal glands.

Muscularis externa is composed of striated muscle in upper third; mixed type in middle third and smooth muscles in lower third. Outer layer comprises longitudinal coat and inner is of circular coat of muscle fibres.

Adventitia is the connective tissue with capillaries.

1.In portal hypertension, the communications between the portal and systemic veins draining the lower end of the oesophagus dilate. These dilatations are called *oesophageal varices.* Rupture of these varices can cause serious haematemesis or vomiting of blood. The oesophageal varices can be visualized radiographically by barium swallow: they produce worm-like shadows.

2.Left atrial enlargement as in mitral stenosis can also be visualized by barium swallow. The enlarged atrium causes a shallow depression on the front of the oesophagus. Barium swallow also helps in the diagnosis of oesophageal strictures, carcinoma and achalasia cardia.

3.The normal indentations on the oesophagus should be kept in mind during oesophagoscopy (Fig. 20.7).

4.The lower end of the oesophagus is normally kept closed. It is opened by the stimulus of a food bolus. In case of neuromuscular incoordination, the lower end of the oesophagus fails to dilate with the arrival of food which, therefore, accumulates in the oesophagus. This condition of neuromuscular incoordination characterized by inability of the oesophagus to dilate is known as 'achalasia cardia'.

5.Improper separation of the trachea from the oesophagus during development gives rise to tracheo-oesophageal fistula.

6.Compression of the oesophagus in cases of mediastinal syndrome causes dysphagia {or difficulty in swallowing).
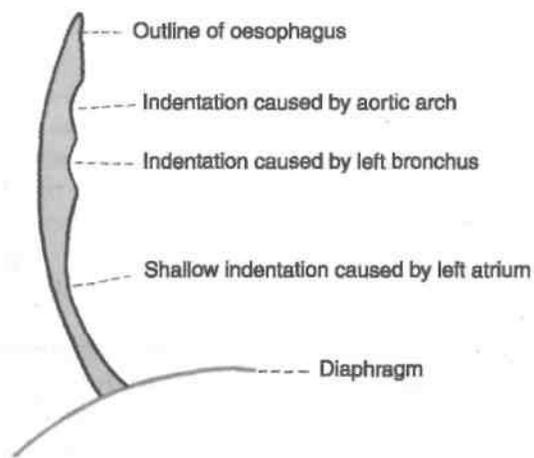
Fig. 20.7: *Tracing of a skiagram taken after a 'barium swallow' showing normal indentations on the oesophagus.*

THE THORACIC DUCT

The thoracic duct is the largest lymphatic vessel in the body. It extends from the upper part of the abdomen to the lower part of the neck, crossing the posterior and superior parts of the mediastinum. It is about 45 cm long. It has a beaded appearance because of the presence of many valves in its lumen (Fig. 20.8).
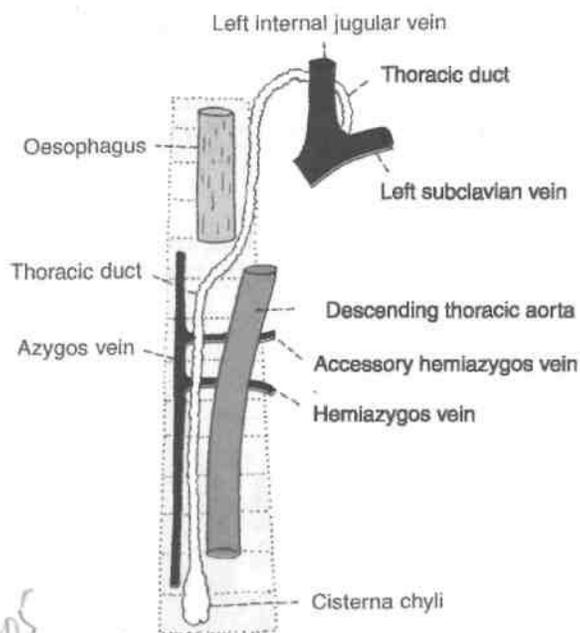
Fig. 20.8: *The course of the thoracic duct.*

Course

The thoracic duct begins as a continuation of the upper end of the cisterna chyli near the lower border of the twelfth thoracic vertebra and enters the thorax through the aortic opening of the diaphragm.

It then ascends through the posterior mediastinum crossing from the right side to the left at the level of the fifth thoracic vertebra. It then runs through the superior mediastinum along the edge of the oesophagus and reaches the neck.

In the neck, it arches laterally at the level of the transverse process of seventh cervical vertebra. Finally it descends in front of the first part of the left subclavian artery and ends by opening into the angle of junction between the left subclavian and left internal jugular veins.

Surface Marking

The thoracic duct is marked by joining the following points.

1. A point 2 cm above the transpyloric plane just to the right of the median plane (Fig. 20.9).
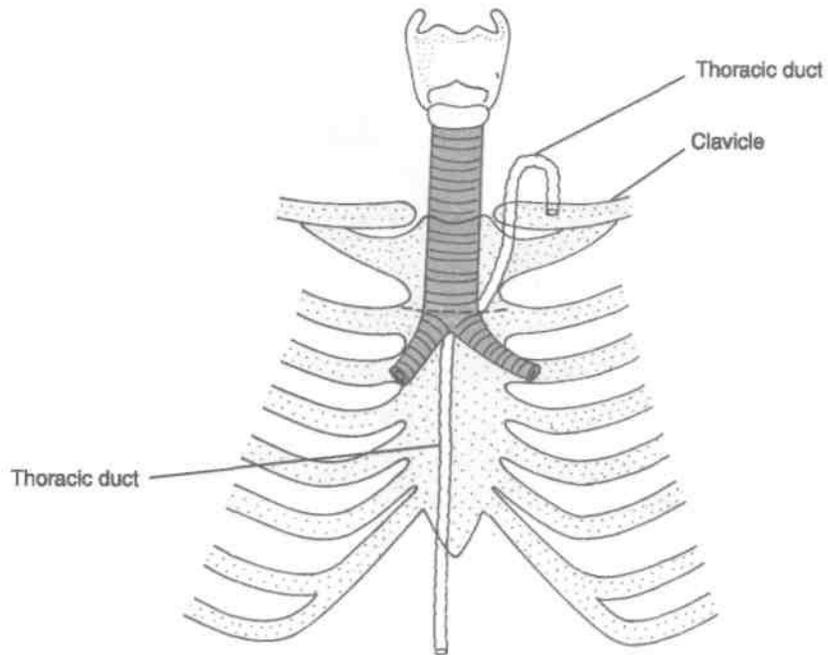
Fig. 20.9: Surface anatomy of the thoracic duct.

1. A point just above the sternal angle 1.3 cm to the left of the median plane.
2. A point 3 cm above the left clavicle 2 cm from the median plane.
3. Lastly it arches laterally for 1.3 cm to end behind the clavicle.

Relations

A. At the Aortic Opening of the Diaphragm
   Anteriorly : Diaphragm

Posteriorly :   Vertebral column

To the right: Azygos vein *To the left*   :   Aorta

B. In the Posterior Mediastinum (Figs 19.3, 19.5)

Anteriorly: (i) Diaphragm, (ii) oesophagus, and (iii) right pleural recess

Posteriorly: (i) Vertebral column, (ii) right posterior intercostal arteries, (iii) terminal parts of the hemiazygos veins (Figs 20.4, 20.6).

To the right: Azygos vein

To the left: Descending thoracic aorta.

C. In the Superior Mediastinum

Anteriorly: (i) Arch of aorta, and (ii) the origin of the left subclavian artery.

Posteriorly: Vertebral column. *To the right:* Oesophagus *To the left:* Pleura.

D. In the Neck

The thoracic duct forms an arch rising about 3-4 cm above the clavicle. The arch has the following relations.

Anteriorly: (i) Left common carotid artery, (ii) left vagus, and (iii) left internal jugular vein.

Posteriorly: (i) Vertebral artery and vein, (ii) sympathetic trunk, (iii) thyrocervical trunk and its branches, (iv) left phrenic nerve, (v) medial border of the scalenus anterior, (vi) prevertebral fascia covering all the structures mentioned, and (vii) the first part of the left subclavian artery.

Tributaries

The thoracic duct receives lymph from, roughly, both halves of the body below the diaphragm and the left half above the diaphragm (Fig. 20.10).

In the thorax, the thoracic duct receives lymph vessels from the posterior mediastinal nodes and from small intercostal nodes. At the root of the neck, efferent vessels of the nodes in the neck form the *left jugular trunk,* and those from nodes in the axilla form the *left subclavian trunk.* These trunks end either in the thoracic duct or in one of the large veins. The *left*
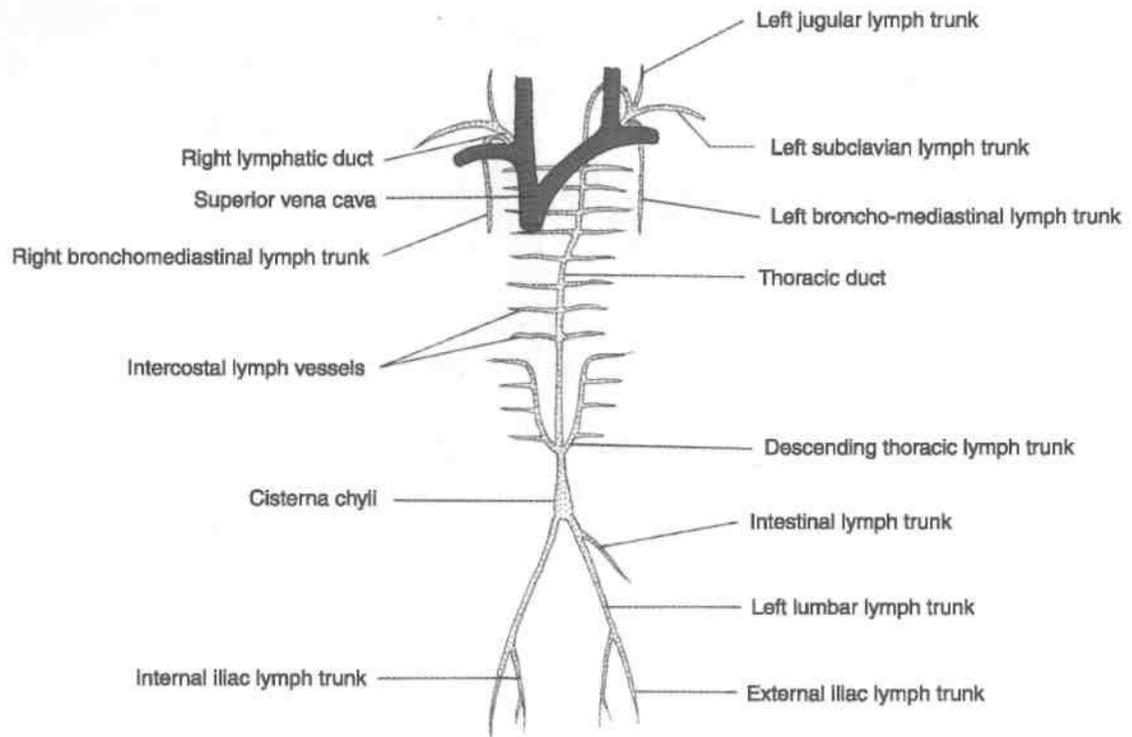
Fig. 20.10: The tributaries of the thoracic duct.

mediastinal trunk drains lymph from the left half of the thorax, usually it ends in the brachiocephalic vein, but may end in the thoracic duct.

„ . ,

1. The thoracic duct may break up into a number of small vessels just before its termination.

2. It may divide in the middle of its course into two vessels which soon unite. Sometimes it may form a plexiform network in the middle.

3. Occasionally it divides in its upper part into two branches, right and left. The left branch ends in the usual manner, and the right opens into the right subclavian vein along with the right lymphatic duct.

Surface Marking and Radiological Anatomy of the Thorax

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Surface marking is the projection of deeper structures on the surface of body.

SURFACE MARKING

The bony and soft tissue surface landmarks have been described in Chapter 12.

The surface marking of important structures is described here.

A. Pleura (Fig. 15.9)
B. Lungs (Fig. 16.5)
C. Heart (Fig. 18.8)
D. Cardiac valves (Fig. 18.18)

Arteries

Internal Mammary (Thoracic) Artery

It is marked byj oining the following points (Fig. 14.10).

(i) A point 1 cm above the sternal end of the clavicle, 3.5 cm from the median plane.

(ii) Points marked over the upper 6 costal cartilages at a distance of 1.25 cm from the lateral sternal border.

(iii) The last point is marked in the sixth space 1.25 cm from the lateral sternal border.

Pulmonary Trunk

(i) First mark the pulmonary valve by a horizontal line 2.5 cm long, mainly along the upper border of the left 3rd costal cartilage and partly over the adjoining part of the sternum (Fig. 18.18).

(ii) Then mark the pulmonary trunk by two parallel lines 2.5 cm apart from the pulmonary orifice upwards to the left 2nd costal cartilage (Fig. 18.6).

Ascending Aorta

(i) First mark the aortic orifice by a slightly oblique line 2.5 cm long running downwards and to the right over the left half of the sternum beginning at the level of the lower border of the left 3rd costal cartilage (Fig. 18.18).

(ii) Then mark the ascending aorta by two parallel lines 2.5 cm apart from the aortic orifice upwards to the right half of the sternal angle (Fig. 19.4).

Arch of the Aorta

Arch of the aorta lies behind the lower half of the manubrium sterni. Its upper convex border is marked by a line which begins at the right end of the sternal angle, arches upwards and to the left through the centre of the manubrium, and ends at the sternal end of the left second costal cartilage. Note that the beginning and the end of the arch lie at the same level. When marked on the surface as described above the arch looks much smaller than it actually is because of foreshortening (Fig. 19.4).

Descending Thoracic Aorta

Descending thoracic aorta is marked by two parallel lines 2.5 cm apart, which begin at the sternal end of the left second costal cartilage, pass downwards and

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medially, and end in the median plane 2.5 cm above the transpyloric plane.

Brachiocephalic Artery

Brachiocephalic artery is marked by a broad line extending from the centre of the manubrium to the right sternoclavicular joint (Fig. 19.4).

Left Common Carotid Artery

The thoracic part of this artery is marked by a broad line extending from a point a little to the left of the centre of the manubrium to the left sternoclavicular joint.

Left Subclavian Artery

The thoracic part of the left subclavian artery is marked by a broad vertical line along the left border of the manubrium a little to the left of the left common carotid artery.

Veins

Superior Vena Cava

Superior vena cava is marked by two parallel lines 2 cm apart, drawn from the lower border of the right first costal cartilage to the upper border of the third right costal cartilage, overlapping the right margin of the sternum (Fig. 19.1).

Right Brachiocephalic Vein

It is marked by two parallel lines 1.5 cm apart, drawn from the medial end of the right clavicle to the lower border of the right first costal cartilage close to the sternum (Fig. 19.1).

Left Brachiocephalic Vein

It is marked by two parallel lines 1.5 cm apart, drawn from the medial end of the left clavicle to the lower border of the first right costal cartilage. It crosses the left sternoclavicular joint and the upper half of the manubrium (Fig. 19.1).

Certain Viscera

Trachea (Thoracic Part)

Trachea is marked by two parallel lines 2 cm apart, drwan from the lower border of the cricoid cartilage to the sternal angle, inclining slightly to the right (Fig. 20.1).

Right Bronchus

Right bronchus is marked by a broad line running downwards and to the right for 2.5 cm from the lower end of the trachea to the sternal end of the right third costal cartilage.

Left Bronchus

Left bronchus is marked by a broad line running downwards and to the left for 5 cm from the lower end of the trachea to the left third costal cartilage 4 cm from the median plane.

Oesophagus

It is marked by two parallel lines 2.5 cm apart by joining the following points (Fig. 20.5).

    (i) Two points 2.5 cm apart at the lower border of the cricoid cartilage across the median plane.

    (ii) Two points 2.5 cm apart at the root of the neck a little to the left of the median plane.

    (iii) Two points 2.5 cm apart at the sternal angle across the median plane, (iv) Two points 2.5 cm apart at the left 7th costal cartilage 2.5 cm from the median plane.

Thoracic Duct

It is marked by joining the following points (Fig. 20.9).

  (i) A point 2 cm above the transpyloric plane slightly to the right of the median plane.

  (ii) A second point 2.5 cm above the left clavicle 2 cm from the median plane, (iii) A third point just above the sternal angle 1.3 cm to the left of the median plane.

Radiography of chest is done to detect a very common disease-the tuberculosis of the lungs.

RADIOGRAPHY

The most commonly taken radiographs are described as posteroanterior (or PA) views. X-rays travel from posterior to the anterior side. A study of such radiographs gives information about the lungs, the diaphragm, the mediastinum, the trachea, and the skeleton of the region (Fig. 21.1).

Following structures have to be examined in posteroanterior view of the thorax.

7. Soft Tissues

Nipples in both the sexes may be seen over the lung fields. The female breasts will also be visualised over the lower part of the lung fields. The extent of the overlap varies according to the size and pendulance of the breasts.
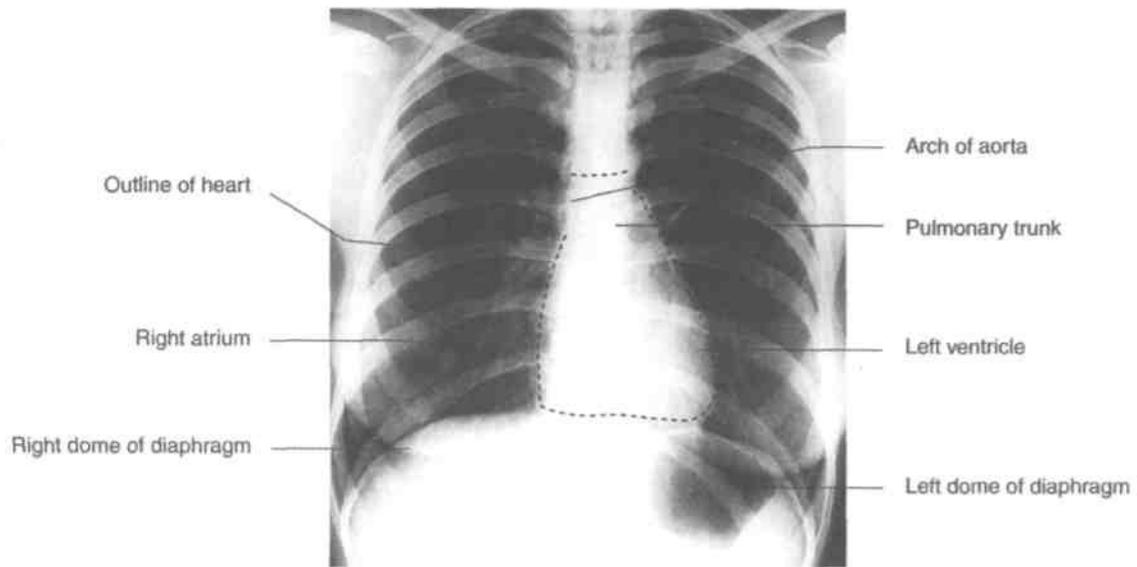
Fig. 21.1: *Posteroanterior view of the thorax.*

2. Bones

The bones of the vertebrae are partially visible. Costotransverse joints are seen on each side. The posterior parts of the ribs are better seen because of the large amounts of calcium contained in them. The ribs get wider and thinner as they pass anteriorly. Costal cartilages are not seen unless these are calcified. The medial borders of the scapulae may overlap the periphery of the lung fields.

3. Trachea

Trachea is seen as air-filled shadow in the midline of the neck. It lies opposite the lower cervical and upper thoracic vertebrae (Fig. 21.1).

4. Diaphragm

Diaphragm casts dome-shaped shadows on the two sides. The shadow on the right side is little higher than on the left side. The angles where diaphragm meets the thoracic cage are the costophrenic angles— the right and the left. Under the left costophrenic angle is mostly the gas in the stomach, while under the right angle is the smooth shadow of the liver.

5. Lungs

The dense shadows are cast by the lung roots due to the presence of the large bronchi, pulmonary bronchial vessels and lymph nodes. The lungs readily permit the passage of the X-rays and are seen as translucent shadows during the full inspiration. Both blood vessels and bronchi are seen as series of

shadows radiating from the lung roots. The smaller bronchi are not seen. The lung is divided into three zones—upper zone is from the apex till the second costal cartilage. Middle zone extends from the second to the fourth costal cartilage. It includes the hilar region. Lower zone extends from the fourth costal cartilage till the bases of the lungs.

6. Mediastinum

Shadow is produced by the superimpositions of structures in the mediastinum. It is chiefly produced by the heart and the vessels entering or leaving the heart. The transverse diameter of heart is half the transverse diameter of the thoracic cage. During inspiration, heart descends down and acquires tubular shape. Right border of the mediastinal shadow is formed from above downwards by right brachiocephalic vein, superior vena cava, right atrium and inferior vena cava. The left border of mediastinal shadow is formed from above downwards by aortic arch (aortic knuckle), left margin of pulmonary trunk, left auricle and left ventricle. The inferior border of the mediastinal shadow blends with the liver and diaphragm.

TOMOGRAPHY

Tomography is a radiological technique by which radiograms of selected layers (depths) of the body can be made. Tomography is helpful in locating deeply situated small lesions which are not seen in the usual radiograms.

Appendix 2

Appendix 2 at the end of the section on thorax .gives a bird's eye view of the sympathetic component of the autonomic nervous system. The course of the typical and atypical intercostal nerves is also mentioned.

Five sample clinicoanatomical problems are solved. In the end, 20 sample multiple choice questions (MCQs) are given to test the knowledge and skill gained by the readers after studying various chapters of the book.

Autonomic Nervous System

The autonomic nervous system comprises sympathetic and parasympathetic components. Sympathetic is active during fright, flight or fight. During any of these activities, the pupils dilate, skin gets pale, blood pressure rises, blood vessels of skeletal muscles, heart, lungs and brain dilate. There is hardly any activity in the digestive tracts due to which the individual does not feel hungry. The person is tense and gets tired soon.

Parasympathetic has the opposite effects of sympathetic. This component is sympathetic to the digestive tract. In its activity digestion and metabolism of food occurs. Heart beats normally. Person is relaxed and can do creative work.

Autonomic nervous system is controlled by brainstem and cerebral hemispheres. These include reticular formation of brainstem, thalamic and hypothalamic nuclei, limbic lobe and prefrontal cortex including the ascending and descending tracts interconnecting these regions.

Sympathetic Nervous System

Sympathetic nervous system is the larger of the two components of autonomic nervous system. It consists of two ganglionated trunks, their branches, prevertebral ganglia, plexuses. It supplies all the viscera of thorax, abdomen and pelvis, including the blood vessels of head and neck, brain, limbs, skin

and the sweat glands as well as arrector pilorum muscle of skin.

The preganglionic fibres are the axons of neurons situated in the lateral horns of T1-L2 segments of spinal cord. They leave spinal cord through their respective ventral roots, to pass in their nerve trunks, and beginning of ventral rami via white ramus com-municans (WRC). There are 14 WRC on each side. These fibres can have following alternative routes:

i. They relay in the ganglion of the sympathetic trunks, postganglionic fibres pass via the grey communicans and get distributed to the blood vessels of muscles, skin, sweat glands and to arrector pili muscles (Fig. A2.1).

ii. These may pass through the corresponding ganglion and ascend to a ganglion higher before terminating in the above manner.

iii. These may pass through the corresponding ganglion and descend to a ganglion lower and then terminate in the above manner.

iv. These may synapse in the corresponding ganglia and pass medially to the viscera like heart, lungs, oesophagus.

v. These white rami communicans pass to corresponding ganglia and emerge from these as WRC (unrelayed) in the form of splanchnic nerves to supply abdominal and pelvic viscera after synapsing in the ganglia situated in the abdominal cavity.

Sympathetic trunk on either side of the body extends from cervical region to the coccygeal region where both trunks fuse to form a single ganglion impar. It has cervical, thoracic, lumbar, sacral and coccygeal parts.

Thoracic Part of Sympathetic Trunk

There are usually 11 ganglia on the sympathetic trunk of thoracic part. The first ganglion lies on neck
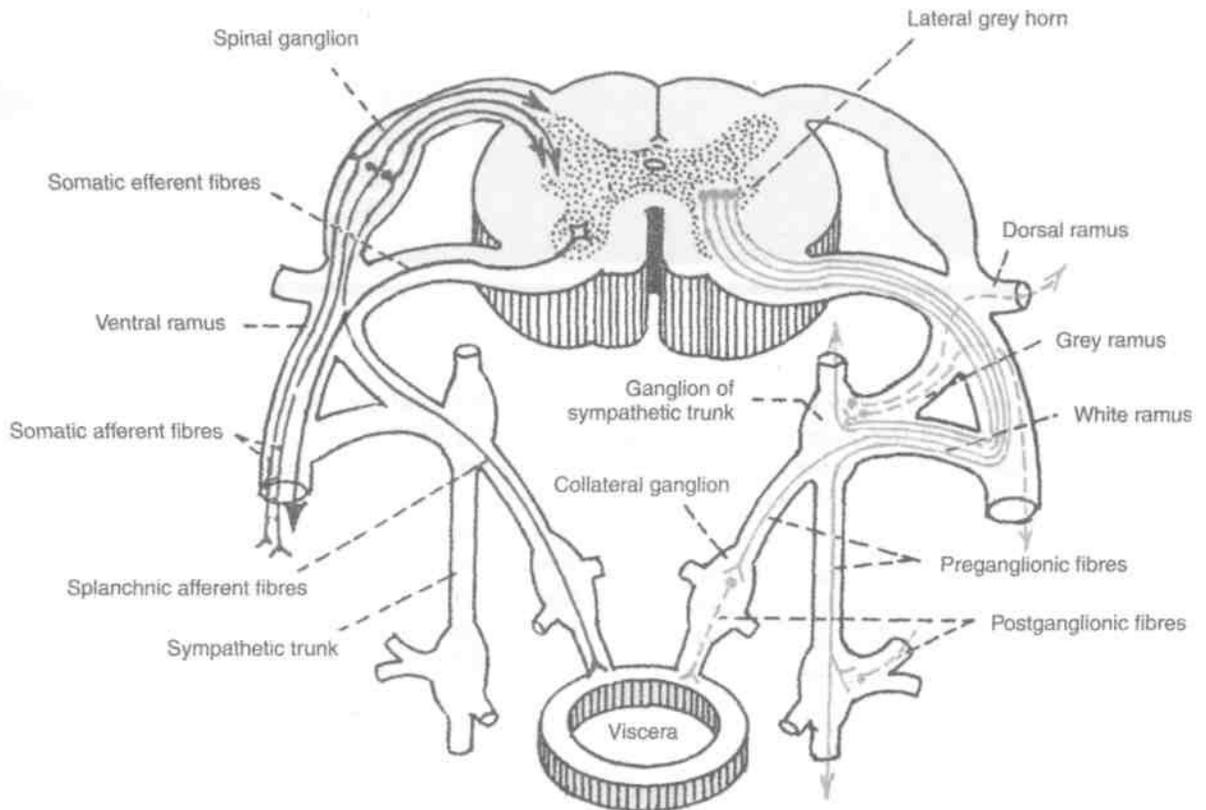
Fig. A2.1: Pathways of sympathetic and somatic nerves.
splanchnic afferent fibres (blue):
sympathetic preganglionic efferent fibres (red)
sympathetic preganglionic efferent fibres (red dotted)
somatic efferent fibres (black)
somatic afferent fibres (blue)

of 1st rib and is usually fused with inferior cervical ganglion and forms stellate ganglion. The lower ones lie on the heads of the ribs. The sympathetic trunk continues with its abdominal part by passing behind the medial arcuate ligament.

The ganglia are connected with the respective spinal nerves via the white ramus communicans (from the spinal nerve to the ganglion) and the grey ramus communicans (from the ganglion to the spinal nerve, i.e. ganglion gives grey).

Branches

1.Grey rami communicans to all the spinal nerves, i.e. T1-T12. The postganglionic fibres pass along the spinal nerves to supply cutaneous blood vessels, sweat glands and arrector pili muscles.

2.White rami communicans from upper 4-6 ganglia travel up to the cervical part of sympathetic trunk of relay in the three cervical ganglia. Fibres from the lower thoracic ganglia T10-L2 pass down as preganglionic fibres to relay in the lumbar or sacral ganglia.

1.The first five ganglia give postganglionic fibres to heart, lungs, aorta and oesophagus.

2.Lower eight ganglia give fibres which are preganglionic (unrelayed) for the supply of abdominal viscera. These are called as splanchnic (visceral) nerves.

Ganglia 5-9 give fibres which constitute greater splanchnic nerve.

Ganglia 9-10 give fibres that constitute lesser splanchnic nerve.

Ganglion 11 gives fibres that constitute lowest splanchnic nerve.

Nerve Supply of Heart Conveyed by the Cardiac Plexuses

Preganglionic sympathetic neurons are located in lateral horns T1-T5 segments of spinal cord. These fibres pass along the respective ventral roots of thoracic nerves, to synapse with the respective ganglia of the sympathetic trunk. After relay the postganglionic fibres form thoracic branches which intermingle with the vagal fibres, to form cardiac plexus.

Some fibres from T1-T5 segments of spinal cord reach their respective ganglia. These fibres then travel up to the cervical part of the sympathetic chain and relay in superior, middle and inferior cervical ganglia. After relay, the postganglionic fibres form the three cervical cardiac nerves. Preganglionic parasympathetic neurons for the supply of heart are situated in the dorsal nucleus of vagus nerve. Sympathetic activity increases the heart rate. Larger branches of coronary are mainly supplied by sympathetic. It causes vasodilatation of coronary arteries. Impulses of pain travel along sympathetic fibres. These fibres pass mostly through left sympathetic trunk and reach the spinal cord via T1-T5 spinal nerves. Thus the pain may be referred to the area of skin supplied by T1-T5 nerves, i.e. retrosternal, medial side of the upper limbs. Since one is more conscious of impulses coming from skin than the viscera one feels as if the pain is in the skin. This is the basis of the referred pain.

Smaller branches of coronary artery are supplied by parasympathetic nerves. These nerves are concerned with slowing of the cardiac cycle.

The nerves reach the heart by two plexuses:

(a) Superficial Cardiac Plexus

Superficial cardiac plexus is formed by the following, (i) Superior cervical cardiac branch of left sympathetic trunk: (ii) Inferior cervical cardiac branch of left vagus nerve.

(b) Deep Cardiac Plexus

Deep cardiac plexus consists of two halves which are interconnected and lie anterior to bifurcation of trachea (Table A2.1).

Branches from the cardiac plexus give extensive branches to pulmonary plexuses, right and left coronary plexuses. Branches from the coronary plexuses supply both the atria and the ventricles. Left ventricle gets richer nerve supply because of its larger size.

Lungs

The lungs are supplied from the anterior and posterior pulmonary plexuses. Anterior plexus is an extension of deep cardiac plexus. The posterior is formed from branches of vagus and T2-T5 sympathetic ganglia. Small ganglia are found on these nerves for the relay of parasympathetic brought via vagus nerve fibres. Parasympathetic is broncho-constrictor or motor whereas sympathetic is inhibitory. Sympathetic stimulation causes relaxation of smooth muscles of bronchial tubes or bronchodilator. The pressure of inspired air also causes bronchodilatation.

TYPICAL INTERCOSTAL NERVE

Typical intercostal nerves are any of the nerves belonging to 3rd to 6th intercostal spaces.

Beginning: Typical thoracic spinal nerve after it has given off dorsal primary ramus or dorsal ramus is called the intercostal nerve. It runs in the intercostal space, i.e. between the lower border of rib above and upper border of rib below.

Course: Typical intercostal nerve enters the posterior part of intercostal space by passing behind the posterior intercostal vessels. So the intercostal nerve lies lowest in the neurovascular bundle. The order from above downwards is vein, artery and nerve (VAN). At first the bundle runs between posterior intercostal membrane and subcostalis, then between inner intercostal and innermost intercostal and lastly between inner intercostal and sternocostalis muscles.

At the anterior end of intercostal space, the intercostal nerve passes in front of internal thoracic vessels, pierces internal intercostal muscle and anterior intercostal membrane to continue as anterior cutaneous branch which ends by dividing into medial and lateral cutaneous branches.

Table A2.1: Components of deep cardiac plexus

Right half	Left half
i. Superior, middle, inferior cervical cardiac branches of right sympathetic trunk	Only middle and inferior branches
ii. Cardiac branches of T2-T4 ganglia of right side	Same
iii. Superior and inferior cervical cardiac branches of right vagus	Only the superior cervical cardiac branch of left vagus
iv. Thoracic cardiac branch of right vagus	Same
v. Two branches of right recurrent laryngeal nerve arising from neck region	Same, but coming from thoracic region

Branches

1.Communicating branches to the sympathetic ganglion close to the beginning of ventral ramus. The anterior ramus containing sympathetic fibres from lateral horn of spinal cord gives off a white ramus communicans to the sympathetic ganglion. These fibres get relayed in the ganglion. Some of these relayed fibres pass via grey ramus communicans to ventral ramus. Few pass backwards in the dorsal ramus and rest pass through the ventral ramus. These sympathetic fibres are sudomotor, pilomotor and vasomotor to the skin and vasodilator to the skeletal vessels.

2.Before the angle, nerve gives a collateral branch that runs along the upper border of lower rib. This branch supplies intercostal muscles, costal pleura and periosteum of the rib.

3.Lateral cutaneous branch arises along the midaxillaiy line. It divides into anterior and posterior branches.

4.The nerve keeps giving muscular, periosteal and branches to the costal pleura during its course.

5.Anterior cutaneous branch is the terminal branch of the nerve.

ATYPICAL INTERCOSTAL NERVES   ~

The thoracic spinal nerves which do not follow absolutely thoracic course are designated as atypical intercostal nerves. Thus Intercostal one, two, are atypical as these two nerves partly supply the upper limb.

The first thoracic nerve entirely joins the brachial plexus as its last rami or root. It gives no contribution to the first intercostal space. That is why the nerve supply of skin of first intercostal space is from the supraclavicular nerves (C3, C4).

The second thoracic or second intercostal nerve runs in the second intercostal space. But its lateral cutaneous branch as intercostobrachial nerve is rather big and it supplies skin of the axilla as well. Third to sixth intercostal nerves are typical.

Also seventh, eight, ninth, tenth, eleventh intercostal nerves are atypical, as these course partly through thoracic wall and partly through anterolateral abdominal wall. Lastly the twelfth thoracic is known as subcostal nerve. It also passes through the anterolateral abdominal muscles. These will be
further stnHiprl in Vnlnmp 9, of this hnnk .

CL1NICOANATOM1CAL PROBLEMS

1. An adult man was stabbed on his upper left side of chest. He was taken to the casualty depart ment of the hospital. The casualty physician noted that the stab wound was in left third intercostal space close to the sternum. Further the patient has engorged veins on the neck and face.

   Clinicoanatomical problems:
   ?What is the site of injury?
   ?Why are the veins of the neck and face engorged?
   ?What procedure would be done as an emergency measure before taking him to operation theatre?

   Ans. The injury is in left third intercostal space injuring the pericardium and right ventricle, causing haemopericardium. Veins of the neck and face are engorged as the venae cavae are not able to pour blood in the right atrium. Pericardial tapping is done to take out the blood from the pericardial cavity. It is done as an emergency measure.

2. A 40-year-old lady while playing tennis, suddenly fell down, holding on to her chest and left arm due to severe pain.

   Clinicoanatomical problems:
   ?Why is the pain in her chest?
   ?Why is the pain in her left arm?

   Ans. Tennis is a very strenuous game. The lady fainted as there was more need for the oxygen. Since it could not be supplied, the myocardium got ischaemic which caused visceral pain. The pain is carried by afferents which travel mostly with left side sympathetic nerves to the thoracic one and thoracic 2-5 segments of the spinal cord. Since somatic nerves (T1-T5) also travel to the same segments, the pain is referred to the skin area. Tl supplies the medial side of arm and T2-T5 supply the intercostal spaces.

3. A 10-year-old boy had mild cough and fever. The physician could feel the increased rate of his pulse, but could not hear the heart beat on the left side of his chest. After some thought the physician was able to feel the heart beat as well.

   Clinicoanatomical problems:
   ?Where is the normal apex beat heart?
   ?Name the congenital anomaly of the heart which could cause inability of heart beat to be felt on the left side.

Ans. Apex beat is normally heard in the left fifth intercostal space, 9 cm from midsternal line, within the left lateral line. The congenital anomaly in this case is dextrocardia, when the heart is placed on the right side of the heart. The apex beat is heard in right fifth intercostal space to the right of the inferior end of the sternum.

4. A 45-year-old man complained of severe cough, loss of weight, alteration of his voice. He has been smoking for last 25 years. Radiograph of the chest followed by biopsy revealed bronchogenic carcinoma in the left upper lobe of the lung.

Clinicoanatomical problems:
?Where did the cancer cells metastasize?
?What caused alteration is his voice?

Ans. The bronchogenic carcinoma spread to the left bronchomediastinal lymph nodes. The left supraclavicular nodes are also enlarged and palpable; so these are called 'sentinal nodes'. The enlarged bronchomediastinal lymph nodes exert pressure on the left recurrent laryngeal nerve in the thorax causing alteration of voice. The cancer of lung is mostly due to heavy smoking.

5. A teenage girl was complaining of breathlessness. The physician heard a 'machine-like' murmur during auscultation on the second left intercostal space, close to the margin of sternum. There was continuous thrill on the same site. On getting radiographs of the chest and angiocardiography, a diagnosis of patent ductus arteriosus was made.

Clinicoanatomical problems:
?What is the 'machine-like' murmur?
?How can the shunting of blood prevented?
?Describe briefly the function of ductus arteriosus during prenatal life. When does it close?

Ans. The ductus arteriosus is a patent channel during fetal life for conducting the blood from left pulmonary artery to arch of aorta beyond the origin of left subclavian artery. This is necessary as lungs are not functioning. After birth, with the functioning of lungs, ductus arteriosus obliterates and becomes ligamentum arteriosum. If this does not take place, as occurs in one out of 3000 births, there is back flow of blood from aorta into pulmonary artery, giving rise to 'machine-like murmur'. Its treatment is surgical.

MULTIPLE CHOICE QUESTIONS

A. Select the best response
1. The most characteristic feature of the thoracic vertebra is
   a. The body is heart-shaped
   b. The spine is oblique
   c. The body has costal facets
   d. Vertebral foramen is small and circular.

2. Which of the following structures passes above the root of the right lung:
   a. Arch of aorta
   b. Azygos vein
   c. Superior vena cana
   d. Right phrenic nerve

3. All the following are the tributaries of coronary sinus except:
   a. Great cardiac vein
   b. Small cardiac vein
   c. Middle cardiac vein
   d. Anterior cardiac vein

4. The following structures in the posterior medi astinum is found immediately posterior to the left atrium:
   a. Azygos vein
   b. Thoracic duct
   c. Oesophagus
   d. Bifurcation of trachea

5. All the following symptoms may be seen in 'mediastinal syndrome' except:
   a. Engorgement of veins in the lower half of the body
   b. Dyspnoea
   c. Dysphagia
   d. Hoarseness of voice

6. All the following statements are true about coro nary arteries except:
   a. These arteries are highly enlarged vasa vasorum
   b. Get filled up during systole of the heart
   c. Are functional end arteries
   d. Are the first branches of aorta

7. All the following statements are true about splanchnic nerves except:
   a. They are medial branches from the lower thoracic sympathetic gangia
   b. They contain postganglionic fibres
   c. They supply only abdominal viscera
   d. The three splanchnic nerves are named greater, lesser and least.

8. Which of the following veins is a direct tributary of superior vena cava.
   a. Hemiazygos vein
   b. Right superior intercostal vein
   c. Right bronchial vein
   d. Azygos vein

9. All the following statements are true about 'right principal bronchus' except:
   a. It is more in line with trachea
   b. It is wider than left principal bronchus
   c. It is longer than left principal bronchus
   d. The inhaled particles tend to pass more to the right bronchus

10. Which of the following does not open into the right atrium
    a. Anterior cardiac vein
    b. Small cardiac vein
    c. Coronary sinus
    d. Venae cordis minimi

B. Match the following on the left side with their appropriate answers on the right side.

11. Arteries and their branches:
    a. Internal thoracic   i. Posterior interventricular
    b. Descending aorta   ii. Posterior intercostal
    c. Right coronary   iii. Anterior interventricular
    d. Left coronary   iv. Anterior intercostal

12. Ribs:
    a. True ribs   i. 8th, 9th and 10th
    b. Atypical ribs   ii. 1st, 11th, 12th
    c. Least fractured ribs   iii. 1st - 7th
    d. Vertebrochondral ribs iv. 1st, 2nd, 10th, 12th

13. Vertebral levels:
    a. Aortic opening in diaphragm   i. T8
    b. Oesophageal opening in diaphragm   ii. T10
    c. Inferior vena caval opening in diaphragm   iii.Til
    d. Gastro-oesophageal junction   iv. T12

14. Mediastinum:
    a. Anterior mediastinum   i. Trachea
    b. Middle mediastinum   ii. Azygos vein
    c. Posterior mediastinum iii. Heart
    d. Superior mediastinum iv. Sternopericardial

C. For each of the incomplete statements or questions below, one or more answers given is/ are correct. Select
   A. If only 1, 2, and 3 are correct
   B. If only 1, 3 are correct
   C. If only 2, 4 are correct
   D. If only '4' is correct
   E. If all are correct

15. The apex of the heart:
    1.Is formed only by left ventricle
    2.Is situated in the 4th intercostal space
    3.Is just medial to midclavicular line
    4.Is directed downwards, backwards and to the left

16. The aortic opening in the diaphragm:
    1.Lies at the lower border of 12th thoracic vertebra
    2.Lies in the central tendinous part of the diaphragm
    3.Transmits aorta, thoracic duct and azygos vein
    4.Is quadrangular in shape

17. The trachea
    1.Extends in cadaver from C6 to T4.
    2.Deviates to the right at its termination
    3.Is lined by ciliated pseudostratified epithelium
    4.Is seen as a vertical radiopaque shadow in radiograph.

18. Thoracic duct
    1.Begins at the lower border of LI.
    2.Is the upward continuation of cisterna chyli
    3.Enters the thorax through vena cava opening in the diaphragm
    4.Ends by opening at the junction of left subclavian and left internal jugular veins.

19. Bronchopulmonary segment.
    1.Is aerated by a segmental bronchus
    2.Is pyramidal in shape with its base directed towards hilum
    3.Is an independent respiratory unit
    4.Is supplied by its own separate branch of pulmonary artery and vein

20. Visceral pleura
    1.Is pain insensitive
    2.Develops from splanchnopleura.
    3.Covers all the surfaces of the lung including fissures but not the hilum
    4.Is innervated by autonomic nerves

Answers to multiple choice questions

13. a - iv   b - ii   c - i   d - iii

1.c 6. b   14. a-iv   b - iii   c - ii   d-i

2.b 7. b   15. B

3.d 8. d   16. B

4.c 9. c   17. A

5.a 10. b   18. C

1.a - iv   b - ii   c - i •   d - iii   19. B

1. a-iii   b - iv   c - ii   d - i   20. E

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