

Chapter

4

Ribs and Sternum

RIBS

INTRODUCTION

Ribs are elongated, arch, flat bones and form the major part of the thoracic cage.

NUMBER

Twelve pairs (they are numbered from above downwards).

CLASSIFICATION OF RIBS

- i. **True ribs (vertebrosternal):** The first seven pairs. They articulate anteriorly with the sternum and posteriorly with the upper seven thoracic vertebrae.
- ii. **False ribs:** The last (lower) five pairs. False ribs are further subdivided into:
 - a. **Vertebrochondral:** The eighth, ninth and tenth pairs, they articulate anteriorly with the costal cartilages of the above and posteriorly with the vertebral column.
 - b. **Vertebral (floating ribs):** The eleventh and the twelfth pairs, they articulate posteriorly with the vertebral column but anteriorly they are free.
- iii. **Longest rib:** Seventh rib.
- iv. **Maximum oblique rib:** Ninth rib.
- v. **The maximum diameter of the thorax:** At the level of eighth rib.
- vi. **Typical ribs:** Third to ninth ribs are typical ribs.
- vii. **Atypical ribs:** First, second, tenth, eleventh and twelfth ribs.

TYPICAL RIBS

Each typical rib consists of:

- i. Anterior or sternal end
- ii. Posterior or vertebral end
- iii. Body or shaft.

ANTERIOR END

- i. It is lower than the vertebral end.
- ii. Presents a cup shaped depression, which articulates with its own costal cartilage.

POSTERIOR END

It consists of: Head, neck and tubercle (Fig. 4.1).

Head

Features (Fig. 4.1)

- i. It has upper and lower facets separated by a crest
- ii. Lower facet articulates with the numerically corresponding thoracic vertebra.
- iii. The upper facet articulates with vertebra above.
- iv. Crest corresponds with the intervertebral disk.

Attachments

- i. **Capsular ligament of the costovertebral joint:** Along the peripheral margins of the head.
- ii. **Radiate ligament:** To the anterior margin of the head (also adjoining anterior surface of the neck).
- iii. **Intra-articular ligament:** To the crest of the head.

Relations

The anterior surface of the head of the lower ribs related to the sympathetic trunk.

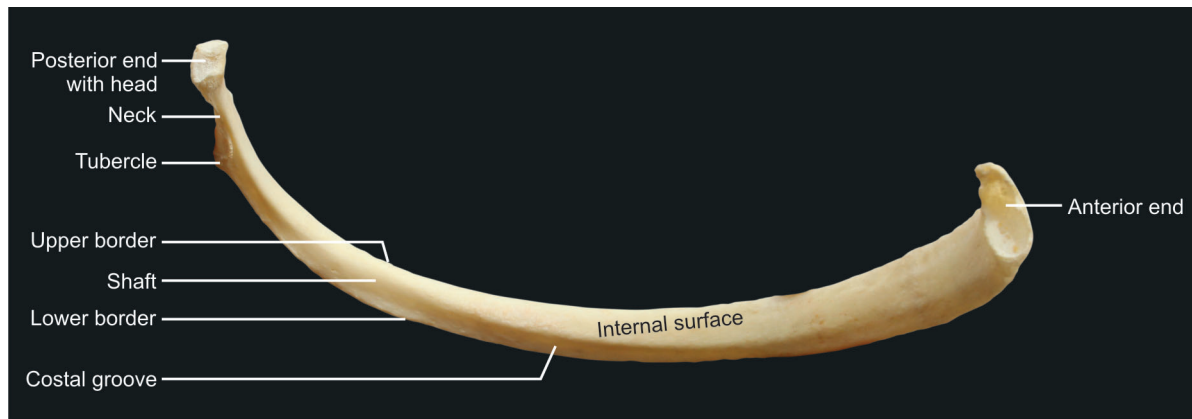


Fig. 4.1: General features of Typical rib (right side)

Neck

Features

- i. It is flattened from before backwards.
- ii. It just succeeds the head.
- iii. Its length about 2.5 cm.
- iv. It lies opposite the corresponding transverse process of the thoracic vertebra.
- v. *Surfaces:* Anterior and posterior.
- vi. *Borders:* Superior and inferior.
- vii. The upper border of the neck is called crest
- viii. Tubercle of the rib situated on the lateral part of the posterior surface (demarcation between neck and shaft).
- ix. The tubercle of the neck presents medial articular part and lateral nonarticular part.
- x. The medial articular part having facet articulates with the transverse process of the numerically corresponding vertebra.

Attachments

- i. **Superior costotransverse ligament:** To the crest of the neck.
- ii. **Inferior costotransverse ligament:** To the posterior surface.
- iii. **Internal intercostal membrane:** To the inferior border and ridge on the anterior surface.
- iv. **Lateral costotransverse ligament:** To the non-articular part of the tubercle.
- v. **Costal pleura:** To the anterior surface.

SHAFT OR BODY

- i. It is flat.
- ii. **Surfaces:**
 - a. Outer or external: It is convex
 - b. Inner or internal: It is concave

iii. Borders

- a. Upper
- b. Lower.
- iv. It is bent and twisted.
- v. At the bent and twisting on the outer surface presents an angle, marked by an oblique ridge which is about 5 cm from the tubercle, known as angle of the rib.
- vi. Close to the anterior end of the outer surface marked by a faint ridge known as anterior angle.
- vii. Presents the costal groove close to the lower border of the inner surface.
- viii. Costal groove become deficient beyond the junction between the anterior and middle third of the rib.
- ix. Lower border is sharp.
- x. Upper border divided into outer and inner lips.

Attachments

i. Origin of

- a. **External obliquus abdominis:** Anterior to the anterior angle of the lower eight ribs.
- b. **Serratus anterior:** Posterior to the anterior angle of the third to eight ribs.
- c. **Latissimus dorsi:** Posterior to the anterior angle of the ninth and tenth ribs.
- d. **Intercostalis intimus:** To the upper margin of the costal groove.
- e. **Intercostalis internus:** To the floor of the costal groove.
- f. **Intercostalis externus:** To the lower border of the costal groove.

ii. Insertion of

- a. **Levator costarum:** To the area between the tubercle and the angle.

- b. **Intercostalis internus and intercostalis intimus:** To the inner lip of the upper border.
- c. **Intercostalis externus:** To the outer lip of the upper border.
- iii. **Thoracolumbar fascia and iliocostocervicalis:** To the ridge at the anterior angle of the shaft.
- iv. **Structure lodges in the costal groove:** From above downwards
 - a. Intercostal vein
 - b. Intercostal artery
 - c. Intercostal nerve

ATYPICAL RIBS

FIRST RIB

Anatomical Position

- i. Anterior expanded end looks forwards and downwards.
- ii. The head looks downwards, forwards and medially.
- iii. The convex border outwardly.
- iv. The superior surface having two grooves, directed upwards.

Side Determination

After holding the bone in anatomical position the outer convex border will determine the side to which side the bone belongs.

Special Features

- i. It is the most curved and strongest of all ribs.
- ii. Consist of outer and inner borders.
- iii. Outer border is convex and inner border is concave.
- iv. It has superior and inferior surfaces.
- v. It is shortest of all the true ribs.
- vi. Head is small and only one facet.
- vii. Neck is rounded directed upwards, backwards and laterally.
- viii. Its angle coincides with the tubercle.
- ix. The rib is bent at the point of angle.
- x. Superior surface of the body is rough irregular with two grooves (Fig. 4.2).
- xi. Inferior surface is smooth and no costal groove (Fig. 4.3).
- xii. Presents of a tubercle, on the inner border called scalene tubercle.

Features with Descriptions

- i. **Facet on the head, its margin:** Attachment to capsular ligament of the first costovertebral joint.
- ii. **Anterior margin of the head:** Attachment to radiate ligament.

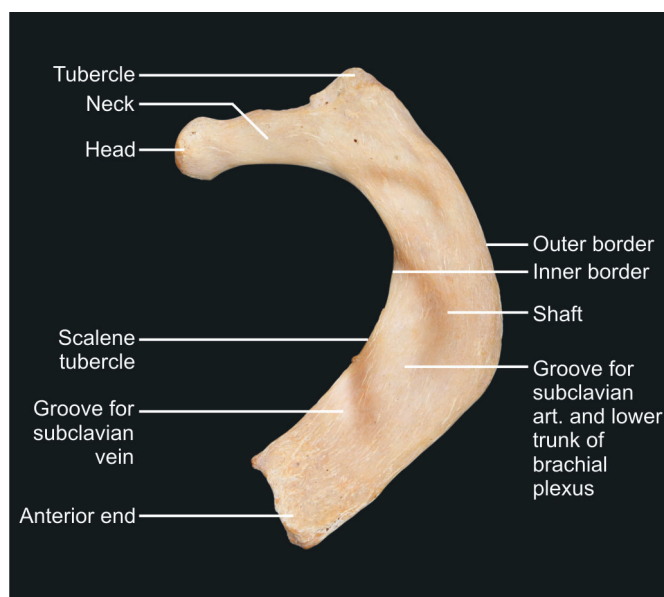


Fig. 4.2: Superior surface of left first rib (general features)

- iii. **Posterior margin of the neck:** Attachment to inferior costotransverse ligament.
- iv. **Superior margin of the neck:** Attached to superior costotransverse ligament.
- v. **Lateral part of the tubercle:** Lateral costotransverse ligament.
- vi. **Relations of the anterior aspect of the neck:** Crossed longitudinally from lateral to medial by:
 - a. First thoracic nerve.
 - b. First posterior intercostal vein.
 - c. Superior intercostal artery.
 - d. Sympathetic trunk with the first thoracic ganglion.
 - e. Sometimes stellate ganglion: It is formed by the first thoracic sympathetic ganglion with the inferior cervical sympathetic ganglion.
 - f. Apex of the lung.
 - g. Cervical pleura
 - h. Suprapleural membrane (Fig. 4.4)
- vii. **The anterior groove on the superior surface lodges:** The subclavian vein (Fig. 4.6).
- viii. **The posterior groove on the superior surface lodges:** Subclavian artery with lower trunk of the brachial plexus (Fig. 4.6).
- ix. **Rough area anterior to anterior groove:**
 - Laterally origin of:** Subclavius muscle.
 - Medially attachment of:** Costoclavicular ligament (Figs 4.4)
- x. **Insertion of scalenus anterior:** Scalene tubercle with ridge on the superior surface (Fig. 4.4).
- xi. **Insertion of scalenus medius:** Rough area posterior to the posterior groove.

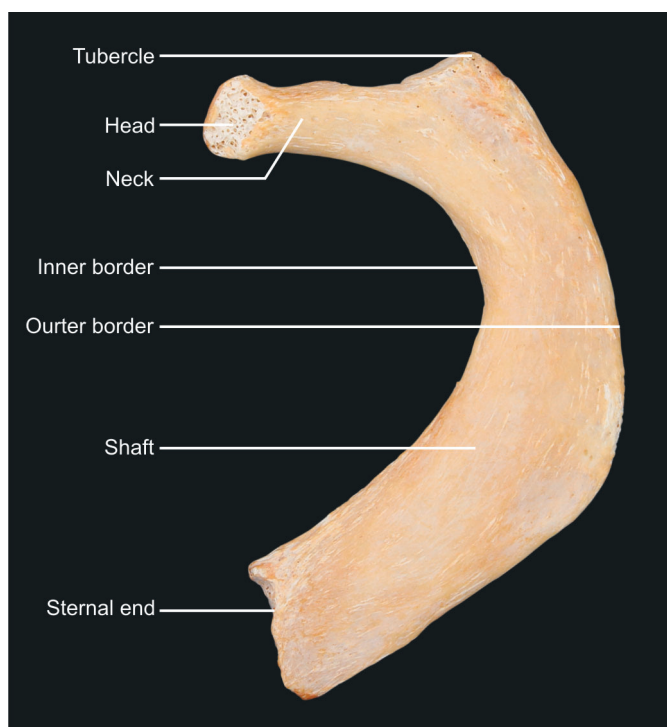


Fig. 4.3: Inferior surface of left first rib (general features)

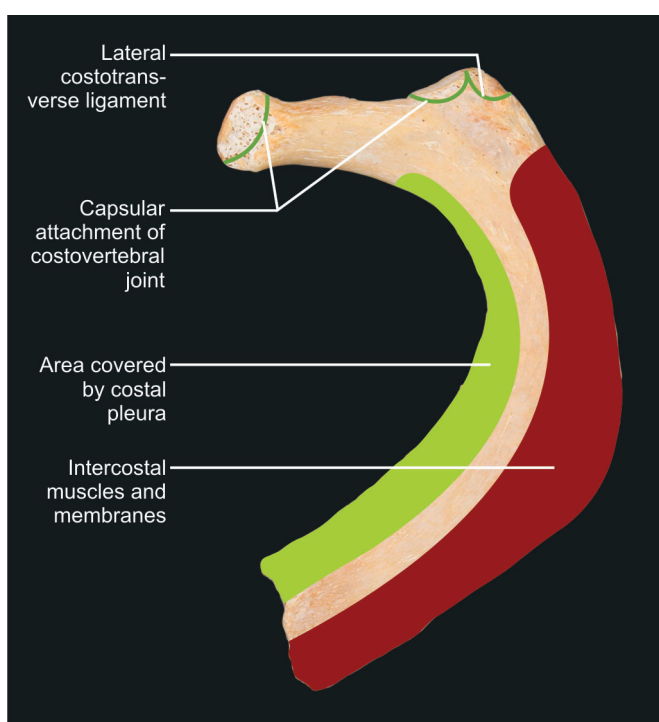


Fig. 4.5: Inferior surface of left first rib (attachments)

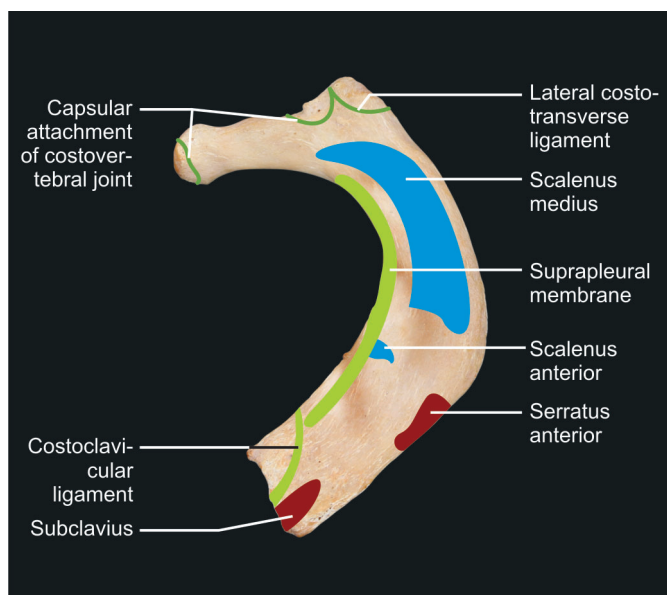


Fig. 4.4: Superior surface of left first rib (attachments)

SECOND RIB

Features

- i. Its curvature is similar to that of first rib
- ii. Length is twice the length of first rib
- iii. Angle lies close to the tubercle
- iv. External surface of the body looks more superiorly than externally
- v. The internal surface looks more inferiorly than internally (Fig. 4.7)
- vi. There is no twisting
- vii. Costal groove is short found only in the posterior part of the internal surface
- viii. Head is small with two indistinct facets
- ix. When placed on a flat surface the entire rib touches it.
- x. On the middle of the external surface presents a muscular impression (Fig. 4.8).

TENTH RIB

Features

- i. It presents a single auricular facet on the head.
- ii. The other features are similar to a typical rib (Fig. 4.9).

ELEVENTH RIB

Features

- i. It presents a single facet on the head.
- ii. There is no neck and no tubercle.

- xii. **Origin of serratus anterior (first digitation):** On the outer border opposite the posterior groove.
- xiii. **Whole inner border attachment of:** Suprapleural membrane (Sibson's fascia).
- xiv. **Origin of intercostalis externus (outer) and intercostalis internus (inner):** Inferior surface close to outer border.
- xv. **Inferior surface:** It is covered by the costal pleura (Fig. 4.5).

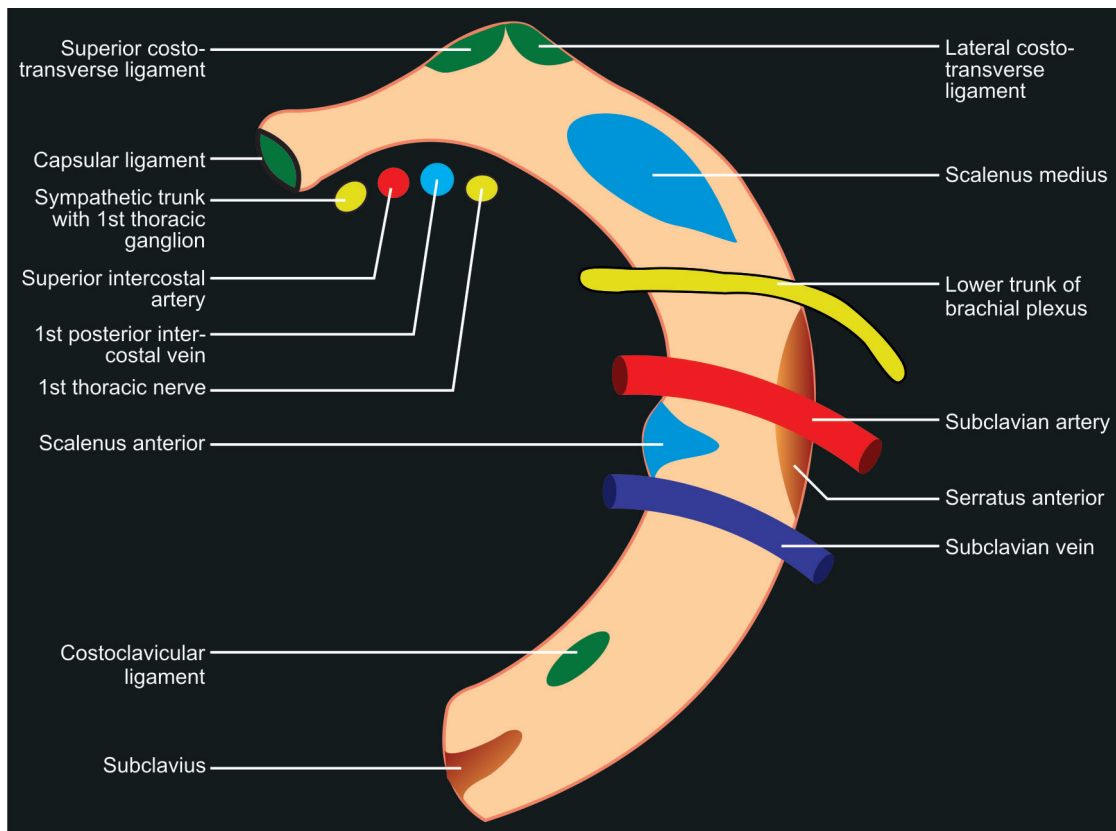


Fig. 4.6: Superior surface of left first rib, showing attachments and relations

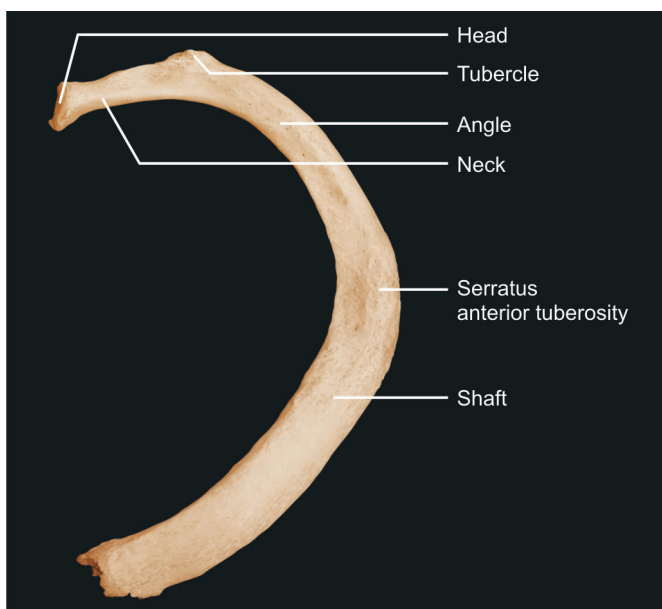


Fig. 4.7: External surface of left second rib (general features)

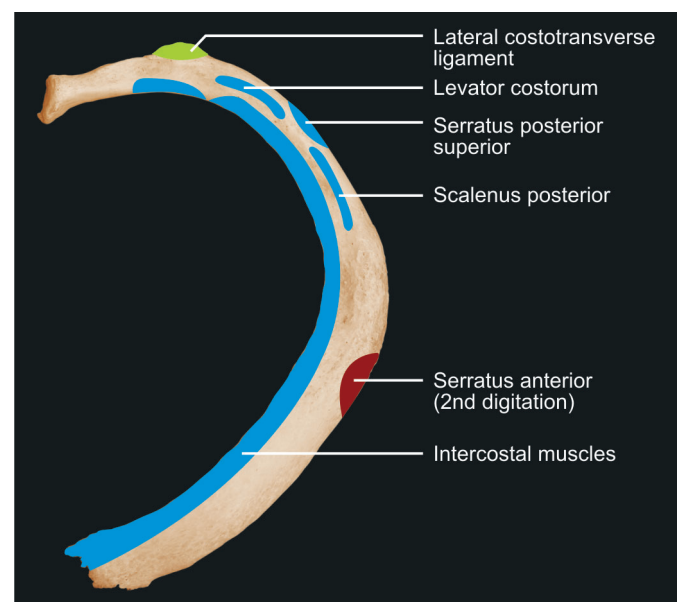


Fig. 4.8: External surface of left second rib (attachments)

- iii. Angle is faintly marked on the outer surface.
- iv. Faintly marked costal groove on the internal surface.
- v. Anterior end is pointed (Fig. 4.10).

TWELFTH RIB

Features

- i. Presents a single facet on its head.
- ii. Anterior end is pointed.



Fig. 4.9: Tenth rib

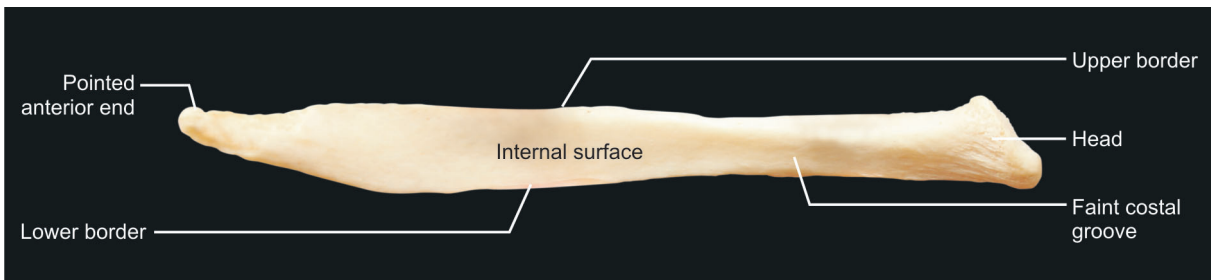


Fig. 4.10: Eleventh rib

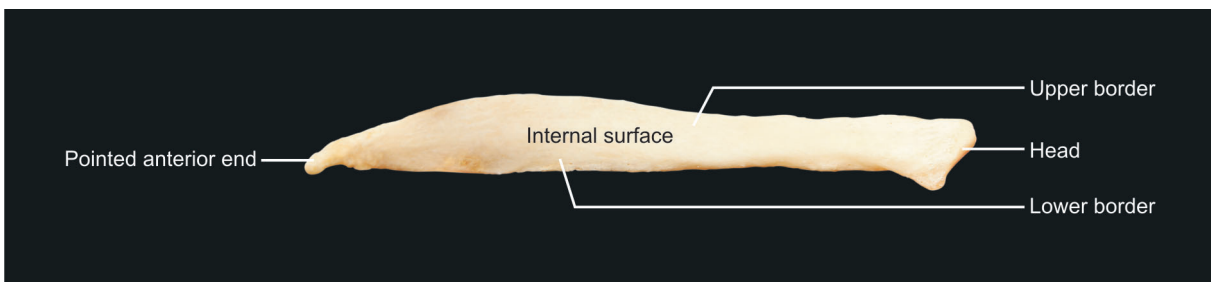


Fig. 4.11: Twelfth rib

- iii. It has no neck, no tubercle
- iv. It has no angle, no costal groove (Fig. 4.11).

CLINICAL ANATOMY

i. Fracture of ribs

- a. Fracture of the middle ribs are most common.
- b. The weakest part of the rib just anterior to its angle.
- c. The broken end of the fracture rib may injured the lung or spleen.
- d. The fracture of the lower ribs may tear the diaphragm results in diaphragmatic hernia.
- e. The fracture of the ribs are more painful because of broken parts move with respiration, laughing, coughing and sneezing.

ii. Cervical ribs

- a. Cervical ribs are commonly asymptomatic.
- b. Clinically cervical ribs very significant as they compress the lower trunk of brachial plexus and cause pain and numbness in the shoulder and upper limb.

- c. Cervical ribs may compress the subclavian artery and cause ischemic muscle pain in the upper limb.

iii. Costovertebral angle: It presents between the lower border of the 12th rib and the body T12 vertebra. It is occupied by costodiaphragmatic pleural recess.

iv. Renal angle: It is formed by the lower border of the 12th rib and the lateral border of erector spine. The renal angle becomes tender on palpation in diseases of kidney.

v. Notching of the ribs: This is in X-ray of the ribs where the lower borders of the ribs are eroded produced by tortuosity and dilatations of the posterior intercostal arteries as a result of coractation of aorta or blockage of subclavian or axillary arteries.

vi. Aspiration of pleural fluid or needle biopsy of liver: To perform these, the needle is pricked through the lower part of the intercostal space to avoid injury to the neurovascular bundle, which are lodges in the costal groove.

STERNUM

INTRODUCTION

The sternum is an elongated flat bone and is a median bone on the anterior chest wall.

CHARACTERISTICS

- i. It is obliquely placed on the anterior chest wall.
- ii. Its anterior surface looks upwards and forwards.
- iii. It is concave posteriorly.
- iv. It is broad, thicker and expanded above and narrow and thinner below.

SEX DIFFERENCES

In males: Body of sternum is more than twice the length of manubrium.

In females: Body of sternum is shorter and less than twice the length of manubrium.

PARTS

- i. Manubrium (Fig. 4.12)
- ii. Body
- iii. Xiphoid process.

Manubrium Sterni

- i. It is the upper triangular segment of the sternum.
- ii. It is broader and thicker above than below.
- iii. Surfaces—anterior and posterior.
- iv. Borders—superior, inferior and two lateral borders.

General Features

Anterior surface

- i. It is smooth and convex from side to side.
- ii. Gently concave from above downwards.

Posterior surface: It is concave.

Superior border

- i. It presents a notch on the median plane, called jugular notch (suprasternal notch).
- ii. It presents another notches on either side of the jugular notch, called clavicular notch (Fig. 4.12).

Inferior border

- i. It is narrow.
- ii. It consists of a small oval facet which articulates with the upper end of the body to form a cartilaginous manubriosternal joint.

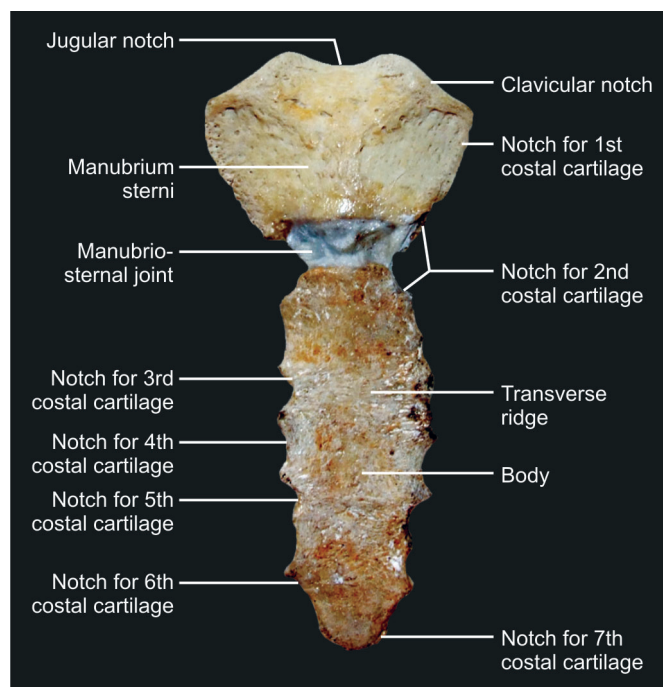


Fig. 4.12: Anterior view of sternum, showing general features

- iii. **The sternal angle (Louis angle):** It is formed by the junction of the manubrium sterni and body of the sternum.
 - a. It lies opposite the level of the lower border of the fourth thoracic vertebra.
 - b. It makes a bony prominence on the anterior chest wall.
 - c. It articulates on either side with the second costal cartilages (important for counting the ribs).
 - d. Sternal angle in males, it is 163.4° and in females it is 165° .

Lateral borders

- i. It presents a cup-shaped depression at its upper part for articulation with the first costal cartilage.
- ii. In the lower part close to the sternal angle, presents a small articular facet, which with a similar facet on the upper end of the body of the sternum articulates with the second costal cartilage.

Attachments

To the jugular notch: From before backwards:

- i. Anterior investing layer of the deep cervical fascia.
- ii. Interclavicular ligament.
- iii. Posterior investing layer of the deep cervical fascia. Between the anterior and posterior investing layers of the deep cervical fascia the space is called suprasternal space or space of Burn.

Anterior surface (Fig. 4.13)

- i. **Origin of pectoralis major**—on either side of manubrium.
- ii. **Origin of sternal head of the sternocleidomastoid**—close to its upper end on either side of the median plane.

Posterior surface (Fig. 4.14)

- i. **Origin of sternohyoid**—from just below the clavicular notch.
- ii. **Origin of sternothyroid**—from opposite the level of first costal facet.

To the clavicular notch

- i. It articulates with the sternal end of the clavicle to form the sternoclavicular joint.
- ii. An articular disk lies in between them.
- iii. Capsular ligament—margins of the clavicular notch.
- iv. Anterior and posterior sternoclavicular ligaments—to the anterior and posterior margins of the clavicular notch respectively.

Body of the Sternum

- i. It is longer and narrower than the manubrium.
- ii. On its anterior surface is marked by transverse ridges due to body of sternum having four segmental developments in early embryonic life.
- iii. Surfaces—anterior and posterior.
- iv. Border—two lateral borders.
- v. Ends—upper and lower.

General Features

Anterior surface: It is flat with three transverse ridges.

Posterior surface: It is slightly concave and marked by less distinct transverse ridges.

Lateral borders

- i. Marked by four cup-shaped articular depressions for articulation with the third, fourth, fifth and sixth costal cartilages (Fig. 4.12).
- ii. The upper part of the lateral border close to the sternal angle presents a small articular facet, which with a similar facet on the lower part of the lateral border of the manubrium articulates with the second costal cartilage.
- iii. Seventh costal cartilage articulates with the xiphisternal joint.
- iv. Sternopericardial (superior and inferior bands) ligament—to the posterior surface.

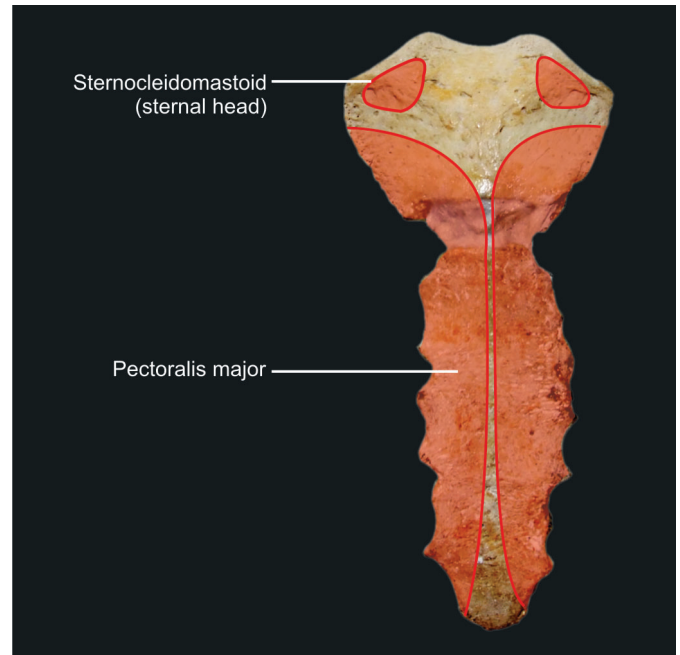


Fig. 4.13: Anterior view of sternum, showing attachments

- v. External intercostal membrane—between the costal notches.

Lower end: Articulates with the xiphoid process, which lies opposite the ninth thoracic vertebra.

Upper end: The upper end articulates with the manubrium to form the sternal angle.

Attachments

- i. **Origin of pectoralis major**—on either side of the anterior surface (Fig. 4.13).
- ii. **Capsular ligament of the sternocostal joints**—on the margins of the costal notches.
- iii. **Radiate sternocostal ligament**—anterior and posterior surfaces opposite the costal notches.
- iv. **Origin of sternocostalis or transversus thoracis**—on either side of the inferior part of the posterior surface (Fig. 4.14).

Xiphoid Process

General Features

- i. It is the smallest and most variable part of the sternum.
- ii. It is about half the thickness of the body of the sternum.
- iii. It is usually triangular with a pointed caudal end.
- iv. It may be curved anteriorly.
- v. It may be bifurcated below.
- vi. It may be deviated to one or the other side.

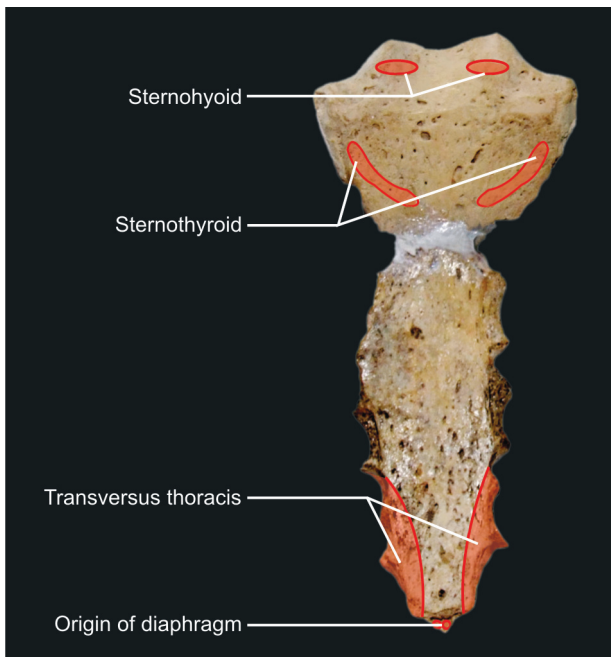


Fig. 4.14: Posterior view of sternum, showing attachments

Attachments

- i. Its upper end unites with body to form the xiphisternal joint.
- ii. Seventh costal cartilage articulates with the xiphisternal joint.
- iii. Lower end or its tip attached to the linea alba.
- iv. Lateral borders insertion to the aponeurosis of the internal oblique and transversus abdominis.
- v. **Anterior surface, insertion of:** Medial fibers of the rectus abdominis and aponeurosis of external oblique muscle.
- vi. **Posterior surface, origin of:** The diaphragm and some fibers of the sternocostalis muscle.

OSSIFICATION

Primary centers

- i. For the manubrium—appears from one to three months of intrauterine life.
- ii. One center for each of the first and second sternebrae—appears fifth month of intrauterine life.
- iii. For the third and fourth sternebrae two in number—appears in the fifth and sixth months respectively in intrauterine life.

Secondary centers

- i. The four pieces body of sternum fuse with one another from below upwards between 14 and 25 years.
 - ii. Xiphoid process starts to ossify in the third year, which fused with the body about fortieth year.
 - iii. The manubrium sterni fused with the body about sixtieth years or in extreme old age.
- The aboves help in age determination.

CLINICAL ANATOMY

- i. **Sternal puncture:** It is useful to aspirate the red bone marrow for hematological examination.
- ii. **Ectopic cordis:** In this condition heart is partly or completely exposed on the surface of the thorax. It occurs due to faulty development of the sternum where two halves of the sternum remains widely separated.
- iii. **Pigeon chest with rickety rosary:** In some people, the sternum projects anteriorly and the chest become flattened on each side. This malformation is called the pigeon chest which is seen in rickets. This condition may be associated with the proliferative changes at the costochondral junctions this feature is known as rickety rosary.
- iv. **Funnel chest:** In this deformity the lower end of the sternum is depressed and the xiphoid process projects forward.
- v. **Midsternotomy:** It is an operation to divide the sternum along the median plane to access the heart and great vessels for surgery.