THE THORACIC WALL

PR.M.D.EL AMRANI PR.H.FENANE DR.CHAIMA KASSI

PLAN:

I. INTRODUCTION

II. DESCRIPTIVE ANATOMY

1. GENERAL OVERVIEW
2. STERNUM
3. RIBS
4. THORACIC SPINE
5. THORACIC JOINTS

III. INTRINSIC MUSCLES OF THE THORAX

IV. OSTEO-MUSCULAR COVERING LAYERS

V. VASCULARIZATION – INNERVATION

VI. CLINICAL APPLICATIONS

VII. CONCLUSION

I – INTRODUCTION:

The thoracic wall is made up of an osteocartilaginous framework: the rib cage, and is maintained by joints and intrinsic muscles. The extrinsic muscles of the thorax, which partially insert onto the rib cage, belong to the upper limbs, back, and abdomen.

II - DESCRIPTIVE ANATOMY:

1. General overview:

The rib cage has the shape of a cone made up of muscular and skeletal elements, with a superior opening and a larger inferior opening.

a. External configuration:

- Its anterior surface is formed by the sternum and costal cartilages. It measures about **12 cm**.
- Its posterior surface is formed by the thoracic vertebrae and the part of the ribs located behind the costal angles. It measures 27 cm.
- Its lateral convex surfaces are formed by the majority of the ribs. They measure about 33 cm.

b. Superior opening:

- It is heart-shaped, inclined downward and forward. It is limited by:

- **Anteriorly**: the jugular notch,
- **Laterally:** the first ribs,
- **Posteriorly:** the thoracic vertebra T1.

- Its diameter is 5 cm sagittally and 10 cm transversally.

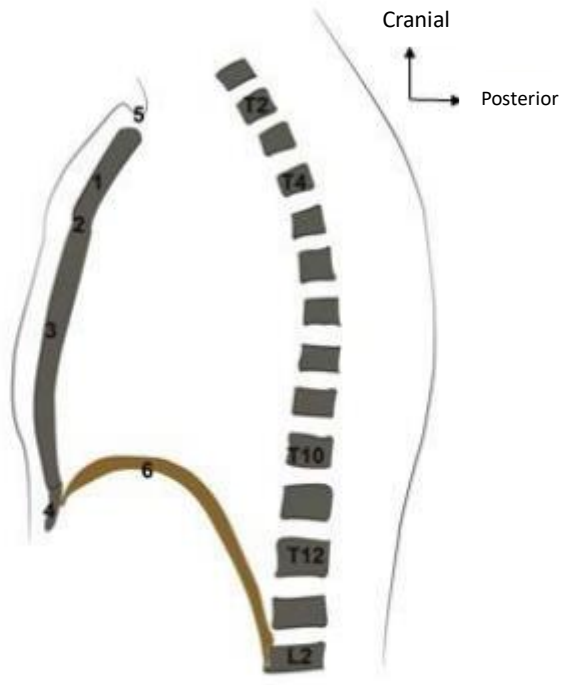
c. Inferior opening:

It is wider than the upper opening, with its plane directed downward and forward. It is limited by:

- **Anteriorly**: the infrasternal angle, defined by the xiphoid process and the 7th costal cartilages,
- **Posteriorly**: the thoracic vertebra T12 and the 12th ribs,

- **Laterally**: the lower border of the last costal cartilage.

Median sagittal section showing the thoracic wall



1- Manubrium
2- Sternal angle
3- Body
4- Xiphoid process
5- Jugular notch
6- Diaphragm
7- Thoracic cavity

2. Sternum :

- It is an impair and median bone of the anterior thoracic wall. It is composed of three parts from top to bottom:

- **The manubrium sterni**,
- **The body**: elongated,
- **The xiphoid process**: small in size.

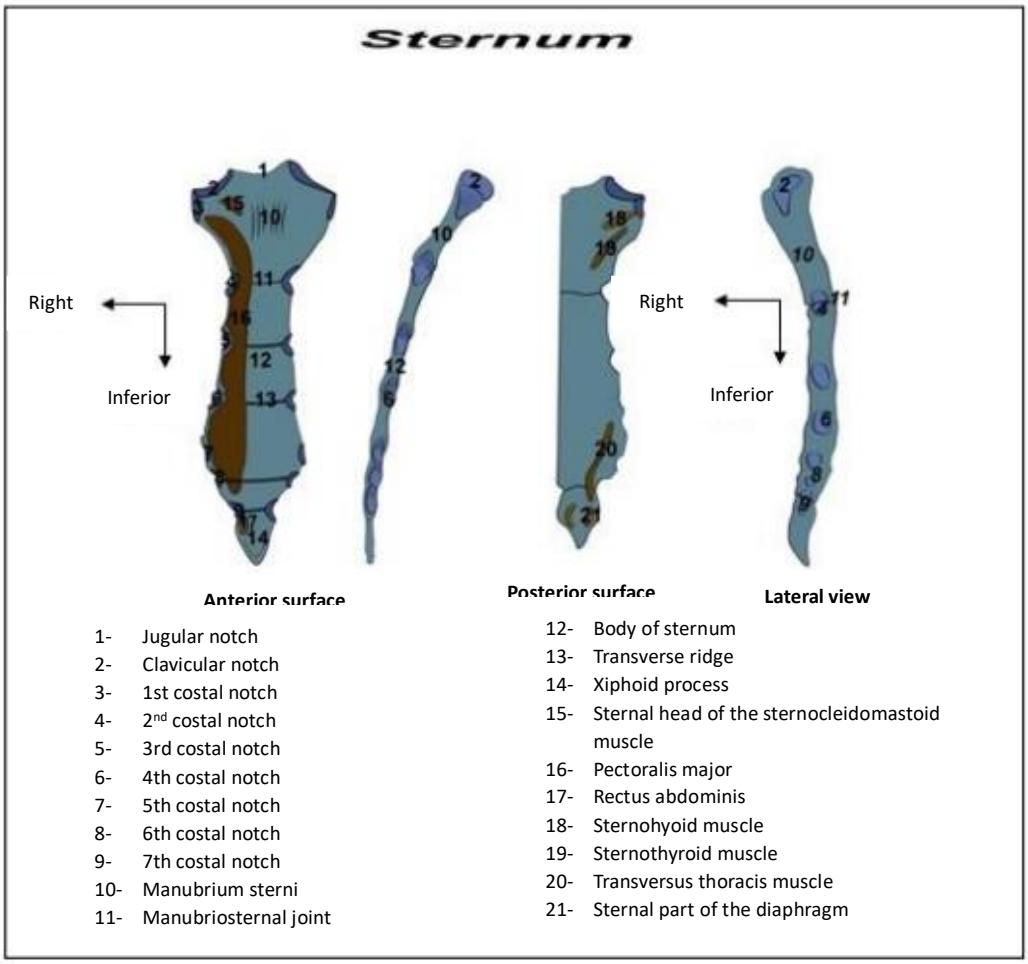
***Note**: It is palpable under the skin, and its easy access allows for bone marrow punctures and blood transfusions.*

- These parts are united by the **manubriosternal symphysis** and the **xiphosternal synchondrosis**.

- Its length is between **15 to 20 cm** and its width is **5 to 6 cm**.

- It has:

- **An anterior surface** which presents:
    - On the manubrium: two oblique ridges directed downward and medially. Above the ridge, the sternocleidomastoid muscle attaches, and below it, the pectoralis major muscle.
    - The sternal angle or Louis' angle: a prominent ridge of the manubriosternal symphysis.
    - On the body: three transverse sternal lines that give attachment to the pectoralis major muscle.
- **A posterior surface** that gives attachment:
    - On the manubrium: to the sternohyoid and sternothyroid muscles.
    - On the body: to the transverse thoracic muscle.
- **Lateral borders**: each border presents seven costal notches that articulate with the costal cartilages. The second notch is located at the union of the manubrium and the body, the seventh notch at the xiphosternal synchondrosis.
- **A superior border**: which has three notches, the **jugular notch** in the middle, and the **clavicular notches** laterally that articulate with the clavicles.
- The **xiphoid process**, which gives attachment:
    - On its **anterior surface**: to the rectus abdominis muscles,
    - On its **posterior surface**: to the diaphragm,
    - On its **apex**: to the linea alba of the abdomen.



***Note: Malformations**:*

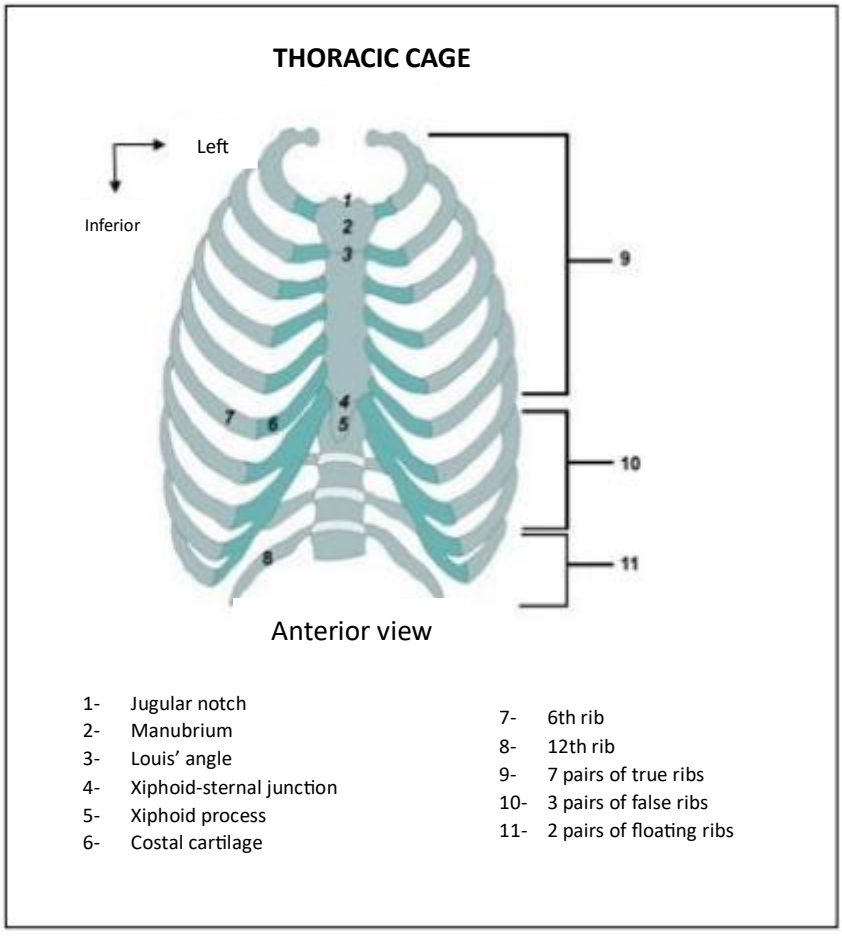
- *Sternal cleft or sternal fissure or sternal bifidity: it is a partial or complete separation of the two lateral sternal pieces.*
- *Pectus excavatum: This is a concave deformity, characterized by a vertical axis depression, centered on the lower part of the sternal body or the xiphoid process.*
- *Pectus arcuatum: This is a protrusion deformity where the manubrium is properly oriented and the sternal body is aligned in the same axis, forming a spur or keel. The xiphoid process is often curved backward.*

3. Ribs:

- The ribs are flat, long, and curved bones that delimit the thorax posteriorly and laterally.
- They articulate with the spine and each extends forward with a costal cartilage.

- There are twelve ribs on each side, numbered from 1 to 12:
  - **True ribs**: from the first to the seventh, they are attached to the sternum by their cartilages.
  - **False ribs**: from the eighth to the tenth, their cartilage unites with the cartilage above them.
  - **Floating ribs**: the eleventh and twelfth ribs end with free cartilage. Ribs 8 to 12 are called asternals.

***Note**: An extra rib can sometimes be found at C7, which may cause thoracic outlet syndrome.*



a. General characteristics of ribs 3 to 9 (typical rib):

The typical rib is medially concave, tilted downward and forward, with a slight medial twist of its anterior part.

Each rib, from back to front, presents:

- **A head**: It has two articular surfaces:
    - An upper surface that articulates with the lower costal surface of the adjacent vertebra.
    - A lower surface that articulates with the upper costal surface of the corresponding vertebra (same number).
- **A neck**: A short region that separates the head from the tubercle.
- **A tubercle**: Located between the neck and the rib body, it has an articular surface that connects with the facet of the transverse process of the corresponding vertebra.
- **A body**: After a short posterior and lateral course, it bends forward and laterally, forming a prominent costal angle at the back.
  It has:
    - Two surfaces: lateral and medial.
    - Two edges: superior and inferior, the latter housing the costal groove, where the intercostal vascular-nerve bundle runs.
- **The anterior end**: It continues with the **costal cartilage.**

Note:

- *Pleural puncture should be done by skimming the inferior border of the upper rib of the chosen space to avoid damaging the vascular-nerve elements.*
- *In the dorsal decubitus position, the costal angles and spinous processes lie on the same plane.*

b. Characteristics of the first rib:

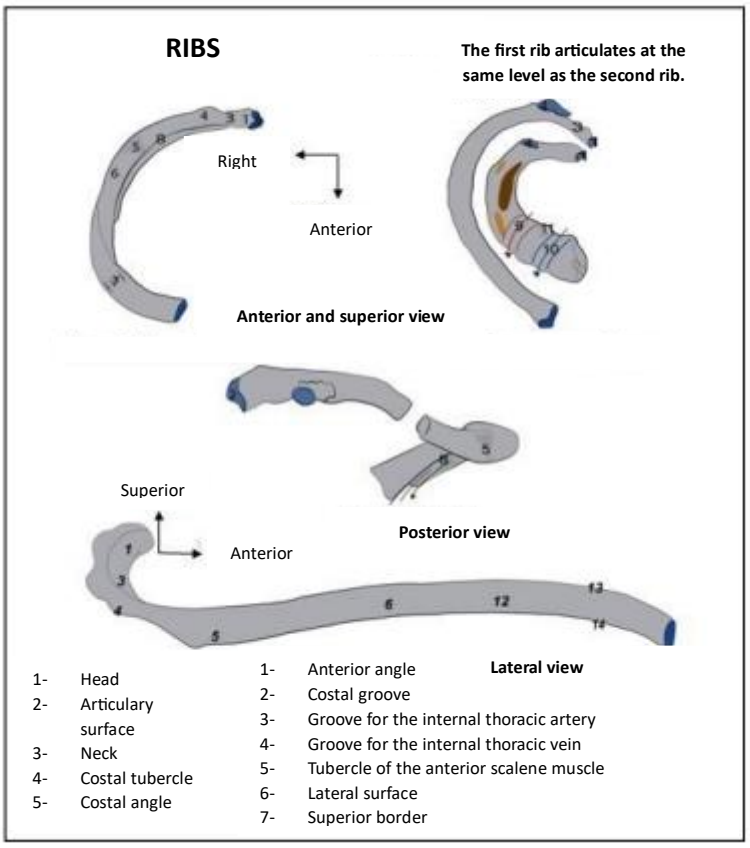
- It is shorter and smaller than the other ribs.
- Its head has only one articular surface for T1.
- Its neck is thin and rounded.
- Its body has two surfaces (superior and inferior) and two edges (medial and lateral).
    - Its superior face has, in its anterior third, the tubercle for the anterior scalene muscle. This separates the groove for the subclavian vein (anterior) and the groove for the subclavian artery (posterior).
      The first rib provides insertion for the muscles: posterior-superior serratus, middle scalene, anterior serratus, and subclavius.

b. Characteristics of the second rib:

It is twice as long as the first rib. It provides insertion for the muscles: posterior scalene, anterior serratus, and posterior-superior serratus.

c. Characteristics of ribs 11 and 12:

These ribs **lack a tubercle** and each has only **one articular surface** for the **T11** and **T12 vertebrae**.



3. Thoracic vertebrae:

There are twelve thoracic vertebrae, characterized by their articulation with the ribs.

a. General features of thoracic vertebrae:

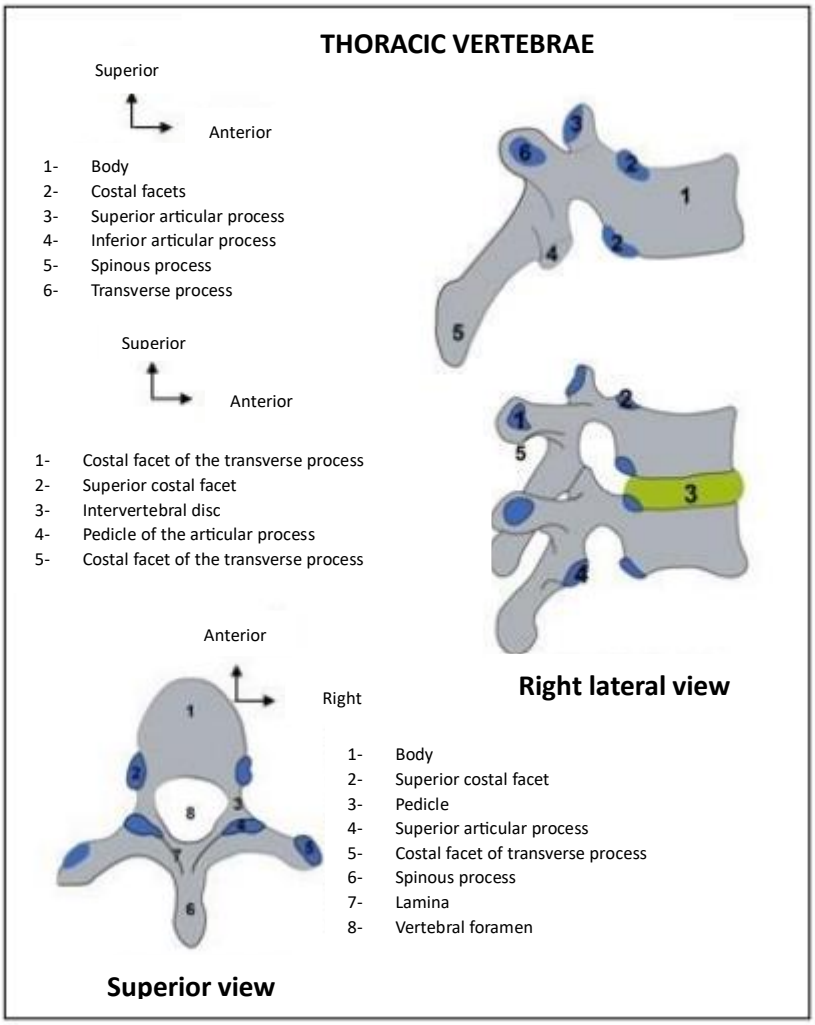
The thoracic vertebra consists of:

- **A vertebral body**: cylindrical, with two costal articular facets on each side. Each facet forms a half-articular surface for articulation with the head of a rib.

- **Two pedicles**: located on the posterior side of the vertebral body.
- **Two vertebral laminae**: extending from the pedicles.
- **A spinous process**: formed by the union of the two laminae.
- **Two transverse processes**: arising at the union of the pedicle and the superior articular process. Each has a **costal facet**.
- **Articular processes**: superior and inferior, protruding above and below the base of the transverse processes.
- **A vertebral foramen**: round and narrow.

b. Specific features of certain thoracic vertebrae:

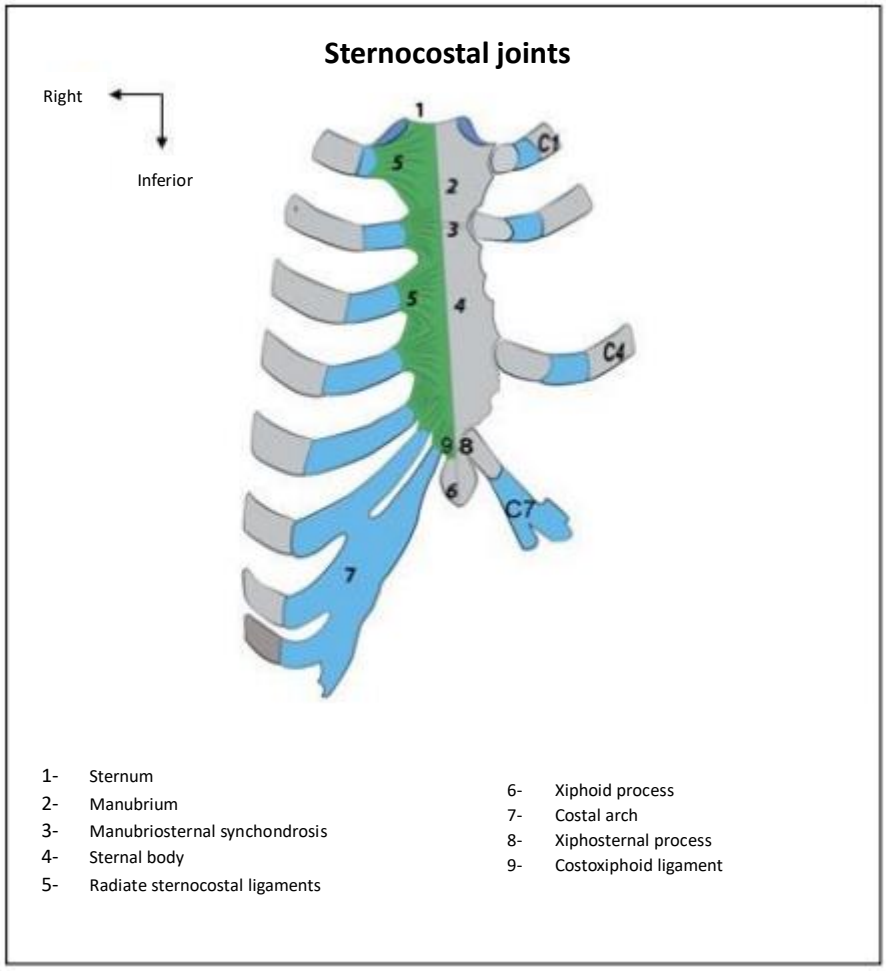
- The upper border of the first thoracic vertebra body has a complete articular facet, and the lower border has a half facet.
- The tenth thoracic vertebra has a single costal facet.
- The eleventh thoracic vertebra has a complete facet on the upper border.
- The twelfth thoracic vertebra has a costal articular facet located in the middle of the lateral surface of the vertebral body.
- The transverse processes of the eleventh and twelfth thoracic vertebrae lack the articular facet.



4. Thoracic articulations:

a. Sternocostal joints:

- These include seven joints that connect the sternum to the seven costal cartilages.
    - The first sternocostal joint: This is a synchondrosis that unites the first costal cartilage to the manubrium.
    - Sternocostal joints 2 to 7: These are synovial joints. The second is against the manubriosternal symphysis, the seventh against the xiphosternal synchondrosis, and the others correspond to the transverse sternal lines.
- It is important to note the presence of the following ligaments at these joints:
    - **Radiate sternocostal ligaments**
    - **Intra-articular sternocostal ligaments**
    - **Costoxiphoid ligaments**



b. Interchondral joints:

These joints unite the contiguous borders of the 6th, 7th, and 8th costal cartilages.

c. Costochondral joint:

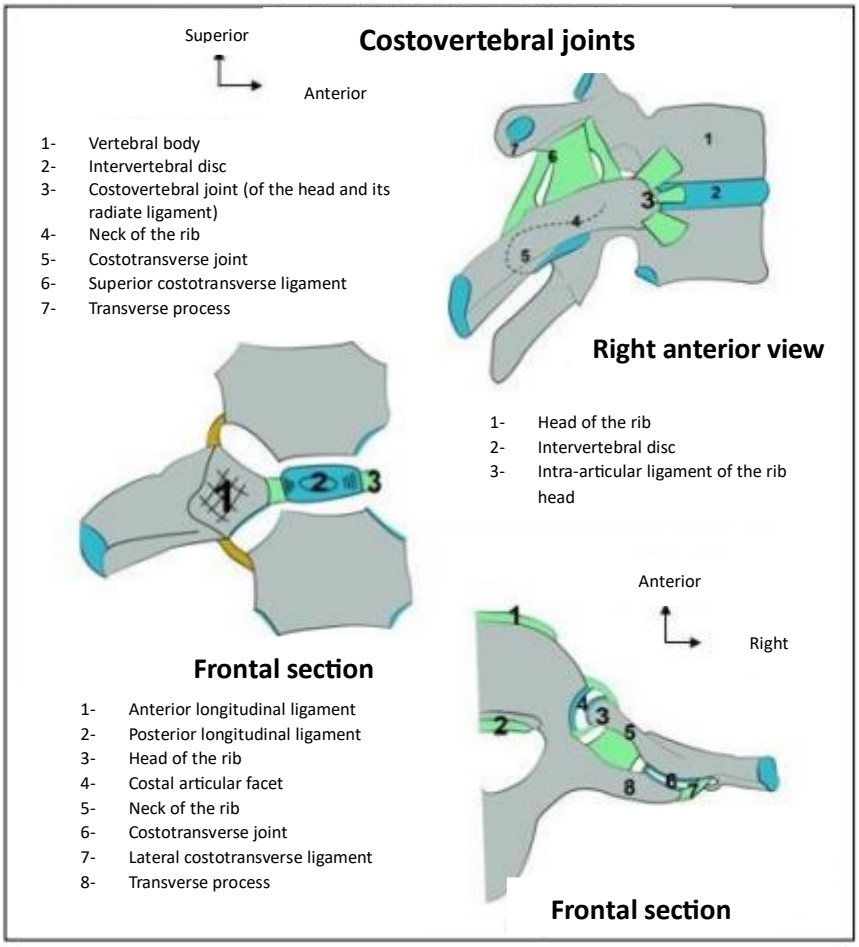
This is a syndesmosis between the rib and its costal cartilage.

d. Costovertebral joints:

These consist of:

- **Costocorporeal joint**: Formed by two joints that unite the head of a rib to two consecutive vertebral bodies through the following ligaments:
    - **Radiate ligament of the costal head**
    - **Intra-articular ligament**

- **Costotransverse joint**: It unites the costal tubercle and the transverse process of the vertebra of the same number through the following ligaments:
    - **Superior costotransverse ligament**
    - **Lateral costotransverse ligament**
    - **Interosseous costotransverse ligament**
    - **Costolamellar ligament**

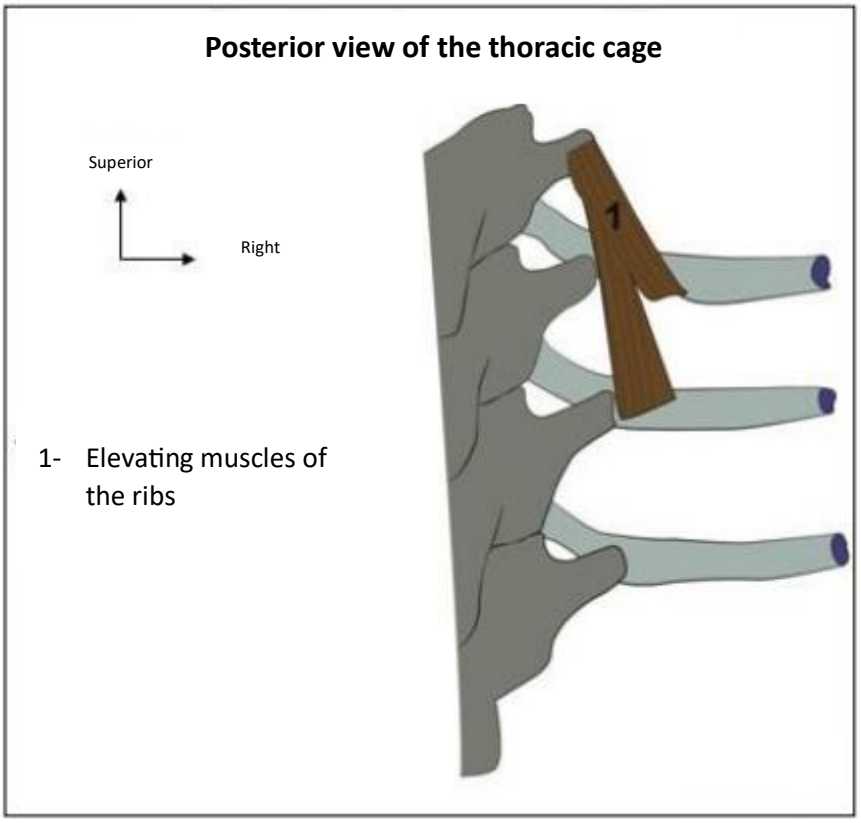


III – INTRINSIC MUSCLES:

They are fully inserted on the rib cage and include the external thoracic muscles, intercostal muscles, and internal thoracic muscles.

1. External thoracic muscles - the elevating muscles of the ribs:

- These muscles originate from the apex of the transverse processes of the ribs from C7 to T11.
- They insert onto the first twelve ribs.
- Their innervation is provided by the intercostal nerves.
- They elevate the ribs, making them inspiratory muscles.

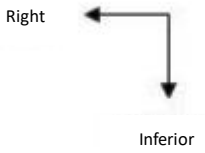


2. Intercostal muscles:

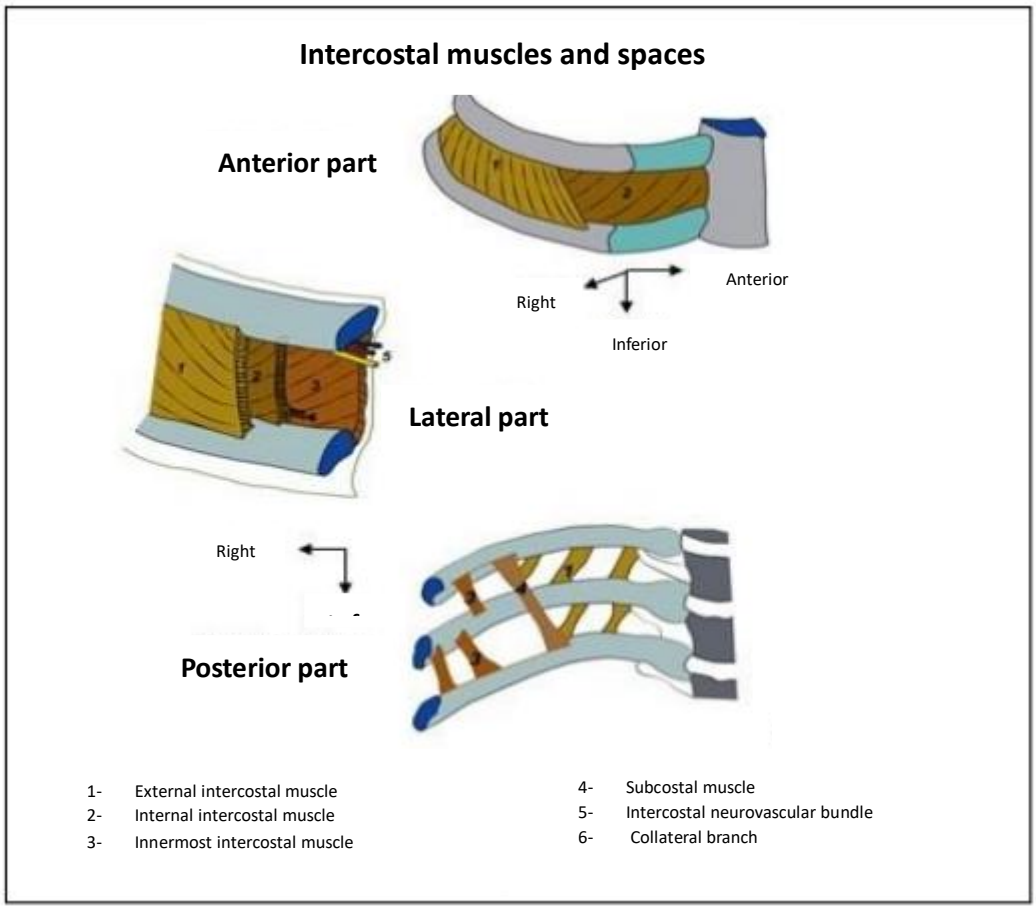
- They are located in each intercostal space and include, from outside to inside, the external, internal, and innermost intercostal muscles.
    - **External intercostal muscle**: It extends from the costo-transverse joints to the costal cartilages.
    - **Internal intercostal muscle**: It extends from the sternum to the rib angles.
    - **Innermost intercostal muscle:** It extends from the costal angles to about 5 cm from the lateral border of the sternum.
- The innervation of these muscles is provided by the **intercostal nerves**.
- Through their tonicity, these muscles unite the ribs and protect the interior of the thorax against atmospheric pressure.

- These are auxiliary respiratory muscles. The external intercostal muscles are inspiratory muscles, while the internal and innermost intercostal muscles are expiratory muscles.

Anterior view of the thoracic cage



1- External intercostal muscle
2- Internal intercostal muscle



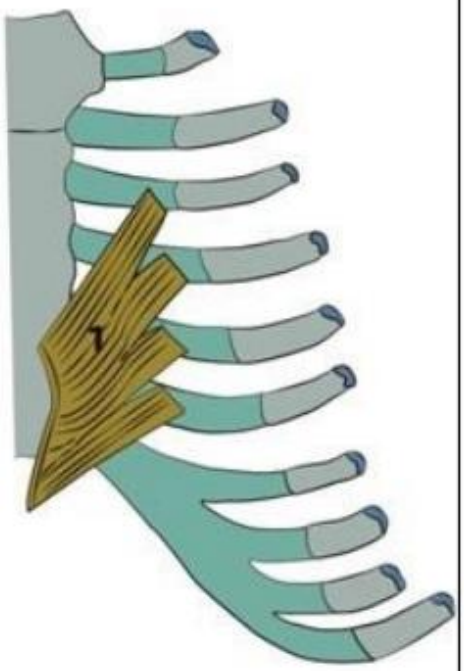
3. Internal thoracic muscles:

The transverse thoracic muscles:

- These are paired, flat muscles that radiate.
- They originate from the posterior surface of the xiphoid process and extend toward the 3rd and 4th ribs, as well as the costal cartilages of ribs 3 to 6.
- Their innervation is provided by the **intercostal nerves**.

Sterno-costal plate: internal view

1- Transverse thoracic muscle



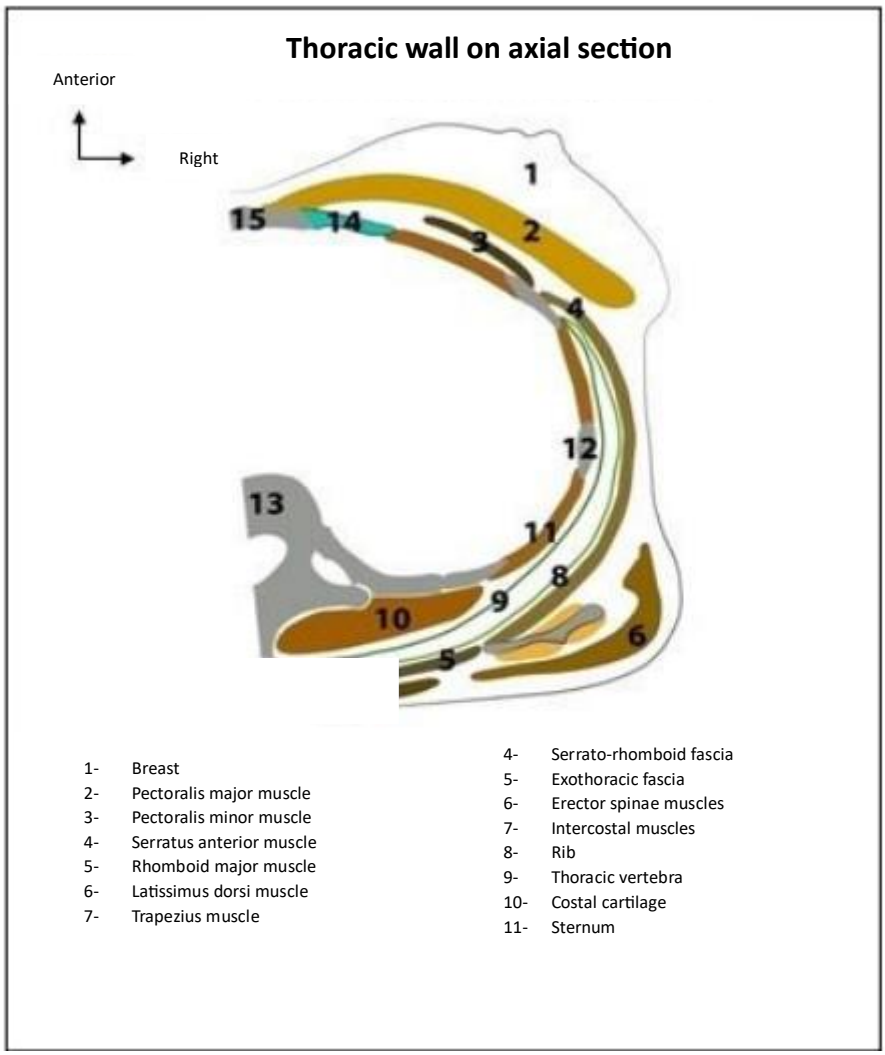
IV – CUTANEOUS-MUSCULAR COVERAGE LAYERS:

These layers are arranged from superficial to deep and include: the **skin**, **subcutaneous tissue**, **fascia**, and **muscular layers**.

Muscular layers:

They are organized into two layers:

- **Posteriorly** *(from superficial to deep)*:
    - The trapezius and latissimus dorsi form a strong lower anchoring structure.
    - The rhomboid and serratus anterior muscles create a continuous plane, connected by a well-defined rhomboid-serratus fascia.
- **Anteriorly**, the coverage layers consist of a single muscular layer:
    - The pectoralis major in the upper region, which inserts only on the costal cartilages and has no direct rib attachment. It is underlaid by the pectoralis minor.
    - The serratus anterior and external oblique muscles laterally.



V – VASCULARIZATION – INNERVATION:

1. Arterial vascularization:

The arterial supply of the thoracic wall originates from:

- **The thoracic aorta**, via the posterior intercostal arteries and the subcostal arteries.
- **The subclavian artery**, via the internal thoracic artery and the supreme intercostal artery.
- **The axillary artery**, via the superior thoracic artery and the lateral thoracic artery.

Note: *The lateral thoracic wall is the preferred site for intercostal space access during thoracic drainage to avoid injury to the internal thoracic artery anteriorly and because posterior access is more challenging*.

2. Venous vascularization:

The venous drainage is ensured by **the intercostal veins**.

3. Innervation:

The innervation of the thoracic wall is primarily provided by **the intercostal nerves**.

VI – CLINICAL APPLICATIONS:

Movements of the thoracic cage:

The thoracic cage is elastic and moves with each respiratory cycle between a position of maximal expiration and maximal inspiration. During inspiration, the ribs become more horizontal, leading to an increase in both the anteroposterior and craniocaudal diameters, as well as an opening of the xiphoid angle. This expansion is made possible by the flexibility of the ribs (torsion along their axis), the mobility of the costovertebral joints, the elasticity of the costal cartilages, and, if necessary, an increase in thoracic kyphosis.

VII - CONCLUSION:

- The thoracic wall is an osteocartilaginous and muscular structure articulated with the thoracic spine, whose integrity is essential for proper respiratory mechanics.

- Its anatomical study is crucial for understanding the pathology of its various components.