Thoracic Cage

Ali Fırat Esmer, MD

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The cone-shaped, flexible rib cage consists of the thoracic vertebrae, 12 paired ribs, costal cartilages, and the sternum. It encloses and protects the thoracic viscera and is directly involved in the
mechanics of breathing. It supports the pectoral girdle and upper extremities, protects and supports the thoracic and upper abdominal viscera.

- Skeleton is formed of,
  - 12 pairs of ribs
  - Sternum
  - Costal cartilages
  - 12 thoracic vertebrae
- Encloses important structures; heart, lungs, great vessels

Ribs

- 12 pairs of ribs
- All attach posteriorly to the thoracic vertebrae
- 7 superior pairs attach directly to the sternum via costal cartilage
  - Called true ribs
- 5 inferior pairs attach indirectly to the sternum or do not attach at all
  - Called false ribs
  - Ribs 8-10 attach indirectly
  - Ribs 11-12 do not attach anteriorly
    - Called floating ribs

- A rib has a **head, neck, tubercle, shaft**, and **angle**
- **Head –** located posteriorly –
- **Neck** is a constricted portion
- The **Tubercle** is a prominence on outer surface of the rib - at the junction of the neck with the shaft. It has a facet for articulation with the transverse process of the numerically corresponding vertebra.

- The **Shaft** is thin, flat and twisted on its long axis. It has a rounded, smooth superior border and a sharp, thin inferior border which has **costal groove (**it accommodates the intercostal vessels and nerve. /The **angle** is where the shaft of the rib bends sharply forward.
- Although the ribs vary structurally, each of the first 10 pairs has a **head** and a **tubercle** for articulation with a vertebra. The last two have a head but no tubercle. In addition, each of the 12 pairs has a **neck, angle,** and **body**

Typical ribs (3rd to 9th)

- Head. Has two articular facets
- articulate with numerically corresponding vertebra
- articulate with one superior vertebra

- Tubercle. Between the shaft and the neck. Has an articular facet for articulating with the transverse process of the corresponding vertebra.

Atypical ribs
(ribs 1st, 2nd, 10th, 11th, 12th)

- 1st rib. Short and wide.
  - Has a single facet at the head (articulates with T1 vertebra)
  - Superior surface has two grooves for subclavian vessels seperated by the scalene tubercle

- 2nd rib. Has a thin body and muscular tubercle for serratus anterior

- 10th-12th ribs. Have single facets at the head

- 11th and 12th ribs. They are short and have no necks or tubercles

- Contribute to the elasticity of the thoracic wall
- First 7 cartilages attach to the sternum directly
- 8th, 9th and 10th cartilages attach to the sternum indirectly

Costal cartilages

Ribs

- **Typical Ribs 2-7**
- Head
- Neck
- Tubercle
- Angle
- Shaft
- Subcostal groove

- **Atypical Ribs 1, 8 -10**

•**Rib 1** - short, flat and supports Subclavian Vessels

• **Ribs 1, 10-12 -** articulate with only 1 vertebra

• **Ribs 11 and 12 –** "floating ribs" – do not articulate with Transverse processes of Vertebrae or Sternum

Clinical note

Rib fractures

- Weakest part is just anterior to the angle
- Broken ribs has the risk of injuring the lungs, spleen or tear of diaphragm
- Painful during respiration, caughing, laughing and sneezing

Flailing chest

- Due to the multiple rib fractures
- A region of the thoracic wall moves paradoxically (inward on inspiration, outward on expiration)

Clinical note

Cervical rib

- Extra ribs attaching the C7 vertebra
- Usually does not attach to the sternum, may attach to the first rib by a fibrous band
- Usually asymptomatic
- Clinically important as it may compress the inferior trunk of the brachial plexus and cause pain or paresthesia in the shoulder and upper limb, and especially in the 4th and 5th digits.
- May also compress the subclavian artery causing ischemic muscle pain in the upper limb

Sternum

- Resembles a dagger
- Fusion of three bones
  - Manubrium-shaped like the knot of a tie; articulates with the clavicles and first two pairs of ribs
  - Body-bulk of sternum; articulates with cartilages of 2^{nd}-7^{th} ribs
  - Xiphoid process-forms inferior end; attachment point for some abdominal muscles

- Manubriosternal joint

– called Sternal Angle/Angle of Louis opposite articulation with 2nd rib – at the level of intervertbral disc between T4 and T5 vertebrae (important for counting the ribs)

Median sternotomy

- Sternum is divided in the median plane for access to the thoracic cavity for surgical operations i.e. coronary artery bypass grafting
- After surgery the split halves are joined with wire sutures

Sternal biopsies

- Because of its easy access under the skin, sternum is a common place for performing bone marrow needle biopsies.
- Bone marrow specimens are used for transplantation and diagnosis of metastatic cancer and blood abnormalities.

Thoracic vertebrae

Characteristics of the thoracic vertebrae:

- Have costal facets or demifacets on their body (for articulation with the heads of the ribs)
  - T2-T9 vertebrae have superior and inferior demifacets
  - T1, T10 (sometimes), T11 and T12 have single facets

- Have costal facets on their transverse processes (for articulation with the tubercles of the ribs), except the inferior two or three thoracic vertebrae

- Have long spinous processes

Joints of the thoracic wall

- Although the joints between the bones of the thorax has limited movement ability, the whole outcome of these movements permit expansion of the cavity during inspiration

- During inspiration, the thoracic cavity can expand in antero-posterior, vertical and transverse dimensions

Costovertebral joints

Ribs articulate with the vertebra at two joints

- Joints between the heads of the ribs and vertebrae

- Costotransverse joints

Joints between the heads of the ribs and vertebrae

• Heads of the ribs articulate with the superior demifacet of the corresponding vertebra and inferior demifacet of the upper vertebra

• Ribs 1, 10 (sometimes), 11 and 12 articulates with the single facets of the corresponding vertebra.

• The joint stability is strengthened by articular capsule, intertransverse ligament and radiate ligament

• Only sligh gliding movements could be done around this joint. However, these slight movements produce relatively large excursion of the distal ends of ribs.

Costotransverse joints

- Between the tubercle of the rib and the costal facet on the anterior surface of the transverse process of the corresponding vertebra

- Has a thin articular capsule and strengthened by lateral costotransverse ligament and superior costotransverse ligament

Sternocostal joints

- Between the sternum and costal cartilages of the 1st to 7th ribs
- 1st is synchondrosis, 2nd-7th are synovial joints
- Has a thin articular capsule and strengthened by the radiate sternocostal ligaments anteriorly and posteriorly

JOINTS OF STERNUM

1. MANUBRIOSTERNAL JOINT:

- cartilaginous joint, symphysis
- between Manubrium and body of Sternum

2. XIPHISTERNAL JOINT

- cartilaginous joint
- between Xiphoid process and body of Sternum
- The Xiphoid process usually fuses with the body of the Sternum during middle age

Movements of the thoracic wall

- Movements of the joints and diaphragm during inspiration increases the volume of the thoracic cavity

- During passive expiration, all of the thoracic muscles and the diaphragm relax and decrease the volume of the thoracic cavity, therefore increasing the intrathoracic pressure (intraabdominal pressure decreases)

- During inspiration, the thoracic cavity expands vertically, laterally and antero-posteriorly

Thoracic apertures

- Superior thoracic aperture
- Inferior thoracic aperture is closed by the diaphragm
    - Apertures in the diaphragm supplies passageway for the structures passing to from thoracic cavity to abdominal cavity

Thoracic apertures

Superior thoracic aperture

- Communicates with the neck and is the passageway for structures passing to from neck to thoracic cavity

- Trachea, eosophagus, and vessels and nerves that supply and drain the head, neck and the upper limbs pass through the superior thoracic aperture

- Bounded by:
  - 1st thoracic vertebra
  - 1st pair of ribs
  - Superior border of the manibrium

Thoracic outlet syndrome

- In clinical terminology, superior thoracic aperture is referred as thoracic outlet
- Various types of thoracic outlet sydromes exist
- Costaclavicular syndrome
  - Results from compression of the subclavian artery between the 1st rib and the clavicle
  - Indicated by pallor and coldness of the upper limb and diminished radial pulse
- Cervical rib syndrome
  - Results from compression of C8 and T1 nerve roots and the inferior trunk of the brachial plexus. Cervical rib may also compress the subclavian artery.

Inferior thoracic aperture

- Communicates with the abdomen
- Closed by the diaphragm
- Diaphragm is pierced by structures passing to from thoracic cavity to abdominal cavity
  - i.e. Esophagus, inferior vena cava, aorta
- Bounded by:
  - 12th thoracic vertebra
  - 11th and 12th pairs of ribs
  - Costal cartilages of ribs 7 to 10
  - Xiphisternal joint

Diaphragm

- Origin-xiphoid process, lower 6 ribs, L1-L3
- Insertion-converges into central tendon
- Action-forms floor of thoracic cavity; pulls central tendon down during respiration creating more space in thoracic cavity

MUSCLES OF THE PECTORAL REGION

There are four muscles in this region

- Pectoralis major muscle
- Pectoralis minor muscle
- Subclavius muscle
- Serratus anterior muscle

MUSCLES OF THE PECTORAL REGION

Pectoralis major (forms the anterior axillary fold)

- Clavicular head: medial half of the clavicle, sternocostal head: 2-6 ribs
- Lateral lip of the intertubercular groove
- Lateral and medial pectoral nerves
- Adduction & medial rotation of the arm (helps in flexion)

MUSCLES OF THE PECTORAL REGION (continued)

Pectoralis minor

- Coracoid process
- Ribs 3-5
- Lateral and medial pectoral nerves
- Stabilizes the scapula by pulling it inferiorly and anteriorly

MUSCLES OF THE PECTORAL REGION (continued)

Subclavius

- First rib
- Middle part of clavicle
- Nerve to subclavius muscle (from the superior trunk)
- Stabilizes the clavicle during shoulder movements

MUSCLES OF THE PECTORAL REGION (continued)

Serratus anterior

- Lateral parts of the first 8 ribs
- Anterior surface of the medial border of the scapula
- Long thoracic nerve (from the roots of the brachial plexus)
- Protracts the scapula and fixes it against the thoracic wall. Inferior fibers help to raise the glenoid cavity and helps the abduction above 90 degrees

CLINICAL NOTE

Paralysis of the serratus anterior

- Injury to ***long thoracic nerve*** may occur with direct trauma or during surgery, especially during the dissection of the axillary lymph nodes
- Patients are unable to abduct the arm above 90 degrees
- When the arm is raised and pushing against a force, the medial border of the scapula moves laterally and posteriorly away from the chest wall, which is called the ***winged scapula***

Muscles of the thoracic wall

Muscles attaching to the ribs such as some upper limb, back, neck and abdominal muscles have function in respiration and they are referred as the accessory muscles of respiration

- Dyspnea is difficulty in breathing as seen in asthma, heart failure etc
- Patients experiencing dyspnea use their accessory muscles of respiration to assist the expansion of thoracic cavity

Accessory muscles of respiration

- Scalene muscles
- SCM
- Pectoral muscles
- Serratus anterior muscle
- Subclavius muscle
- Latissimus dorsi muscle
- Muscles of the antero-lateral abdominal wall

Muscles of the thoracic wall

- Serratus posterior muscles
- Levator costarum muscles
- Intercostal muscles
- Subcostal muscle
- Transverse thoracic muscle

These muscles either elevate or depress the ribs helping to increse the volume of the thoracic cavity

External, internal and innermost intercostal muscles

O. Inferior borders of the ribs
I. Superior borders of the ribs below
N. Intercostal nerves

External intercostal muscles
Elevate the ribs

Internal intercostal muscles
Depress (interosseous part) the ribs

Innermost intercostal muscles
Elevate (interchondral part) and depress (interosseous part) the ribs

Subcostal muscles

O. Internal surface of the lower ribs
I. Superior borders of 2nd or 3rd ribs below
N. Intercostal nerves
F. Elevate ribs

Transversus thoracis muscle

O. Posterior surface of lower sternum
I. Internal surface of costal cartilages 2nd-6th
N. Intercostal nerves
F. Depress ribs

Nerves of the thoracic wall

- Thoracic wall is innervated by 12 pairs of thoracic nerves which are the ventral rami of the thoracic spinal nerves
  - Ventral ramus of the 12th spinal nerve is called the *subcostal nerve*

- Dorsal rami of the thoracic spinal nerves pass posteriorly and innervate the structures on the back of the thoracic region

Herpes zoster infection

- Dermatomally distributed skin lesion (shingles)
- Causative agent is a virus that effects the spinal ganglia
- Characterized with sharp, burning pain, within the involved dermatome (skin supplied by a spinal nerve)
- The skin becomes red and vesicular eruptions are seen
- Muscular weakness usually occurs at the same myotomes

- Dermatome is the skin area supplied by a segment of the spinal cord
- Myotome is the group of muscles supplied by a segment of the spinal cord

Intercostal nerve block

- Local anesthesia supplied by injecting local anesthetic agent around the intercostal nerves

- Due to the overlap of innervation between the adjacent dermotomes, in order to produce an effective anasthesia in a particular area, two or more intercostal nerves have to be blocked