
Structures of the Thorax that Produce Respiratory Movements

- Bones & Joints of the Thorax
- Muscles of Respiration
- Pleurae & Pleural cavities

Respiratory Movements of the Chest
  - Inspiration
    - It requires expansion of the thorax and increase of the:
      - Anteroposterior diameter of the thoracic chest
      - Transverse (lateral) diameter of the thoracic chest
      - Vertical diameter of the thoracic chest
  - Expiration
    - It requires decrease of the above diameters and volume of thoracic cavity
Bones of the Thoracic Cage

- 12 thoracic vertebrae
  - 12 pairs of ribs articulate with them
- 12 pairs of ribs (24 costal bones)
  - Rib 1–7 "true" ribs
    - They have direct attachment to sternum
  - Rib 8-12 "false" ribs
    - Rib 8-10 have attachment to sternum via the costal arch and cartilage of 7th rib
    - Costal arch is formed by cartilages of 7 to 10 ribs
  - Rib 11-12 "floating" ribs
    - They do not form costotransverse joints and have no attachment to the sternum or costal arch
- One sternum. (It gives attachment to 2 clavicles.)
  - 7 upper pairs of ribs articulate with it directly & ribs from 8 to 10 indirectly via the costal arch
Superior Thoracic Aperture

- Common carotid artery
- Vertebra T1
- Trachea
- Internal jugular vein
- Manubrium of sternum
- Superior thoracic aperture
- Rib I
- Apex of right lung
- Subclavian artery and vein
- Rib II

Inferior Thoracic Aperture

- Xiphoid process
- Inferior thoracic aperture
- Costal margin
- Right dome
- Central tendon
- Left dome
- Esophageal hiatus
- Aortic hiatus
- Rib XI
- Rib XII
- Vertebra T12
Surface Markings of Ribs & Sternum

Male

Female

Typical Thoracic Vertebra (6)
(Presence of Costal Demifacets)
Atypical Thoracic Vertebrae

Superior vertebral notch

Inferior vertebral notch

The 1st & 2nd Ribs

Origin of subclavius muscle
Insertion of middle scalene muscle

Origin of serratus anterior muscle (2nd digitation)
Not Twisted Shaft
Insertion of posterior scalene muscle

Grooves for subclavian vein and artery

Head of 1st rib
Neck of 1st rib
Tuberole of 1st rib (no angle)
Head of 2nd rib
Neck of 2nd rib
Tuberole of 2nd rib
Angle of 2nd rib
A Typical Rib

Twisted Shaft

Sternum (Front view)
Joints of Thoracic Cage

- **Costovertebral Joints**
  - Sinovial
    - Joints of costal heads with vertebral bodies
      - They are reinforced by following ligaments: Radiate, Intraarticular
    - Costotransverse joints
      - They are reinforced by following ligaments
        - Superior & Lateral Costotransverse ligaments

- **Sternocostal joints**
  - Chondrosternal synovial joints (from 2nd to 7th ribs)
    - They are reinforced by Ligaments: Radiate sternocostal & Intraarticular
  - Interchondral synovial joints (from 6th to 9th cartilages)
    - They are reinforced by Lateral & Medial Interchondral Ligaments
  - Synchondrosis of 1st costal cartilage with Manubrium Sterni

- **Costochondral Junctions**
  - between ribs and their cartilages

- **Sternal Joints – Symphyses**
  - Manubriosternal
  - Xiphisternal
Chondrosternal & Interchondral Joints

Muscles of Inspiration

- Quiet and Forceful Inspiration
- External intercostals
- Diaphragm
- Forceful Inspiration
- Scaleni (anterior, medius, posterior)
- Sternocleidomastoid
- Serratus anterior
- Serratus posterior superior
- Pectoralis major
- Pectoralis minor
- Levatores Costarum
- Quadratus Lumborum
Muscles of Expiration

- **Quiet and Forceful Expiration**
- Internal & innermost intercostals
- Subcostals
- **Forceful Expiration**
- Transversus thoracis
- Rectus abdominis
- Obliquus externus abdominis
- Obliquus internus abdominis
- Transversus abdominis
- Latissimus dorsi
- Serratus posterior inferior
Intercostal Nerve Block

Sites for Injection
1. Angle of rib (preferred)
2. Posterior axillary line
3. Anterior axillary line
4. Infiltration at fracture site
5. Parasternal

Optimal point to inject is angle of rib because rib is here most easily palpable. Injection of several adjacent nerves may be necessary because of overlapping innervation.

Needle introduced to contact lower border of rib (1). Withdrawn slightly, directed caudad, advanced 1/2 inch to slip under rib and enter intercostal space (2). To avoid pneumothorax, aspirate before injecting 5 ml anesthetic.

Thoracentesis

Thoracentesis performed to obtain sample for testing
Accessory Muscles of Respiration

Sternocleidomastoid

Pectoralis Major

Latissimus Dorsi

Serratus Anterior

Rectus Abdominis

Pectoralis Minor

External Oblique

External Intercostals

Anterolateral Abdominal Muscles

Rectus Sheath

Cross Section Below Arcuate Line

Aponerotic of internal oblique muscle does not split at this level but passes completely anterior to rectus abdominis muscle and is fused there with both aponeuroses of external oblique muscle and that of transversus abdominis muscle. Thus, posterior layer of rectus sheath is absent below arcuate line and rectus abdominis muscle lies on transversalis fascia.
Accessory Muscles of Respiration

Lateral Thoracic Wall

- Middle scalene muscle
- Phrenic nerve
- Anterior scalene muscle
- Subclavian artery and vein
- Subclavian vein
- Superior thoracic artery
- Intercostal anterior nerve
- External intercostal membrane (anterior to internal intercostal muscle)
- Perforating branch of internal thoracic artery and anterior external branch of intercostal nerve
- External intercostal muscle
- Lateral cutaneous branches of intercostal nerves and posterior intercostal arteries

- Serratus anterior muscle
- Scapula (inserted)
- Subscapularis muscle
- Thoracodorsal muscle
- Lateral thoracic artery
- Long thoracic nerve

Accessory Muscles of Respiration

- Superior nuchal line of skull
- Spinalis process of C2 vertebra
- Sternocephalic and sternomandibular muscle
- Posterior triangle of neck
- Trapezius muscle
- Spine of scapula
- Deltoid muscle
- Intraspinalis cervicis
- Latissimus dorsi muscle (enlarged)
- Spinalis process of T1 vertebra
- Thoracolumbar fascia
- External oblique muscle
- Internal oblique muscle
- Lumbar (Pelvis) triangle
- Iliac crest
- Gluteus maximus muscle (gluteus medius muscle)
- Serratus posterior inferior muscle
- 12th rib
- Erector spinae muscle
- External oblique muscle
- Internal oblique muscle
PLEURA

**Pleura**: is a serous membrane, investing the lungs and lining the walls of the pleural cavities.

- **Visceral Pleura**: The inner membrane of the pleural cavity, or the membrane immediately surrounding the lung. It covers each lobe invaginating into the fissure(s) of the lung (where there are extension(s) of the pleural cavity between lobes) and it is reflected over the root of the lung to the mediastinum, where it is continuous with the Parietal Pleura.

- **Parietal Pleura**: The outer membrane, lining the walls of the pleural cavity. It is subdivided into four parts:
  - **The Costal Pleura**: That portion of the parietal pleura bordering the rib-cage.
  - **The Mediastinal Pleura**: That portion of the parietal pleura bordering the mediastinum.
  - **The Diaphragmatic Pleura**: That portion of the parietal pleura bordering the diaphragm.
  - **The Cervical Pleura**: That portion of the parietal pleura above the level of the superior thoracic aperture, projecting to the root of the neck.

Pleurae

*Lungs in Situ*

Anterior View
Arrangement of Pleura

The arrangement of pleura and lungs is similar to that of a partly expanded balloon against which one puts one's fist. The rubber adjacent to the fist is like the visceral pleura, while the outer rubber is like the parietal pleura.

The space between the visceral and parietal pleural membranes is the pleural sac, or cavity. It contains a very small amount of pleural fluid, for lubrication of adjacent surfaces during lung movements.

Arrangement of Pleura

DEMONSTRATION OF PLEURAE AND THE LUNGS

Each lung is surrounded by two layers of serous membrane known as the pleurae.

The visceral and parietal pleurae are actually a continuation of the same membrane.

The relationship between the pleurae and the lungs can be demonstrated by pushing a fist into a water-filled balloon.
PLEURAL CAVITY

- Pleural Cavity is a slit-like cavity (containing a capillary film of serous fluid) between the visceral and parietal pleurae (with a negative sub atmospheric pressure).
- There are two (right and left) pleural cavities separated by the mediastinum in which the lungs are contained. All surfaces of the lung, covered by the visceral pleura, are surrounded by the pleural cavity.
- The Pleural Recess is an extension of pleural cavity limited by two adjacent parts of the parietal pleura, which a lung can enter only during a deep inspiration. There are three main paired pleural recesses on each side of the thorax:
  - Costodiaphragmatic Recess: reflection between the costal pleura and diaphragmatic pleura.
  - Costomediastinal Recess: reflection between the mediastinal pleura and costal pleura.
  - The left costomediastinal recess is larger than the right, due to the cardiac notch — the impression left on the left lung from the heart.
  - Mediastinodiaphragmatic Recess: reflection between the mediastinal pleura and diaphragmatic pleura.
Pleural Cavity

Pleural Cavities

Right lung

Left lung
Right Pleural Cavity

Surface Markings of Pleurae

1. Oblique fissure
2. Transverse fissure
3. Back border of lung
4. Back border of pleura
5. Anterior border of lung
6. Anterior border of pleura

Parietal Pleura
Visceral Pleura
Respiratory Movements & Structures Producing Them

**Inspiration**
- Elevation of sternal ends of ribs
  - Pump handle (forward & upward) movement of sternum
    - Increase of anteroposterior diameter of the chest
- Elevation of lateral shafts of ribs
  - Bucket handle movement of ribs (upward & laterally)
    - Increase of lateral (transverse) diameter of the chest
- Depression (lowering) of Diaphragm
  - Increase of vertical size of the chest
- It results in expansion of the chest and drop of pressure in pleural cavities. It causes expansion of lungs and drop of pressure in alveoli. Atmospheric air will enter lungs through the airway and inflate & expand them.

**Expiration**
- Pump handle (backward & downward) movement of sternum
  - Depression of sternal ends of ribs
  - Decrease of anteroposterior diameter of chest
- Bucket handle movement of ribs (downward & medially)
  - Depression of lateral shafts of ribs
  - Decrease of lateral diameter of chest
- Elevation of Diaphragm
  - Decrease of vertical size of chest
- It results in reduction of chest volume and squeeze of lungs. Because of this and elastic recoil of lungs alveolar air will be pushed through airway into atmosphere

Events occurring during inhalation and exhalation:

**Movements of ribs at costovertebral joints:**
- Up and down gliding movements of costal head and tubercle, which permit rotation of costal neck around its long axis
  - **Upward rotation** brings about elevation of shaft and sternal end of a rib during inspiration (tubercle glides Down)
  - **Downward rotation** brings about depression of shaft and sternal end of a rib during expiration (tubercle glides Up)

**Bucket-handle** inspiratory movement, when pail handle is raising, its convexity moves laterally, increasing transverse diameter of thorax. It occurs during elevation of shafts of ribs. Depression of shafts causes expiration.

**Pump-handle** inspiratory movement, when sternal end is elevating it also moves anteriorly like a pump handle, increasing anteroposterior diameter of thorax. Depression of sternal end causes expiration.

**Movements of Diaphragm:**
- Depression of Diaphragm during its Contraction increases vertical diameter of thorax & causes Inspiration
- During relaxation Diaphragm is pushed up by abdominal organs thus decreasing vertical diameter of thorax and this causes Expiration
Expansion of the Thorax in Inspiration

Elevation of lateral aspect of ribs in inspiration

Sternum moves forward in inspiration because of rib elevation

Diaphragm descends to increase thoracic capacity in inspiration

Expansion of Thorax in Inspiration (Bucket handle action)

Expanding box

Expanding thoracic cavity

Bucket handle action

Lateral expansion
Expansion of Thorax in Inspiration (Pump handle action)

Anteroposterior expansion

Descent of diaphragm

FIGURE 3-13 The different ways in which capacity of thoracic cavity is increased during inspiration.

Bucket-Handle Movement of Ribs

Bucket handle movement

Elevation of lateral shaft of rib

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Figure 1-15. The “bucket-handle” inspiratory movement. A, when the pail handle is raised, its convexity moves laterally, away from its attachments. B, similarly, when the intercostal muscles contract the ribs move superolaterally, increasing the transverse diameter of the thorax.
Pump-Handle Movement of Ribs

Figure 1-16. The “pump-handle” inspiratory movement. Anterior parts of the ribs move anteriorly like a pump handle. This action moves the sternum up and down, increasing and decreasing the anteroposterior diameter of the thorax.

Forces During Quiet Breathing

A. At rest
   1. Respiratory muscles are at rest.
   2. Pleural and intrathoracic pressures are equal.
   3. Air pressure in bronchus is equal to atmospheric pressure.
   4. There is no airflow.

B. During inspiration
   - Inspiratory muscles contract and chest expands.
   - Alveolar pressure decreases with respect to pressure at alveolus.
   - Air flows into lungs.

C. During expiration
   - Inspiratory muscles relax.
   - Alveolar pressure increases.
   - Air flows out of lungs.
Arterial Supply of the Thoracic Cage

Venous Drainage of the Thoracic Cage