

Thorax

The thorax, commonly referred to as the chest, is the portion of the trunk of the body that lies between the neck and the abdomen. The anatomy of the thorax reflects its special role in respiration. The roof of the thorax is an imaginary plane through which structures transition with the neck above. The thorax has a well defined floor, the diaphragm, and circumferential thoracic walls that define an inner body cavity called the thoracic cavity.

Thoracic Wall

The skeletal and muscular components of the thoracic wall serve to protect the underlying viscera and, with the diaphragm, comprise the mechanical units responsible for respiration. The thoracic portion of the vertebral column houses the spinal cord and contributes to the upright posture of humans. The ribs and sternum contain red bone marrow capable of hematopoiesis. Bones of the thoracic wall are attachment sites for muscles of the head, neck, upper limbs, and abdomen. Clinically the thoracic wall is susceptible to injury and disease and many diagnostic and therapeutic procedures are performed on or through the thoracic wall.

Clinical Note: 1) Thoracic wall injuries may result from penetrating trauma (e.g. bullet wound) or blunt trauma (e.g. car accidents, falls, contact sports). 2) Contusion – a bruise or injury without a break in the skin.

Vertebrae

Parts of a Typical Vertebra

- 1) body - weight bearing
 - a) intervertebral disc – joint between adjacent vertebral bodies; allows movement in any direction
- 2) pedicles
- 3) laminae
- 4) vertebral arch = two pedicles + two laminae
 - a) vertebral foramen
- 5) spine (syn. spinous process)
- 6) transverse processes
- 7) superior and inferior articular processes
 - a) facet - any of the polished plane surfaces of a cut gem (Webster's New World Dictionary)
 - b) facet joints - synovial joints between apposing superior and inferior articular processes; orientation controls the types of movements between adjacent vertebrae
- 8) superior and inferior vertebral notches
 - a) intervertebral foramina – openings circumscribed by adjacent vertebral notches

Features of Thoracic Vertebrae

- 1) 12 in number, named T1 (1st) through T12 (12th) thoracic vertebra
- 2) increase in size from T1 to T12; lower two more resemble lumbar vertebrae
- 3) laminae - overlap with their neighbor's below
- 4) spines - long and slender, directed inferiorly over their neighbor below
- 5) costal facets– sites of articulation with ribs
 - a) superior and inferior costal facets - located on a vertebral body
 - b) transverse costal facet - located on a transverse process

Ribs

Parts of a Typical Rib

- 1) head
- 2) neck
- 3) tubercle
- 4) articular facets – two per head and one per tubercle
- 5) body (syn. shaft)
- 6) angle
- 7) costal groove

Other

- 1) 12 pairs (left and right) named (numbered) 1st through 12th ribs
- 2) typical ribs - 2nd through 9th ribs; have all the features described above
- 3) atypical ribs - 1st, 10th, 11th, & 12th ribs; lack some of the features described above, e.g. may lack tubercles, one articular facet per head, a unique body shape, etc.
- 4) costal cartilage – a bar of hyaline cartilage attached to the anterior end of a rib; attachment site called a costochondral joint

Clinical Note: 1) Fracture – breaking of a part, especially a bone. 2) Rib fractures are the most common major trauma-induced thoracic injury. The diagnosis is based on localized pain, tenderness, and swelling; the site of the fracture can often be identified with palpation. If not obvious the potential for intrathoracic injuries associated with the trauma, such as a tearing of the underlying lung by a sharp edge of the fracture, must be considered. A fracture of the 1st rib, which is short, thick, stout, and covered by the clavicles, is a cardinal sign of significant enough trauma to cause intrathoracic injury.

Costovertebral Joints

Definition

- 1) costovertebral joints – a collective term for the synovial joints between ribs and vertebrae

Two Sets of Costovertebral Joints

- 1) joints of the heads of ribs
 - a) articulation of the articular facets on a rib head with the costal facets on a vertebral body
 - b) typical ribs - rib head to same-numbered vertebral body and the vertebral body immediately above, e.g. head of 6th rib to T6 and T5 vertebral bodies
 - c) atypical ribs - heads of 1st, 10th, 11th, and 12th ribs only articulate with the same-numbered vertebral body
- 2) costotransverse joints
 - a) articulation of the articular facet on a rib tubercle with the costal facet on the transverse process of the same-numbered vertebra, e.g. tubercle of 6th rib to transverse process of T6 vertebra
 - b) atypical ribs – the 11th and 12th ribs lack costotransverse joints

Axis of Movement of a Rib

- 1) an oblique axis that passes through the two sets of costovertebral joints
- 2) coupled to the slope and curvature of a rib, the oblique axis of movement permits the anterior end of the rib to move anterior-superior/posterior-inferior while the lateral side of the rib currently moves lateral-superior/medial-inferior (significant in mechanics of respiration)

Sternum

Three Parts of the Sternum

- 1) manubrium - clavicular and jugular notches
- 2) body - 7 pairs of costal notches
- 3) xiphoid process

Joints of the Sternum

- 1) sternoclavicular joints - manubrium to clavicles (synovial joints)
- 2) manubriosternal joint - manubrium to body of the sternum (a symphysis)
 - a) sternal angle - bony ridge at manubriosternal joint
- 3) xiphisternal joint - xiphoid process to body of the sternum (a symphysis)
- 4) sternocostal (syn. sternochondral) joints - sternum to costal cartilages (synovial joints except for 1st ribs, which are primary cartilaginous [united by hyaline cartilage] joints)

Clinical Notes: 1) Sternal fracture – usually requires major blunt trauma; present in about 4% of patients in major automobile accidents, typically a transverse fracture through the upper and mid-body regions of the sternum. With the heart positioned directly behind the sternum a sternal fracture is often associated with myocardial contusion. 2) Median sternotomy (sternal splitting) – surgical technique used to expose the mediastinum and lungs; the sternum is bisected from the jugular notch through the xiphoid process. 3) Sternal biopsy – the interior of the sternum is a common site for the aspiration of red bone marrow for diagnostic and therapeutic purposes. The midline of the sternum lies subcutaneously and the marrow cavity is readily accessible by the insertion of a needle through the compact bone on the anterior surface.

Thoracic Cage

Definition

- 1) the anatomically assembled ribs, thoracic vertebrae, and sternum

Articulations

- 1) anterior articulations
 - a) true ribs – ribs 1 through 7, articulate directly with the sternum (form sternocostal joints)
 - b) false ribs – do not articulate directly with the sternum
 - i) ribs 8 through 10 - form an interchondral joint (synovial type) with the costal cartilage of the rib immediately above
 - ii) ribs 11 and 12 - have no anterior articulations; end blindly in the body wall (also called floating ribs)
- 2) posterior articulations
 - a) costovertebral joints (ribs to vertebrae)
 - b) intervertebral discs and facet joints (vertebrae to vertebrae)

General Features of the Thoracic Cage

- 1) somewhat cone-shaped with widest dimension inferiorly
- 2) tallest dimension posteriorly (12 thoracic vertebrae), shortest dimension anteriorly (sternum)
- 3) flattened from front to back
- 4) ribs descend from posterior to anterior
- 5) 11 intercostal spaces
- 6) superior thoracic aperture (called thoracic outlet by clinicians)
 - a) circumscribed by the upper bony margin of the thoracic cage (T1, 1st ribs, manubrium)
 - b) neck above, thorax below
- 5) inferior thoracic aperture
 - a) circumscribed by the lower bony margin of the thoracic cage (T12, 12th – 7th ribs, xiphoid process)

- b) closed by the diaphragm - thorax above, abdomen below
- 6) costal margins - formed by costal cartilages of the 7th through 10th ribs
- 7) sternal angle - level of articulation of the 2nd ribs with the sternum

Clinical Notes: 1) Thoracic wall plasticity - The young age and large quantity of cartilage in a child's thoracic cage imparts a pliability that protects the ribs and sternum from fracture during trauma; however, the enhanced pliability increases the likelihood of force exposure to intrathoracic viscera (contusion injury). It's the opposite for an adult, who is more likely to get fractured ribs or sternum (less pliability due to less of a cartilaginous framework [ossification with age] and cartilage loses its elasticity with age) but the strength and firmness of the thoracic cage reduces the chance (in comparison to a child) of force trauma to intrathoracic viscera. Elderly individuals are the most vulnerable in that they may have a brittle thoracic cage that provides little protection either to fracture or force-induced trauma to underlying viscera. 2) "Slipping ribs" - collective term for sternocostal, costochondral, or interchondral joint dislocations (dislocation - displacement of a part; Dorland's Medical Dictionary). Typically the dislocation is induced by trauma, which may include recurrent heavy coughing and heavy lifting. Symptoms include localized pain, swelling, and unusual mobility at the joint. Radiography is typically not used in the diagnosis since cartilage is radiolucent in plain film while CT and MRI are expensive and should be unnecessary. 3) Extra ribs - the 7th cervical and 1st lumbar vertebrae will occasionally have ribs of various sizes and shapes. A "lumbar rib" is of no clinical significance although it may render inaccurate the counting of ribs from the posterior surface of the body or in identifying vertebral levels in radiographs. A "cervical rib" is potentially clinically significant due to the pressure it may bear on the large neurovascular structures that pass over the underlying 1st ribs of the T1 vertebra. 4) Thoracic outlet syndrome - a collection of syndromes with a variety of etiologies but whose common denominator is the compression of the subclavian blood vessels and/or the brachial plexus at the superior thoracic aperture. One of the more common etiologies is the presence of a cervical rib.

Intercostal Muscles

- 1) occupy the intercostal spaces
- 2) three incomplete layers; however, enough overlap in the distributions of the three layers that the entire intercostal space is draped with muscle
 - a) external intercostal muscle - most superficial
 - b) internal intercostal muscle
 - c) innermost intercostal muscle - deepest
- 3) functions:
 - a) draw the ribs toward each other, resulting in their elevation or depression depending on whether the top or the bottom of the rib cage is fixed in place
 - b) aid in maintaining the structural integrity (the "seal") of the thoracic wall
 - c) protect underlying viscera

Clinical Notes: 1) Thoracotomy - Surgically incising the chest wall with entrance into the thoracic cavity; the final incision is through the intercostal muscles of an intercostal space. Lateral and posterolateral thoracotomies are the most common incisions in general thoracic surgery; the 4th intercostal space is the usual entry point. 2) Flail chest - The word flail means exhibiting abnormal mobility, as in a flail joint. Flail chest is typically the result of direct thoracic trauma (e.g. automobile accident) resulting in fractures or dislocations of ribs and/or the sternum along two separate lines that result in a segment of the thoracic wall (e.g. parts of three sequential ribs and their intervening intercostal muscles) that is independently movable by virtue of its lack of bony attachments to the remainder of the thoracic wall.

Neurovascular Supply of the Thoracic Wall

Intercostal Nerves

- 1) the anterior rami of the 1st through 11th thoracic spinal nerves; one per intercostal space
- 2) run in the costal grooves

- 3) types of nerve fibers
 - a) sympathetic for blood vessels, sweat glands, and arrector pili muscles of the chest wall
 - b) motor to the intercostal muscles
 - c) segmentally arranged cutaneous branches to the skin
 - d) sensory and sympathetic innervation to the mammary glands
- 4) 7th through 11th intercostal nerves pass under the costal margins to enter abdominal wall
- 5) subcostal nerve (anterior ramus of T12) – runs below the 12th rib
- 6) posterior rami of T1 – T12 spinal nerves provide sensory and motor innervation to the mid back region

Clinical Note: Intercostal nerve block – typically used as a supplement to general anesthesia, as a postoperative analgesia (relief of pain without loss of consciousness), or for the relief of pain associated with rib fractures, cancer, or herpes zoster (a painful viral infection of dorsal root ganglia). The initial entry site of the needle is on the external surface of the rib forming the upper border of the intercostal space of choice and then the needle is “walked-off” the rib to its lower edge just below the costal groove.

Blood Supply

- 1) posterior intercostal arteries
 - a) one per intercostal space
 - b) primarily branches of the descending thoracic aorta
 - c) run in the costal groove
 - d) supply blood to the intercostal muscles, skin and overlying upper limb muscles, and the mammary glands
 - e) dorsal branches - provide muscular and cutaneous branches to the mid back region as well as branches to the spinal cord
- 2) anterior intercostal arteries
 - a) two per intercostal space
 - b) those to the upper six intercostal spaces are branches of the internal thoracic arteries
 - c) those to the lower five intercostal spaces are branches of the musculophrenic arteries
 - d) supply blood to the intercostal muscles, skin, overlying upper limb muscles, and the mammary glands
- 3) intercostal veins
 - a) posterior intercostal veins drain into the azygos system of veins
 - b) anterior intercostal veins drain into the internal thoracic and musculophrenic veins

Lymphatics

- 1) deep and superficial components
- 2) superficial lymphatic vessels - lymph flows to axillary lymph nodes
 - a) drain skin, mammary glands, and overlying upper limb muscles
- 3) deep lymphatic vessels - lymph flows to parasternal lymph nodes (located at the anterior ends of the intercostal spaces) and intercostal lymph nodes (located at the posterior ends of intercostal spaces)
 - a) drain the intercostal muscles, ribs, sternum, and mammary glands

Clinical Note: Parasternal lymph nodes of the thoracic wall are a major site of lymphatic drainage of the mammary glands, particularly the medial halves of the glands.

Surface Anatomy of the Thoracic Wall

Clinical Note: Defining positions on the chest wall - Defining the position of a thoracic abnormality noted during a physical exam requires that the location of the abnormality be defined in both the vertical axis and around the circumference of the chest wall, the intersection of the two being the position of the abnormality, e.g. right 4th intercostal space just lateral to the midclavicular line.

Landmarks of the Thoracic Wall

- 1) denote left and right sides, e.g. left 3rd rib, right 4th intercostal space
- 2) jugular notch - midline superior surface of the manubrium
- 3) sternal angle - bony elevation at manubriosternal joint
 - a) 2nd ribs - located immediately lateral to the sternal angle; anteriorly count ribs and intercostal spaces from their position
- 4) 1st ribs are difficult to palpate due to the overlying clavicles
- 5) costal margins – costal cartilages of the 7th through 10th ribs
- 6) proximal ends of the costal cartilages of the 5th, 6th, and 7th ribs are very close together, creating very narrow and difficult to palpate 5th and 6th intercostal spaces close to the sternum
- 7) xiphoid-costal junction – junction of xiphoid process and costal cartilage of 7th rib
- 8) bone of a rib cannot be distinguished from its costal cartilage by palpation although the costochondral junction often exhibits a slight expansion
- 9) the 12th ribs are usually palpable and thus provide a posterior starting point to count ribs and intercostal spaces
- 10) inferior angle of the scapula is usually palpable – located at or slightly above the 7th rib
- 11) spines of thoracic vertebrae - with the neck flexed run a finger from the base of the skull to the posterior midline of the neck, the first prominent bony knob encountered is the spine of the 7th cervical vertebra from which the T1 and subsequent thoracic spines can be counted.
- 12) vertebral line - passes through the midline of the vertebral column, essentially interconnecting the spinous processes of vertebrae
- 13) midsternal line - passes vertically through the midline of the sternum
- 14) anatomical landmarks associated with musculoskeletal components of the upper limbs that are used in thoracic localizations
 - a) midaxillary lines – descend vertically from the apices of the axillae; lie 90 degrees from the midsternal and vertebral lines
 - b) anterior and posterior axillary lines - descend vertically from the anterior and posterior axillary folds created by large underlying muscles (pectoralis major and latissimus dorsi) of the upper limb
 - c) midclavicular lines - pass vertically through the midpoints of the clavicles
 - d) scapular lines - pass vertically through the tips of the inferior angles of the scapulae

Diaphragm

The diaphragm is the major muscle used in quiet respiration. It forms a muscular partition between the thorax and abdomen, being the floor of the thoracic cavity and the roof of the abdominal cavity. It also participates in changing the pressure within the abdominal cavity as occurs during defecation, parturition (child birth), etc.

Components

- 1) three muscular parts
 - a) sternal part - origin from the xiphoid process
 - b) costal part - origin from lower six ribs and their costal cartilages
 - c) lumbar part
 - i) origin from fascial condensations over the psoas major and quadratus lumborum muscles (called medial and lateral arcuate ligaments respectively)
 - ii) left and right crura (sing. crus) – origin from the bodies of the upper 2 or 3 lumbar vertebrae and their intervertebral discs
- 2) central tendon – central region comprised of dense connective tissue; is the tendon of insertion of the muscle fibers of the diaphragm and, although an insertion, it has no bony

attachments

- 3) shape of the diaphragm
 - a) dome-shaped, or actually two domes
 - b) inverted J

Hiatuses

- 1) hiatuses - openings
- 2) aortic hiatus – transmits the descending thoracic aorta and the thoracic duct (T12 level)
- 3) esophageal hiatus – transmits the esophagus and vagus nerves (T10 level)
- 4) caval foramen (opening) – transmits the inferior vena cava; only hiatus within the central tendon (T8 level)

Clinical Note: Hiatal hernia – protrusion of a piece of gut through the esophageal hiatus of the diaphragm. In the most common type the gastroesophageal junction and adjacent part of the stomach moves into the mediastinum. Etiologies include increased abdominal pressure due to pregnancy, obesity, or vomiting; many do not produce symptoms.

Neurovascular Supply

- 1) motor innervation from the phrenic nerves (C3, C4, C5) – the diaphragm is striated muscle that is under limited voluntary control
- 2) various arterial sources - pericardiophrenic arteries, lower intercostal arteries, superior and inferior phrenic arteries

Function

- 1) muscle of respiration (for details, see Mechanics of Respiration)
- 2) contributes to changing intra-abdominal pressure (e.g. defecation, child birth, etc.)

Authored by:

Raymond J. Walsh, Ph.D.
Professor & Chair
Department of Anatomy & Cell Biology
The George Washington University
School of Medicine & Health Sciences

ISBN 0-9655384-9-4