

The Chest Wall, Chest Cavity, Lungs, and Pleural Cavities



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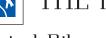
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Sternum and Marrow Biopsy

Since the sternum possesses red hematopoietic marrow throughout life, it is a common site for marrow biopsy. Under a local anesthetic, a wide-bore needle is introduced into the marrow cavity through the anterior surface of the bone. The sternum may also be split at operation to allow the surgeon to gain easy access to the heart, great vessels, and thymus.





Cervical Rih

A cervical rib (i.e., a rib arising from the anterior tubercle of the transverse process of the seventh cervical vertebra) occurs in about 0.5% of humans (CD Fig. 3-1). It may have a free anterior end, may be connected to the first rib by a fibrous band, or may articulate with the first rib. The importance of a cervical rib is that it can cause pressure on the lower trunk of the brachial plexus in some patients, producing pain down the medial side of the forearm and hand and wasting of the small muscles of the hand. It can also exert pressure on the overlying subclavian artery and interfere with the circulation of the upper limb.

Bib Excision

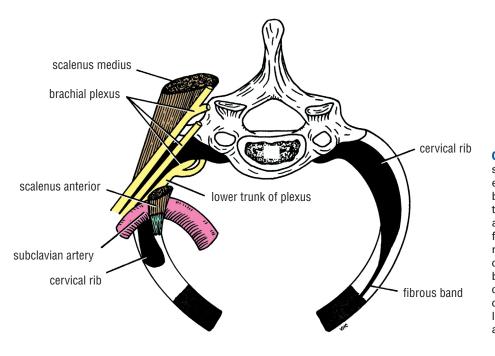
Rib excision is commonly performed by thoracic surgeons wishing to gain entrance to the thoracic cavity. A longitudinal incision is made through the periosteum on the outer surface of the rib and a segment of the rib is removed. A second longitudinal incision is then made through the bed of the rib, which is the inner covering of periosteum. After the operation, the rib regenerates from the osteogenetic layer of the periosteum.



HE INTERCOSTAL NEBVES

Skin Innervation of the Chest Wall and Referred Pain

Above the level of the sternal angle, the cutaneous innervation of the anterior chest wall is derived from the supraclavicular nerves (C3 and 4). Below this level, the anterior and lateral cutaneous branches of the intercostal nerves supply



CD Figure 3-1 Thoracic outlet as seen from above. Note the presence of the cervical ribs (*black*) on both sides. On the right side of the thorax, the rib is almost complete and articulates anteriorly with the first rib. On the left side of the thorax, the rib is rudimentary but is continued forward as a fibrous band that is attached to the first costal cartilage. Note that the cervical rib may exert pressure on the lower trunk of the brachial plexus and may kink the subclavian artery.

oblique bands of skin in regular sequence. The skin on the posterior surface of the chest wall is supplied by the posterior rami of the spinal nerves. The arrangement of the dermatomes is shown in CD Figures 1-2 and 1-3.

An intercostal nerve supplies not only areas of skin but also the ribs, costal cartilages, intercostal muscles, and the parietal pleura lining the intercostal space. Furthermore, the seventh to eleventh intercostal nerves leave the thoracic wall and enter the anterior abdominal wall so that they, in addition, supply dermatomes on the anterior abdominal wall, muscles of the anterior abdominal wall, and parietal peritoneum. This latter fact is of great clinical importance because it means that disease in the thoracic wall may be revealed as pain in a dermatome that extends across the costal margin into the anterior abdominal wall. For example, a pulmonary thromboembolism or pneumonia with pleurisy involving the costal parietal pleura could give rise to abdominal pain and tenderness and rigidity of the abdominal musculature. The abdominal pain in these instances is called referred pain.

Herpes Zoster

Herpes zoster, or shingles, is a relatively common condition caused by the reactivation of the latent varicella-zoster virus in a patient who has previously had chickenpox. The lesion is seen as an inflammation and degeneration of the sensory neuron in a cranial or spinal nerve with the formation of vesicles and inflammation of the skin. In the thorax, the first symptom is a band of dermatomal pain in the distribution of the sensory neuron in a thoracic spinal nerve, followed in a few days by a skin eruption. The condition occurs most frequently in patients older than 50 years.

Anatomy of Intercostal Nerve Block

Area of Anesthesia

The skin and the parietal pleura cover the outer and inner surfaces of each intercostal space, respectively; the seventh to eleventh intercostal nerves supply the skin and the parietal peritoneum covering the outer and inner surfaces of the abdominal wall, respectively. Therefore, an intercostal nerve block will also anesthetize these areas. In addition, the periosteum of the adjacent ribs is anesthetized.

Indications

Intercostal nerve block is indicated for repair of lacerations of the thoracic and abdominal walls, for relief of pain in rib fractures, and to allow pain-free respiratory movements.

Procedure

To produce analgesia of the anterior and lateral thoracic and abdominal walls, the intercostal nerve should be blocked before the lateral cutaneous branch arises at the midaxillary line. The ribs may be identified by counting down from the second (opposite sternal angle) or up from the twelfth. The needle is directed toward the rib near the lower border (Text Fig. 3-4) and the tip comes to rest near the subcostal groove, where the local anesthetic is infiltrated around the nerve. Remember that the order of structures lying in the neurovascular bundle from above downward is intercostal vein, artery, and nerve and that these structures are situated between the posterior intercostal membrane of the internal intercostal muscle and the parietal pleura. Furthermore, laterally the nerve lies between the internal intercostal muscle and the innermost intercostal muscle.

Anatomy of Complications

Complications include pneumothorax and hemorrhage.

Pneumothorax can occur if the needle point misses the subcostal groove and penetrates too deeply through the parietal pleura.

Hemorrhage is caused by the puncture of the intercostal blood vessels. This is a common complication, so aspiration should always be performed before injecting the anesthetic. A small hematoma may result.



Chest Cage Distortion

The shape of the thorax can be distorted by congenital anomalies of the vertebral column or by the ribs. Destructive disease of the vertebral column that produces lateral flexion or scoliosis results in marked distortion of the thoracic cage.

Chest Trauma

Traumatic injury to the thorax is common, especially as a result of automobile accidents.

Mechanics of Chest Trauma

Chest organ injuries from blunt trauma occur as the result of rapid acceleration or deceleration, by compression, or by a sudden increase in intrathoracic or intraabdominal pressure. A knife wound piercing the chest wall injures the organs along its path. A bullet wound does not follow a straight path but yaws, tumbles, and may fragment, causing widespread tissue damage. In addition, the kinetic energy generated by a speeding bullet may damage tissue that is distant from the actual path of the bullet.

Rib Contusion

Bruising of a rib, secondary to trauma, is the most common rib injury. In this painful condition, a small hemorrhage occurs beneath the periosteum.

Rib Fractures

Fractures of the ribs are common chest injuries. In children, the ribs are highly elastic, and fractures in this age group are therefore rare. Unfortunately, the pliable chest wall in the young can be easily compressed so that the underlying lungs and heart may be injured. With increasing age, the rib cage becomes more rigid, owing to the deposit of calcium in the costal cartilages, and the ribs become brittle. The ribs then tend to break at their weakest part, their angles.

The ribs prone to fracture are those that are exposed or relatively fixed. Ribs five through 10 are the most commonly fractured ribs. The first four ribs are protected by the clavicle and pectoral muscles anteriorly and by the scapula and its associated muscles posteriorly. The eleventh and twelfth ribs float and move with the force of impact.

Because the rib is sandwiched between the skin externally and the delicate pleura internally, it is not surprising that the jagged ends of a fractured rib may penetrate the lungs and present as a **pneumothorax**.

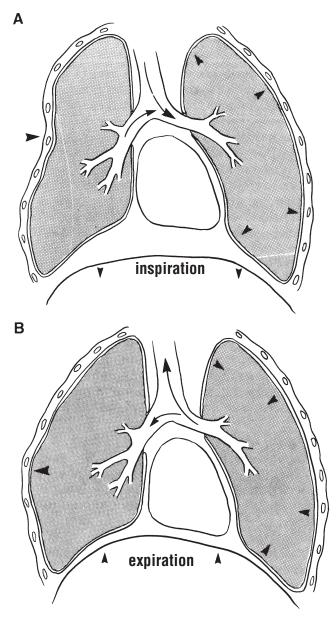
Severe localized pain is usually the most important symptom of a fractured rib. The periosteum of each rib is innervated by the intercostal nerves above and below the rib. To encourage the patient to breathe adequately, it may be necessary to relieve the pain by performing an intercostal nerve block.

Flail Chest

In severe crush injuries, a number of ribs may break. If limited to one side, the fractures may occur near the rib angles and anteriorly near the costochondral junctions. This causes flail chest, in which a section of the chest wall is disconnected to the rest of the thoracic wall. If the fractures occur on either side of the sternum, the sternum may be flail. In either case, the stability of the chest wall is lost, and the flail segment is sucked in during inspiration and driven out during expiration, producing paradoxic and ineffective respiratory movements (CD Fig. 3-2).

Fractured Sternum

The sternum is a resilient structure that is held in position by relatively pliable costal cartilages and bendable ribs. For these reasons, fracture of the sternum is not common; however, it does occur in high-speed motor vehicle accidents. Remember that the heart lies posterior to the sternum and may be severely contused by the sternum on impact.



CD Figure 3-2 Flail chest is a condition in which a portion of the chest wall is drawn inward during inspiration and bulges outward during expiration; it occurs when several ribs are fractured in two or more places. **A.** On inspiration the fractured ribs are pulled inward as the pressure within the chest decreases. The inspired air passing down the trachea tends to be drawn into the lung on the unaffected side. **B.** On expiration the fractured ribs are pushed outward as the pressure within the chest rises. Note that some of the air in the bronchi tends to enter the lung on the affected side as well as passing up the trachea.

Traumatic Injury to the Back of the Chest

The posterior wall of the chest in the midline is formed by the vertebral column. In severe posterior chest injuries, the possibility of a vertebral fracture with associated injury to the spinal cord should be considered. Remember also the presence of the scapula, which overlies the upper seven ribs. This bone is covered with muscles and is fractured only in cases of severe trauma.

Traumatic Injury to the Chest and Abdominal Viscera

When the anatomy of the thorax is reviewed, it is important to remember that the upper abdominal organs—namely, the liver, stomach, and spleen—may be injured by trauma to the rib cage. In fact, any injury to the chest below the level of the nipple line may involve abdominal organs as well as chest organs.



Hiccup

Hiccup is the involuntary spasmodic contraction of the diaphragm accompanied by the approximation of the vocal folds and closure of the glottis of the larynx. It is a common condition in normal individuals and occurs after eating or drinking as a result of gastric irritation of the vagus nerve endings. It may, however, be a symptom of disease such as pleurisy, peritonitis, pericarditis, or uremia.

Paralysis of the Diaphragm

A single dome of the diaphragm may be paralyzed by crushing or sectioning of the phrenic nerve in the neck. This may be necessary in the treatment of certain forms of lung tuberculosis, when the physician wishes to rest the lower lobe of the lung on one side. Occasionally, the contribution from the fifth cervical spinal nerve joins the phrenic nerve late as a branch from the nerve to the subclavius muscle. This is known as the accessory phrenic nerve. To obtain complete paralysis under these circumstances, the nerve to the subclavius muscle must also be sectioned.

Penetrating Injuries of the Diaphragm

Penetrating injuries can result from stab or bullet wounds to the chest or abdomen. Any penetrating wound to the chest below the level of the nipples should be suspected of causing damage to the diaphragm until proved otherwise. The arching domes of the diaphragm can reach the level of the fifth rib (the right dome can reach a higher level).

Rupture of the Diaphragm

In severe crushing injuries to the chest or abdomen, the diaphragm may rupture, usually through the central tendon. Herniation of abdominal viscera into the thorax may occur, especially if the left dome of the diaphragm is the site of the rupture. The rupture of the right dome or the central tendon is usually plugged by the large right lobe of the liver, unless the opening is very great. A ruptured diaphragm, if not repaired, may result in a delayed herniation of abdominal contents.

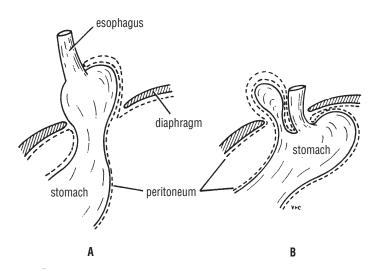


Congenital Herniae

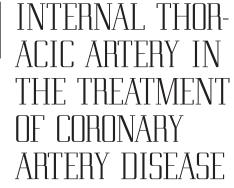
Congenital herniae may occur as the result of incomplete fusion of the septum transversum, the dorsal mesentery, and the pleuroperitoneal membranes from the body wall. The herniae occur at the following sites: (1) the pleuroperitoneal canal (more common on the left side; caused by failure of fusion of the septum transversum with the pleuroperitoneal membrane), (2) the opening between the xiphoid and costal origins of the diaphragm, and (3) the esophageal hiatus.

Acquired Herniae

Acquired herniae may occur in middle-aged people with weak musculature around the esophageal opening in the diaphragm. These herniae may be either sliding or parae-sophageal (CD Fig. 3-3).







In patients with occlusive coronary disease caused by atherosclerosis, the diseased arterial segment can be bypassed by inserting a graft. The graft most commonly used is the great saphenous vein of the leg. In some patients, the myocardium can be revascularized by surgically mobilizing one of the internal thoracic arteries and joining its distal cut end to a coronary artery.

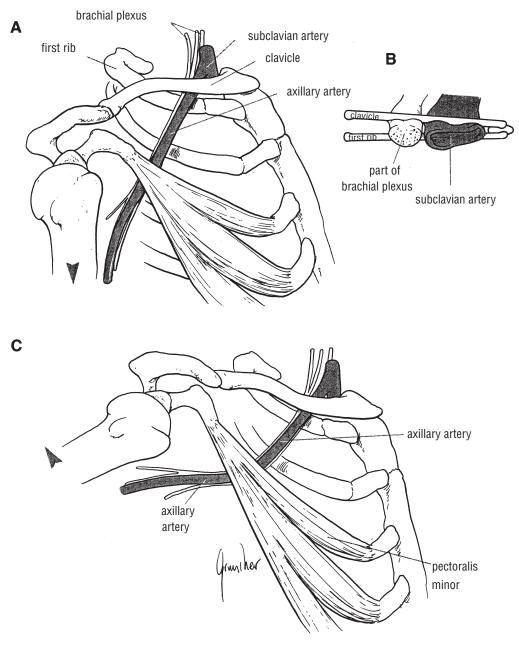


THE CLAVICLE AND ITS RELATIONSHIP WITH THE THORACIC OUTLET

The Thoracic Outlet Syndromes

The brachial plexus of nerves (C5, 6, 7, and 8 and T1) and the subclavian artery and vein are closely related to the upper surface of the first rib and the clavicle as they enter the upper limb see (see CD Fig. 3-4). It is here that the

CD Figure 3-3 A. Sliding esophageal hernia. **B.** Parae-sophageal hernia.

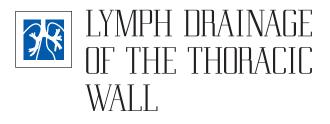


CD Figure 3-4 Examples of thoracic outlet syndrome. **A.** The relationship between the brachial plexus, the subclavian and axillary arteries, the clavicle, the first rib, and the pectoralis minor tendon. **B.** How the cords of the brachial plexus and the subclavian artery can be squeezed between the clavicle and the first rib in some individuals. **C.** How the axillary artery and the branches of the brachial plexus might be pressed upon by the pectoralis minor tendon when the arm is abducted at the shoulder joint.

nerves or blood vessels may be compressed between the bones. Most of the symptoms are caused by pressure on the lower trunk of the plexus producing pain down the medial side of the forearm and hand and wasting of the small muscles of the hand. Pressure on the blood vessels may compromise the circulation of the upper limb. Examples of the thoracic outlet syndromes are shown in CD Fig. 3-4.

The Adson Maneuver

This maneuver was commonly used in making the diagnosis of thoracic outlet syndrome; recently the reliability of the test has been questioned. The patient takes a deep breath (raises the first rib), extends the neck (takes up the slack of the brachial nerve plexus and subclavian vessels), and turns his or her chin to the side being examined (narrows the interval between the scalene muscles); at the same time the pulse of the radial artery is palpated. Disappearance or reduction of the pulse, and possibly coldness and paleness of the hand, would indicate that the subclavian artery is being compressed by the scalene muscles and/or the first (or cervical) rib. In addition to looking for vascular compromise, the physician should also look for replication of the nerve symptoms down the arm.

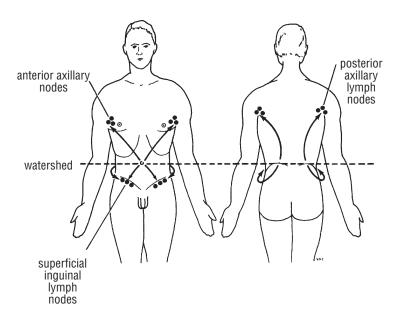


The lymph drainage of the skin of the anterior chest wall passes to the anterior axillary lymph nodes; that from the posterior chest wall passes to the posterior axillary nodes (CD Fig. 3-5). The lymph drainage of the intercostal spaces passes forward to the internal thoracic nodes, situated along the internal thoracic artery, and posteriorly to the posterior intercostal nodes and the paraaortic nodes in the posterior mediastinum. The lymphatic drainage of the breast is described in the next section.



Witch's Milk in the Newborn

While the fetus is in the uterus, the maternal and placental hormones cross the placental barrier and cause proliferation



of the duct epithelium and the surrounding connective tissue. This proliferation may cause swelling of the mammary glands in both sexes during the first week of life; in some cases a milky fluid, called witch's milk, may be expressed from the nipples. The condition is resolved spontaneously as the maternal hormone levels in the child fall.

Breast Examination

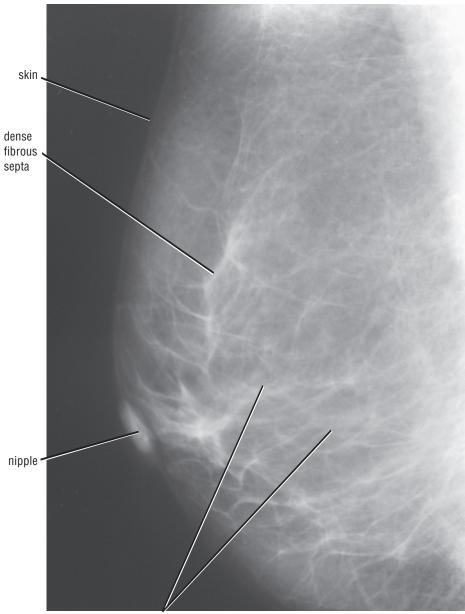
The breast is one of the common sites of cancer in women. It is also the site of different types of benign tumors and may be subject to acute inflammation and abscess formation. For these reasons, clinical personnel must be familiar with the development, structure, and lymph drainage of this organ.

With the patient undressed to the waist and sitting upright, the breasts are first inspected for symmetry. Some degree of asymmetry is common and is the result of unequal breast development. Any swelling should be noted. A swelling can be caused by an underlying tumor, cyst, or abscess formation. The nipples should be carefully examined for evidence of retraction. A carcinoma within the breast substance can cause retraction of the nipple by pulling on the lactiferous ducts. The patient is then asked to lie down so that the breasts can be palpated against the underlying thoracic wall. Finally, the patient is asked to sit up again and raise both arms above her head. With this maneuver, a carcinoma tethered to the skin, the suspensory ligaments, or the lactiferous ducts produces dimpling of the skin or retraction of the nipple.

Mammography

Mammography is a radiographic examination of the breast (CD Fig. 3-6). This technique is extensively used for screening the breasts for benign and malignant tumors and cysts.

CD Figure 3-5 Lymph drainage of the skin of the thorax and abdomen. Note that levels of the umbilicus anteriorly and iliac crests posteriorly may be regarded as watersheds for lymph flow.



glandular tissue supported by connective tissue

CD Figure 3-6 Mediolateral mammogram showing the glandular tissue supported by the connective tissue septa.

Extremely low doses of x-rays are used so that the dangers are minimal and the examination can be repeated often. Its success is based on the fact that a lesion measuring only a few millimeters in diameter can be detected long before it is felt by clinical examination.

Supernumerary and Retracted Nipples

Supernumerary nipples occasionally occur along a line extending from the axilla to the groin; they may or may not be associated with breast tissue. This minor congenital anomaly may result in a mistaken diagnosis of warts or moles. A longstanding retracted nipple is a congenital deformity caused by a failure in the complete development of the nipple. A retracted nipple of recent occurrence is usually caused by an underlying carcinoma pulling on the lactiferous ducts.

The Importance of Fibrous Septa

The interior of the breast is divided into 15 to 20 compartments that radiate from the nipple by fibrous septa that extend from the deep surface of the skin. Each compartment contains a lobe of the gland. Normally, the skin feels completely mobile over the breast substance. However, should the fibrous septa become involved in a scirrhous carcinoma or in a disease such as a breast abscess, which results in the production of contracting fibrous tissue, the septa will be pulled on, causing dimpling of the skin. The fibrous septa are sometimes referred to as the suspensory ligaments of the mammary gland.

An acute infection of the mammary gland may occur during lactation. Pathogenic bacteria gain entrance to the breast tissue through a crack in the nipple. Because of the presence of the fibrous septa, the infection remains localized to one compartment or lobe in the beginning. Abscesses should be drained through a radial incision to avoid spreading of the infection into neighboring compartments; a radial incision also minimizes the damage to the radially arranged ducts.

Lymph Drainage and Carcinoma of the Breast

The importance of knowing the lymph drainage of the breast in relation to the spread of cancer from that organ cannot be overemphasized. The lymph vessels from the medial quadrants of the breast pierce the second, third, and fourth intercostal spaces and enter the thorax to drain into the lymph nodes alongside the internal thoracic artery. The lymph vessels from the lateral quadrants of the breast drain into the anterior or pectoral group of axillary nodes. It follows, therefore, that a cancer occurring in the lateral quadrants of the breast tends to spread to the axillary nodes. Thoracic metastases are difficult or impossible to treat, but the lymph nodes of the axilla can be removed surgically.

Approximately 60% of carcinomas of the breast occur in the upper lateral quadrant. The lymphatic spread of cancer to the opposite breast, to the abdominal cavity, or into lymph nodes in the root of the neck is caused by obstruction of the normal lymphatic pathways by malignant cells or destruction of lymph vessels by surgery or radiotherapy. The cancer cells are swept along the lymph vessels and follow the lymph stream. The entrance of cancer cells into the blood vessels accounts for the metastases in distant bones.

In patients with localized cancer of the breast, most surgeons do a simple mastectomy or a lumpectomy, followed by radiotherapy to the axillary lymph nodes and/or hormone therapy. In patients with localized cancer of the breast with early metastases in the axillary lymph nodes, most authorities agree that radical mastectomy offers the best chance of cure. In patients in whom the disease has already spread beyond these areas (e.g., into the thorax), simple mastectomy, followed by radiotherapy or hormone therapy, is the treatment of choice.

Radical mastectomy is designed to remove the primary tumor and the lymph vessels and nodes that drain the area.

This means that the breast and the associated structures containing the lymph vessels and nodes must be removed en bloc. The excised mass is therefore made up of the following: a large area of skin overlying the tumor and including the nipple; all the breast tissue; the pectoralis major and associated fascia through which the lymph vessels pass to the internal thoracic nodes; the pectoralis minor and associated fascia related to the lymph vessels passing to the axilla; all the fat, fascia, and lymph nodes in the axilla; and the fascia covering the upper part of the rectus sheath, the serratus anterior, the subscapularis, and the latissimus dorsi muscles. The axillary blood vessels, the brachial plexus, and the nerves to the serratus anterior and the latissimus dorsi are preserved. Some degree of postoperative edema of the arm is likely to follow such a radical removal of the lymph vessels draining the upper limb.

A modified form of radical mastectomy for patients with clinically localized cancer is also a common procedure and consists of a simple mastectomy in which the pectoral muscles are left intact. The axillary lymph nodes, fat, and fascia are removed. This procedure removes the primary tumor and permits pathologic examination of the lymph nodes for possible metastases.



Polythelia

Supernumerary nipples occasionally occur along a line corresponding to the position of the milk ridge. They are liable to be mistaken for moles.

Retracted Nipple or Inverted Nipple

Retracted nipple is a failure in the development of the nipple during its later stages. It is important clinically, because normal suckling of an infant cannot take place, and the nipple is prone to infection.

Micromastia

An excessively small breast on one side occasionally occurs, resulting from lack of development.

Macromastia

Diffuse hypertrophy of one or both breasts occasionally occurs at puberty in otherwise normal girls.

Gynecomastia

Unilateral or bilateral enlargement of the male breast occasionally occurs, usually at puberty. The cause is unknown, but the condition is probably related to some form of hormonal imbalance.



Deflection of Mediastinum

In the cadaver, the mediastinum, as the result of the hardening effect of the preserving fluids, is an inflexible, fixed structure. In the living, it is very mobile; the lungs, heart, and large arteries are in rhythmic pulsation, and the esophagus distends as each bolus of food passes through it.

If air enters the pleural cavity (a condition called **pneu-mothorax**), the lung on that side immediately collapses and the mediastinum is displaced to the opposite side. This condition reveals itself by the patient's being breathless and in a state of shock; on examination, the trachea and the heart are found to be displaced to the opposite side.

Mediastinitis

The structures that make up the mediastinum are embedded in loose connective tissue that is continuous with that of the root of the neck. Thus, it is possible for a deep infection of the neck to spread readily into the thorax, producing a mediastinitis. Penetrating wounds of the chest involving the esophagus may produce a mediastinitis. In esophageal perforations, air escapes into the connective tissue spaces and ascends beneath the fascia to the root of the neck, producing **subcutaneous emphysema**.

Mediastinal Tumors or Cysts

Because many vital structures are crowded together within the mediastinum, their functions can be interfered with by an enlarging tumor or organ. A tumor of the left lung can rapidly spread to involve the mediastinal lymph nodes, which on enlargement may compress the left recurrent laryngeal nerve, producing paralysis of the left vocal fold. An expanding cyst or tumor can partially occlude the superior vena cava, causing severe congestion of the veins of the upper part of the body. Other pressure effects can be seen on the sympathetic trunks, phrenic nerves, and sometimes the trachea, main bronchi, and esophagus.

Mediastinoscopy

Mediastinoscopy is a diagnostic procedure whereby specimens of tracheobronchial lymph nodes are obtained without opening the pleural cavities. A small incision is made in the midline in the neck just above the suprasternal notch, and the superior mediastinum is explored down to the region of the bifurcation of the trachea. The procedure can be used to determine the diagnosis and degree of spread of carcinoma of the bronchus.



Pleural Fluid

The pleural space normally contains 5 to 10 mL of clear fluid, which lubricates the apposing surfaces of the visceral and parietal pleurae during respiratory movements. The formation of the fluid results from hydrostatic and osmotic pressures. Since the hydrostatic pressures are greater in the capillaries of the parietal pleura than in the capillaries of the visceral pleura (pulmonary circulation), the pleural fluid is normally absorbed into the capillaries of the visceral pleura. Any condition that increases the production of the fluid (e.g., inflammation, malignancy, congestive heart disease) or impairs the drainage of the fluid (e.g., collapsed lung) results in the abnormal accumulation of fluid, called a pleural effusion. The presence of 300 mL of fluid in the costodiaphragmatic recess in an adult is sufficient to enable its clinical detection. The clinical signs include decreased lung expansion on the side of the effusion, with decreased breath sounds and dullness on percussion over the effusion.

Pleurisy

Inflammation of the pleura (**pleuritis** or **pleurisy**), secondary to inflammation of the lung (e.g., **pneumonia**), results in the pleural surfaces becoming coated with inflammatory exudate, causing the surfaces to be roughened. This roughening produces friction, and a **pleural rub** can be heard with the stethoscope on inspiration and expiration. Often the exudate becomes invaded by fibroblasts, which lay down collagen and bind the visceral pleura to the parietal pleura, forming **pleural adhesions**.

Pneumothorax

As a result of disease or injury (stab or gunshot wounds), air can enter the pleural cavity from the lungs or through the chest wall (pneumothorax).

Spontaneous Pneumothorax

A spontaneous pneumothorax is a condition in which air enters the pleural cavity suddenly without its cause being immediately apparent. After investigation, it is usually found that air has entered from a diseased lung and a bulla (bleb) has ruptured. The resulting signs of pneumothorax are absent or diminished breath sounds over the affected lung and deflection of the trachea to the opposite side.

Open Pneumothorax

Open pneumothorax occurs when the air enters the pleural cavity through an opening in the chest wall and may result from stab or bullet wounds (CD Fig. 3-7). Sucking pneumothorax occurs when the hole in the chest wall is larger than the glottis. With each inspiration the negative pressure created is more effective at sucking air in through the chest wound than air entering through the glottis; this produces a sucking sound. The lung cannot be expanded, and respiration is compromised.

Tension Pneumothorax

Tension pneumothorax occurs when air is sucked into the pleural cavity through a chest wound with each inspiration but does not escape (CD Fig. 3-8). This can occur as the result of clothing and/or the layers of the chest wall combining to form a valve so that air enters on inspiration but cannot exit through the wound. In these circumstances, the air pressure builds up on the wounded side and pushes the mediastinum progressively over to the opposite side. Because of the anatomic thin walls of the great veins (vena cavae) and the atria of the heart, the increase in air pressure within the chest cavity interferes with blood return to the heart; the patient may die because of lack of venous return. The clinical signs are hypertension, hyperresonance to percussion on the affected side, the engorgement of the neck veins, and the evidence of mediastinal deflection. Eventually, hypotension (secondary to lack of venous return) results. The treatment is immediate decompression of the affected side by the insertion of a needle thoracostomy.

Fluid in the Pleural Cavity

Pleural Effusion

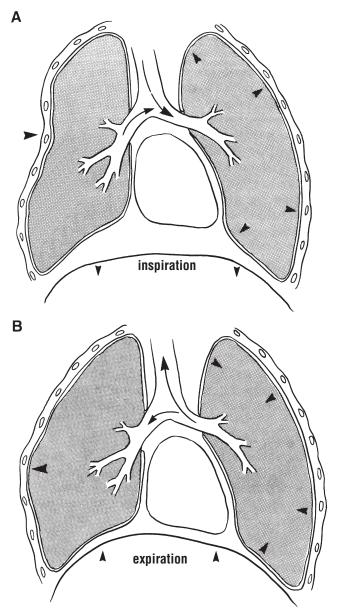
The presence of fluid in the cavity is referred to as a pleural effusion. Fluid (serous, blood, or pus) can be drained from the pleural cavity through a wide-bore needle, as described later in this section.

Hydropneumothorax

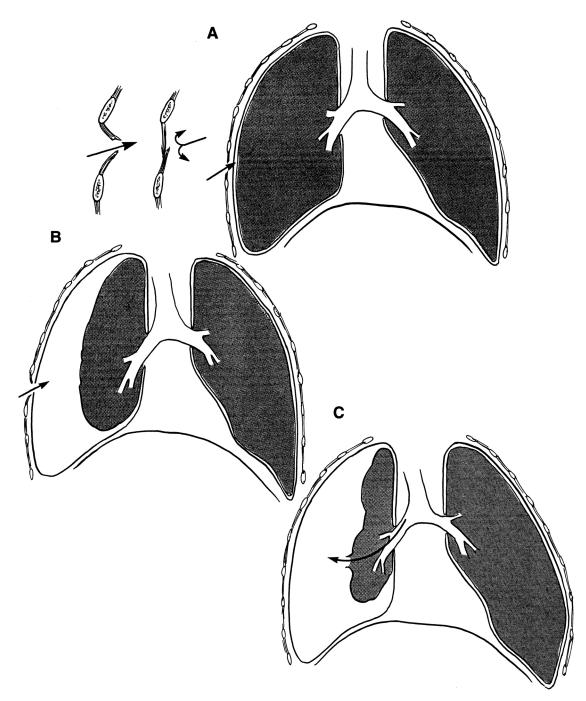
Air in the pleural cavity associated with serous fluid is known as hydropneumothorax.

Pyopneumothorax

Air in the pleural cavity associated with pus is known as pyopneumothorax.



CD Figure 3-7 Open pneumothorax without tension. **A.** On inspiration air is drawn in through the wound in the chest wall at atmospheric pressure, and the lung partially or completely collapses (depending on the size of the hole in the chest wall) from its own inherent elasticity; the mediastinum is deflected to the opposite side. **B.** On expiration air passes out of the chest wound as the diaphragm rises and the mediastinum is deflected to the same side. With large chest openings (larger than the cross-sectional area of trachea), air will preferentially use the hole in the chest wall rather than passing up and down the trachea, and respiratory ventilation will cease.



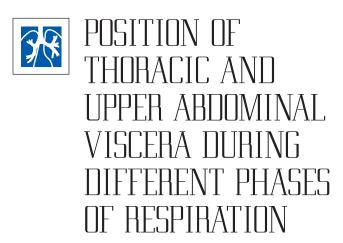
CD Figure 3-8 Tension pneumothorax. **A.** Following penetration of the chest wall, clothing and/or tissue create a valve-like mechanism that permits air entry into the pleural space during inspiration but prevents exit during expiration. **B.** The lung collapses on the wounded side and the buildup of air pressure with each respiration causes severe deflection of the mediastinum to the opposite side. **C.** Spontaneous pneumothorax with air entering the pleural space through a ruptured bulla; the lung collapses and the mediastinum is deflected to the opposite side.

Hemopneumothorax

Air in the pleural cavity associated with blood is known as hemopneumothorax.

Empyema

A collection of pus (without air) within the pleural cavity is called an empyema.



It is important to remember that the pleura, lungs, and heart in the chest cavity, and the upper abdominal viscera in the abdominal cavity, move extensively during the different phases of respiration. This movement largely results from the rising and falling of the diaphragm. It is particularly important when trying to work out the path taken by a sharp instrument or bullet following penetrating wounds to the lower chest.



The cervical dome of the parietal pleura and the apex of the lungs extend into the neck so that at their highest point they lie about 1 in. (2.5 cm) above the clavicles (see text Fig. 3-51). Consequently, they are vulnerable to stab wounds in the root of the neck.



The sudden caving in of the anterior chest wall associated with fractures of the sternum and ribs causes a dramatic rise in intrathoracic pressure. Apart from the immediate evidence of respiratory distress, the anatomy of the venous system plays a significant role in the production of the characteristic vascular signs of traumatic asphyxia. The thinness of the walls of the thoracic veins and the right atrium of the heart causes their collapse under the raised intrathoracic pressure, and venous blood is dammed back in the veins of the neck and head. This produces venous congestion; bulging of the eyes, which become injected; and swelling of the lips and tongue, which become cyanotic. The skin of the face, neck, and shoulders becomes purple.



CARDIOPULMONARY RESUSCITATION

Cardiopulmonary resuscitation (CPR), achieved by compression of the chest, was originally believed to succeed because of the compression of the heart between the sternum and the vertebral column. Now it is recognized that the blood flows in CPR because the whole thoracic cage is the pump; the heart functions merely as a conduit for blood. An extrathoracic pressure gradient is created by external chest compressions. The pressure in all chambers and locations within the chest cavity is the same. With compression, blood is forced out of the thoracic cage. The blood preferentially flows out the arterial side of the circulation and back down the venous side because the venous valves in the internal jugular system prevent a useless oscillatory movement. With the release of compression, blood enters the thoracic cage, preferentially down the venous side of the systemic circulation.



Thoracocentesis

Needle Thoracostomy

A needle thoracostomy is necessary in patients with tension pneumothorax (air in the pleural cavity under pressure) or to drain fluid (blood or pus) away from the pleural cavity to allow the lung to reexpand. It may also be necessary to withdraw a sample of pleural fluid for microbiologic examination.

Anterior Approach

For the anterior approach, the patient is in the supine position. The sternal angle is identified, and then the second costal cartilage, the second rib, and the second intercostal space are found in the midclavicular line.

Lateral Approach

For the lateral approach, the patient is lying on the lateral side. The second intercostal space is identified as above, but the anterior axillary line is used.

The skin is prepared in the usual way, and a local anesthetic is introduced along the course of the needle above the upper border of the third rib. The thoracostomy needle will pierce the following structures as it passes through the chest wall (see text Fig. 3-4): (a) skin, (b) superficial fascia (in the anterior approach the pectoral muscles are then penetrated), (c) serratus anterior muscle, (d) external intercostal muscle, (e) internal intercostal muscle, (f) innermost intercostal muscle, (g) endothoracic fascia, and (h) parietal pleura. The needle should be kept close to the upper border of the third rib to avoid injuring the intercostal vessels and nerve in the subcostal groove.

Tube Thoracostomy

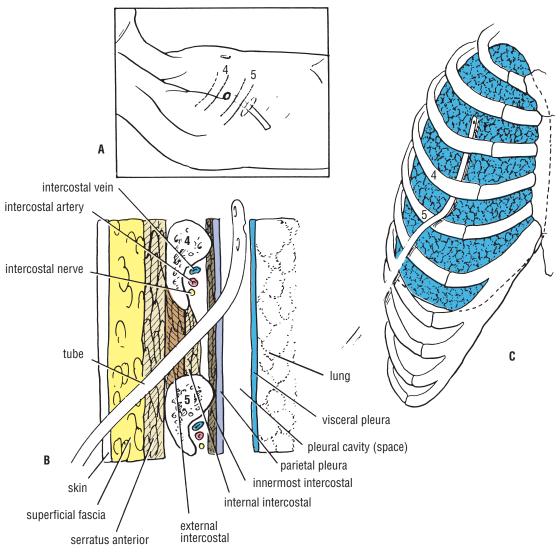
The preferred insertion site for a tube thoracostomy is the fourth or fifth intercostal space at the anterior axillary line (CD Fig. 3-9). The tube is introduced through a small incision. The neurovascular bundle changes its relationship to the ribs as it passes forward in the intercostal space. In the most posterior part of the space, the bundle lies in the middle of the intercostal space. As the bundle passes forward to the rib angle, it becomes closely related to the lower border

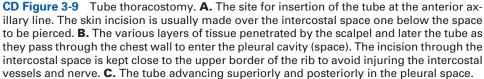
of the rib above and maintains that position as it courses forward.

The introduction of a thoracostomy tube or needle through the lower intercostal spaces is possible provided that the presence of the domes of the diaphragm is remembered as they curve upward into the rib cage as far as the fifth rib (higher on the right). Avoid damaging the diaphragm and entering the peritoneal cavity and injuring the liver, spleen, or stomach.

Thoracotomy

In patients with penetrating chest wounds with uncontrolled intrathoracic hemorrhage, thoracotomy may be a





life-saving procedure. After preparing the skin in the usual way, the physician makes an incision over the fourth or fifth intercostal space, extending from the lateral margin of the sternum to the anterior axillary line (CD Fig. 3-10). Whether to make a right or left incision depends on the site of the injury. For access to the heart and aorta, the chest should be entered from the left side. The following tissues will be incised (see CD Fig. 3-9): (a) skin, (b) subcutaneous tissue, (c) serratus anterior and pectoral muscles, (d) external intercostal muscle and anterior intercostal membrane, (e) internal intercostal muscle, (f) innermost intercostal muscle, (g) endothoracic fascia, and (h) parietal pleura.

Avoid the **internal thoracic artery**, which runs vertically downward behind the costal cartilages about a fingerbreadth lateral to the margin of the sternum, and the **intercostal vessels** and **nerve**, which extend forward in the subcostal groove in the upper part of the intercostal space (see CD Fig. 3-9).



Compression of the Trachea

The trachea is a membranous tube kept patent under normal conditions by U-shaped bars of cartilage. In the neck, a unilateral or bilateral enlargement of the thyroid gland can cause gross displacement or compression of the trachea. A dilatation of the aortic arch (**aneurysm**) can compress the trachea. With each cardiac systole the pulsating aneurysm may tug at the trachea and left bronchus, a clinical sign that can be felt by palpating the trachea in the suprasternal notch.

Tracheitis or Bronchitis

The mucosa lining the trachea is innervated by the recurrent laryngeal nerve and, in the region of its bifurcation, by the pulmonary plexus. A tracheitis or bronchitis gives rise to a raw, burning sensation felt deep to the sternum instead of actual pain. Many thoracic and abdominal viscera, when diseased, give rise to discomfort that is felt in the midline. It seems that organs possessing a sensory innervation that is not under normal conditions directly relayed to consciousness display this phenomenon. The afferent fibers from these organs traveling to the central nervous system accompany autonomic nerves.

Inhaled Foreign Bodies

Inhalation of foreign bodies into the lower respiratory tract is common, especially in children. Pins, screws, nuts, bolts, peanuts, and parts of chicken bones and toys have all found their way into the bronchi. Parts of teeth may be inhaled while a patient is under anesthesia during a difficult dental extraction. Because the right bronchus is the wider and more direct continuation of the trachea (see text Fig. 3-22), foreign bodies tend to enter the right instead of the left bronchus. From there, they usually pass into the middle or lower lobe bronchi.

Bronchoscopy

Bronchoscopy enables a physician to examine the interior of the trachea; its bifurcation, called the **carina**; and the main bronchi (CD Figs. 3-11 and 3-12). With experience, it is possible to examine the interior of the lobar bronchi and the beginning of the first segmental bronchi. By means of this procedure, it is also possible to obtain biopsy specimens of mucous membranes and to remove inhaled foreign bodies (even an open safety pin).



THE LUNGS

Clinical Examination of the Chest

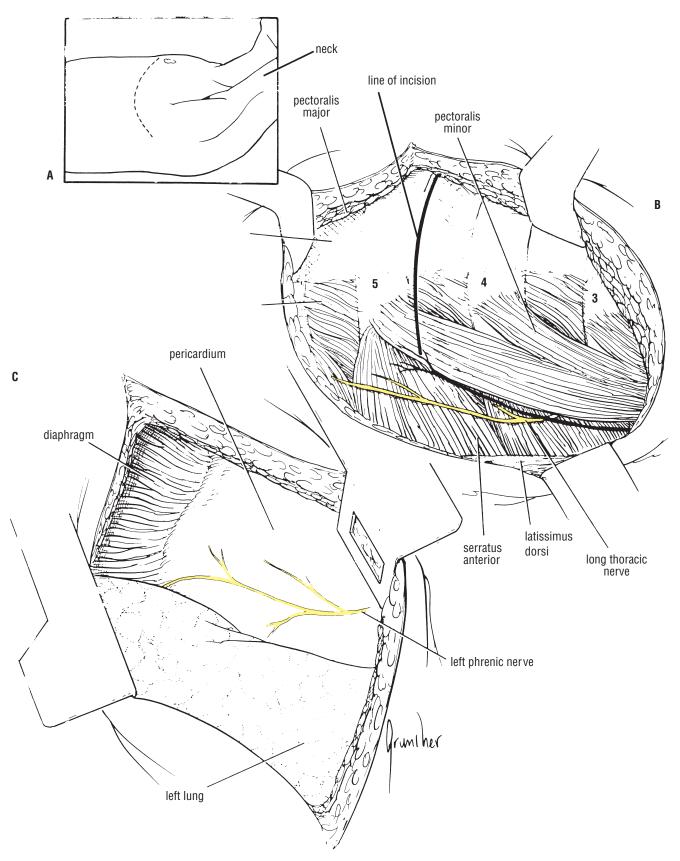
As medical personnel, you will be examining the chest to detect evidence of disease. Your examination consists of inspection, palpation, percussion, and auscultation.

Inspection shows the configuration of the chest, the range of respiratory movement, and any inequalities on the two sides. The type and rate of respiration are also noted.

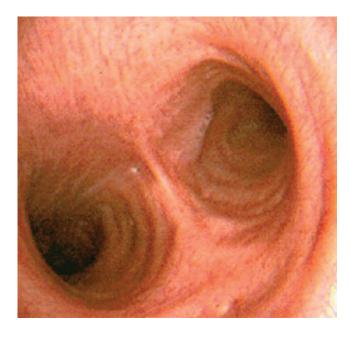
Palpation enables the physician to confirm the impressions gained by inspection, especially of the respiratory movements of the chest wall. Abnormal protuberances or recession of part of the chest wall is noted. Abnormal pulsations are felt and tender areas detected.

Percussion is a sharp tapping of the chest wall with the fingers. This produces vibrations that extend through the tissues of the thorax. Air-containing organs such as the lungs produce a resonant note; conversely, a more solid viscus such as the heart produces a dull note. With practice, it is possible to distinguish the lungs from the heart or liver by percussion.

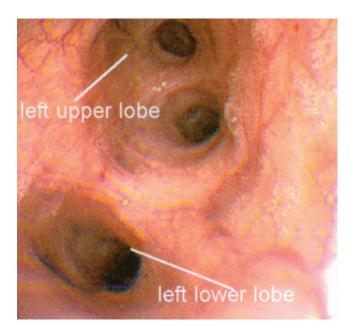
Auscultation enables the physician to listen to the breath sounds as the air enters and leaves the respiratory passages. Should the alveoli or bronchi be diseased and filled with fluid, the nature of the breath sounds will be altered. The rate and rhythm of the heart can be confirmed by auscultation, and the various sounds produced by the heart and its valves during the different phases of the cardiac cycle can be heard. It may be possible to detect friction sounds produced by the rubbing together of diseased layers of pleura or pericardium.



CD Figure 3-10 Left thoracotomy. **A.** Site of skin incision over fourth or fifth intercostal space. **B.** The exposed ribs and associated muscles. The line of incision through the intercostal space should be placed close to the upper border of the rib to avoid injuring the intercostal vessels and nerve. **C.** The pleural space opened and the left side of the mediastinum exposed. The left phrenic nerve descends over the pericardium beneath the mediastinal pleura. The collapsed left lung must be pushed out of the way to visualize the mediastinum.



CD Figure 3-11 The bifurcation of the trachea as seen through an operating bronchoscope. Note the ridge of the carina seen in the center and the opening into the right main bronchus on the right, which is a more direct continuation of the trachea. (Courtesy of E.D. Andersen.)



CD Figure 3-12 The interior of the left main bronchus as seen through an operating bronchoscope. The openings into the left upper lobe bronchus and its division and the left lower lobe bronchus are indicated. (Courtesy of E. D. Andersen.)

To make these examinations, the physician must be familiar with the normal structure of the thorax and must have a mental image of the normal position of the lungs and heart in relation to identifiable surface landmarks. Furthermore, it is essential that the physician be able to relate any abnormal findings to easily identifiable bony landmarks so that he or she can accurately record and communicate them to colleagues.

Since the thoracic wall actively participates in the movements of respiration, many bony landmarks change their levels with each phase of respiration. In practice, to simplify matters, the levels given are those usually found at about midway between full inspiration and full expiration.

For physical examination of the patient, it is good to remember that the upper lobe of the lungs is most easily examined from the front of the chest and the lower lobe from the back. In the axilla, areas of all three lobes can be examined (see text Fig. 3-53).

Trauma to the Lungs

A physician must always remember that the apex of the lung projects up into the neck (1 in. [2.5 cm] above the clavicle) and can be damaged by stab or bullet wounds in this area.

Fractured Ribs and the Lungs

Although the lungs are well protected by the bony thoracic cage, a splinter from a fractured rib can nevertheless penetrate the lung, and air can escape into the pleural cavity, causing a pneumothorax and collapse of the lung. It can also find its way into the lung connective tissue. From there, the air moves under the visceral pleura until it reaches the lung root. It then passes into the mediastinum and up to the neck. Here, it may distend the subcutaneous tissue, a condition known as **subcutaneous emphysema**.

The changes in the position of the thoracic and upper abdominal viscera and the level of the diaphragm during different phases of respiration relative to the chest wall are of considerable clinical importance. A penetrating wound in the lower part of the chest may or may not damage abdominal viscera, depending on the phase of respiration at the time of injury.

Pain and Lung Disease

Lung tissue and the visceral pleura are devoid of painsensitive nerve endings, so that pain in the chest is always the result of conditions affecting the surrounding structures. In tuberculosis or pneumonia, for example, pain may never be experienced.

Once lung disease crosses the visceral pleura and the pleural cavity to involve the parietal pleura, pain becomes a prominent feature. Lobar pneumonia with pleurisy, for example, produces a severe tearing pain, accentuated by inspiring deeply or coughing. Because the lower part of the costal parietal pleura receives its sensory innervation from the lower five intercostal nerves, which also innervate the skin of the anterior abdominal wall, pleurisy in this area commonly produces pain that is referred to the abdomen. This has sometimes resulted in a mistaken diagnosis of an acute abdominal lesion.

In a similar manner, pleurisy of the central part of the diaphragmatic pleura, which receives sensory innervation from the phrenic nerve (C3, 4, and 5), can lead to referred pain over the shoulder because the skin of this region is supplied by the supraclavicular nerves (C3 and 4).

Surgical Access to the Lungs

Surgical access to the lungs or mediastinum is commonly undertaken through an intercostal space. Special rib retractors that allow the ribs to be widely separated are used. The costal cartilages are sufficiently elastic to permit considerable bending. Good exposure of the lungs is obtained by this method.

Segmental Resection of the Lung

A localized chronic lesion such as that of tuberculosis or a benign neoplasm may require surgical removal. If it is restricted to a bronchopulmonary segment, it is possible to carefully dissect out a particular segment and remove it, leaving the surrounding lung intact. Segmental resection requires that the radiologist and thoracic surgeon have a sound knowledge of the bronchopulmonary segments and that they cooperate fully to localize the lesion accurately before operation.

Pulmonary Contusion

This condition is caused by a sudden rapid compression of the chest wall and underlying lung. It may be produced by blunt trauma or gunshot wounds. Because of the pliability of the chest wall in children, lung contusion is often present in the absence of rib fractures. The localized endothelial damage to the capillaries results in the transudation of fluid into the lung parenchyma, thus compromising lung function. In cases of blunt trauma, the area of damage to the lung will depend on the site of impact and will not be determined by anatomic subdivisions of the lung.

Tracheobronchial Injury

The lung root is the site where the mobile lung is connected by the main bronchi to the relatively fixed lower end of the trachea. It is not surprising, therefore, to find that when a rapid deceleration or shearing force is applied to the lungs, injuries occur to the bronchi. In the majority of patients, the tear occurs within 1 in. of the carina.

Bronchogenic Carcinoma

Bronchogenic carcinoma accounts for about one third of all cancer deaths in men and is becoming increasingly common in women. It commences in most patients in the mucous membrane lining the larger bronchi and is therefore situated close to the hilum of the lung. The neoplasm rapidly spreads to the tracheobronchial and bronchomediastinal nodes and may involve the recurrent laryngeal nerves, leading to hoarseness of the voice. Lymphatic spread via the bronchomediastinal trunks may result in early involvement in the lower deep cervical nodes just above the level of the clavicle. Hematogenous spread to bones and the brain commonly occurs.

Conditions That Decrease Respiratory Efficiency

Constriction of the Bronchi (Bronchial Asthma)

One of the problems associated with bronchial asthma is the spasm of the smooth muscle in the wall of the bronchioles. This particularly reduces the diameter of the bronchioles during expiration, usually causing the asthmatic patient to experience great difficulty in expiring, although inspiration is accomplished normally. The lungs consequently become greatly distended and the thoracic cage becomes permanently enlarged, forming the so-called **barrel chest**. In addition, the air flow through the bronchioles is further impeded by the presence of excess mucus, which the patient is unable to clear because an effective cough cannot be produced.

Loss of Lung Elasticity

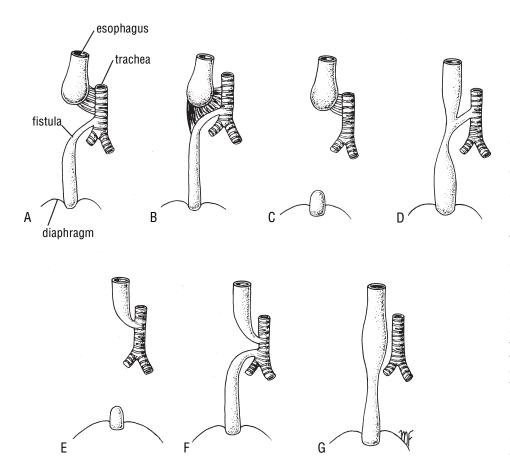
Many diseases of the lungs, such as **emphysema** and **pulmonary fibrosis**, destroy the elasticity of the lungs, and thus the lungs are unable to recoil adequately, causing incomplete expiration. The respiratory muscles in these patients have to assist in expiration, which no longer is a passive phenomenon.

Loss of Lung Distensibility

Diseases such as **silicosis**, **asbestosis**, **cancer**, and **pneumonia** interfere with the process of expanding the lung in inspiration. A decrease in the compliance of the lungs and the chest wall then occurs, and a greater effort has to be undertaken by the inspiratory muscles to inflate the lungs.

Postural Drainage

Excessive accumulation of bronchial secretions in a lobe or segment of a lung can seriously interfere with the normal



flow of air into the alveoli. Furthermore, the stagnation of such secretions is often quickly followed by infection. To aid in the normal drainage of a bronchial segment, a physiotherapist often alters the position of the patient so that gravity assists in the process of drainage. Sound knowledge of the bronchial tree is necessary to determine the optimum position of the patient for good postural drainage.

CONGENITAL ANOMALIES OF THE TRACHEA AND LUNGS

Esophageal Atresia and Tracheoesophageal Fistula

If the margins of the laryngotracheal groove fail to fuse adequately, an abnormal opening may be left between the laryngotracheal tube and the esophagus. If the tracheoesophageal

CD Figure 3-13 Different types of esophageal atresia and tracheoesophageal fistula. A. Complete blockage of the esophagus with a tracheoesophageal fistula. B. Similar to type A, but the two parts of the esophagus are joined together by fibrous tissue. C. Complete blockage of the esophagus; the distal end is rudimentary. D. A tracheoesophageal fistula with narrowing of the esophagus. E. An esophagotracheal fistula; the esophagus is not connected with the distal end, which is rudimentary. F. Separate esophagotracheal and tracheoesophageal fistulas. G. Narrowing of the esophagus without a fistula. In most cases, the lower esophageal segment communicates with the trachea, and types A and B occur more commonly.

septum formed by the fusion of the margins of the laryngotracheal groove should be deviated posteriorly, the lumen of the esophagus would be much reduced in diameter. The different types of atresia, with and without fistula, are shown in CD Fig. 3-13). Obstruction of the esophagus prevents the child from swallowing saliva and milk, and this leads to aspiration into the larynx and trachea, which usually results in pneumonia. With early diagnosis, it is often possible to correct this serious anomaly surgically.

Neonatal Lobar Emphysema

This condition occurs shortly after birth and is an overdistention of one or more lobes of the lung. It is a result, in many cases, of a failure of development of bronchial cartilage, which causes the bronchi to collapse. Air is inspired through the collapsed bronchi, but it is trapped during expiration.

Congenital Cysts of the Lung

Lung cysts may be solitary or may form multiple honeycomb-like masses. They are believed to be caused by separation of lung tissue occurring during development. Prompt surgical removal of the cysts is necessary to prevent compression and collapse of surrounding lung and infectious complications.

<u>Clinical Problem Solving Questions</u>

Read the following case histories/questions and give the best answer for each.

A 31-year-old soldier received a shrapnel wound in the neck during the Persian Gulf War. Recently, during a physical examination, it was noticed that when he blew his nose or sneezed, the skin above the right clavicle bulged upward.

- 1. The upward bulging of the skin could be explained by A. injury to the cervical pleura.
 - B. damage to the suprapleural membrane.
 - C. damage to the deep fascia in the root of the neck.
 - D. ununited fracture of the first rib.

A 52-year-old woman was admitted to the hospital with a diagnosis of right-sided pleurisy with pneumonia. It was decided to remove a sample of pleural fluid from her pleural cavity. The resident inserted the needle close to the lower border of the eighth rib in the anterior axillary line. The next morning he was surprised to hear that the patient had complained of altered skin sensation extending from the point where the needle was inserted downward and forward to the midline of the abdominal wall above the umbilicus.

- 2. The altered skin sensation in this patient after the needle thoracostomy could be explained by which of the following?
 - A. The needle was inserted too low down in the intercostal space.
 - B. The needle was inserted too close to the lower border of the eighth rib and damaged the eighth intercostal nerve.
 - C. The needle had impaled the eighth rib.
 - D. The needle had penetrated too deeply and pierced the lung.

A 68-year-old man complained of a swelling in the skin on the back of the chest. He had noticed it for the last 3 years and was concerned because it was rapidly enlarging. On examination, a hard lump was found in the skin in the right scapula line opposite the seventh thoracic vertebra. A biopsy revealed that the lump was malignant.

- 3. Because of the rapid increase in the size of the tumor, the following lymph nodes were examined for metastases:
 - A. Superficial inguinal nodes
 - B. Anterior axillary nodes
 - C. Posterior axillary nodes
 - D. External iliac nodes
 - E. Deep cervical nodes

A 65-year-old man and a 10-year-old boy were involved in a severe automobile accident. In both patients the thorax had been badly crushed. Radiographic examination revealed that the man had five fractured ribs but the boy had no fractures.

- 4. What is the most likely explanation for this difference in medical findings?
 - A. The patients were in different seats in the vehicle.
 - B. The boy was wearing his seat belt and the man was not.
 - C. The chest wall of a child is very elastic, and fractures of ribs in children are rare.
 - D. The man anticipated the impact and tensed his muscles, including those of the shoulder girdle and abdomen.

On examination of a posteroanterior chest radiograph of an 18-year-old woman, it was seen that the left dome of the diaphragm was higher than the right dome and reached to the upper border of the fourth rib.

- 5. The position of the left dome of the diaphragm could be explained by the following conditions **except** which?
 - A. The left lung could be collapsed.
 - B. There is a collection of blood under the diaphragm on the left side.
 - C. There is an amoebic abscess in the left lobe of the liver.
 - D. The left dome of the diaphragm is normally higher than the right dome.
 - E. There is a peritoneal abscess beneath the diaphragm on the left side.

A 43-year-old man was involved in a violent quarrel with his wife over another woman. In a fit of rage, the wife picked up a carving knife and lunged forward at her husband, striking his anterior neck over the left clavicle. The husband collapsed on the kitchen floor, bleeding profusely from the wound. The distraught wife called for an ambulance.

- 6. On examination in the emergency department of the hospital the following conditions were found **except** which?
 - A. A wound was seen about 1 in. (2.5 cm) wide over the left clavicle.
 - B. Auscultation revealed diminished breath sounds over the left hemithorax.
 - C. The trachea was deflected to the left.
 - D. The left upper limb was lying stationary on the table, and active movement of the small muscles of the left hand was absent.

E. The patient was insensitive to pin prick along the lateral side of the left arm, forearm, and hand.

A 72-year-old man complaining of burning pain on the right side of his chest was seen by his physician. On examination the patient indicated that the pain passed forward over the right sixth intercostal space from the posterior axillary line forward as far as the midline over the sternum. The physician noted that there were several watery blebs on the skin in the painful area.

- 7. The following statements are correct **except** which? A. This patient has herpes zoster.
 - B. A virus descends along the cutaneous nerves, causing dermatomal pain and the eruption of vesicles.
 - C. The sixth right intercostal nerve was involved.
 - D. The condition was confined to the anterior cutaneous branch of the sixth intercostal nerve.

An 18-year-old woman was thrown from a horse while attempting to jump a fence. She landed heavily on the ground, striking the lower part of her chest on the left side. On examination in the emergency department she was conscious but breathless. The lower left side of her chest was badly bruised, and the ninth and tenth ribs were extremely tender to touch. She had severe tachycardia, and her systolic blood pressure was low.

- 8. The following statements are possibly correct **except** which?
 - A. There was evidence of tenderness and muscle spasm in the left upper quadrant of the anterior abdominal wall.
 - B. A posteroanterior radiograph of the chest revealed fractures of the left ninth and tenth ribs near their angles.
 - C. The blunt trauma to the ribs had resulted in a tear of the underlying spleen.
 - D. The presence of blood in the peritoneal cavity had irritated the parietal peritoneum, producing reflex spasm of the upper abdominal muscles.
 - E. The muscles of the anterior abdominal wall are not supplied by thoracic spinal nerves.

A 55-year-old man states that he has noticed an alteration in his voice. He has lost 40 lb (18 kg) and has a persistent cough with blood-stained sputum. He smokes 50 cigarettes a day. On examination, the left vocal fold is immobile and lies in the adducted position. A posteroanterior chest radiograph reveals a large mass in the upper lobe of the left lung with an increase in width of the mediastinal shadow on the left side.

- 9. The symptoms and signs displayed by this patient can be explained by the following statements **except** which?
 - A. This patient has advanced carcinoma of the bronchus in the upper lobe of the left lung, which was seen as a mass on the chest radiograph.

- B. The carcinoma had metastasized to the bronchomediastinal lymph nodes, causing their enlargement and producing a widening of the mediastinal shadow seen on the chest radiograph.
- C. The enlarged lymph nodes had pressed on the left recurrent laryngeal nerve.
- D. Partial injury to the recurrent laryngeal nerve resulted in paralysis of the abductor muscles of the vocal cords, leaving the adductor muscles unopposed.
- E. The enlarged lymph nodes pressed on the left recurrent nerve as it ascended to the neck anterior to the arch of the aorta.

A 35-year-old woman had difficulty breathing and sleeping at night. She says she falls asleep only to wake up with a choking sensation. She finds that she has to sleep propped up in bed on pillows with her neck flexed to the right.

- 10. The following statements concerning this case are correct **except** which?
 - A. Veins in the skin at the root of the neck are congested.
 - B. The U-shaped cartilaginous rings in the wall of the trachea prevent it from being kinked or compressed.
 - C. The left lobe of the thyroid gland is larger than the right lobe.
 - D. On falling asleep, the patient tends to flex her neck laterally over the enlarged left thyroid lobe.
 - E. The enlarged thyroid gland extends down the neck into the superior mediastinum.
 - F. The brachiocephalic veins in the superior mediastinum were partially obstructed by the enlarged thyroid gland.

A 15-year-old boy was rescued from a lake after falling through thin ice. The next day, he developed a severe cold, and 3 days later his general condition deteriorated. He became febrile and started to cough up bloodstained sputum. At first, he had no chest pain, but later, when he coughed, he experienced severe pain over the right fifth intercostal space in the midclavicular line.

- 11. The following statements would explain the patient's signs and symptoms **except** which?
 - A. The patient had developed lobar pneumonia and pleurisy in the right lung.
 - B. Disease of the lung does not cause pain until the parietal pleura is involved.
 - C. The pneumonia was located in the right middle lobe.
 - D. The visceral pleura is innervated by autonomic nerves that contain pain fibers.
 - E. Pain associated with the pleurisy was accentuated when movement of the visceral and parietal pleurae occurred, for example, on deep inspiration or coughing.

A 2-year-old boy was playing with his toy car when his baby-sitter noticed that a small metal nut was missing from the car. Two days later the child developed a cough and became febrile.

- 12. This child's illness could be explained by the following statements **except** which?
 - A. The child had inhaled the nut.
 - B. The metal nut could easily be seen on posteroanterior and right oblique radiographs.
 - C. The left principal bronchus is the more vertical and wider of the two principal bronchi, and inhaled foreign bodies tend to become lodged in it.
 - D. The nut was successfully removed through a bronchoscope.
 - E. Children who are teething tend to suck on hard toys.

A 23-year-old woman was examined in the emergency department because of the sudden onset of respiratory distress. The physician was listening to breath sounds over the right hemithorax and was concerned when no sounds were heard on the front of the chest at the level of the tenth rib in the midclavicular line.

- 13. The following comments concerning this patient are correct except which?
 - A. In a healthy individual, the lower border of the right lung in the midclavicular line in the midrespiratory position is at the level of the sixth rib.
 - B. The parietal pleura in the midclavicular line crosses the tenth rib.

- C. The costodiaphragmatic recess is situated between the lower border of the lung and the parietal pleura.
- D. The lung on extreme inspiration could descend in the costodiaphragmatic recess only as far as the eighth rib.
- E. No breath sounds were heard because the stethoscope was located over the liver.

A 36-year-old woman with a known history of emphysema (dilatation of alveoli and destruction of alveolar walls with a tendency to form cystic spaces) suddenly experiences a severe pain in the left side of her chest, is breathless, and is obviously in a state of shock.

- 14. Examination of this patient reveals the following findings **except** which?
 - A. The trachea is displaced to the right in the suprasternal notch.
 - B. The apex beat of the heart can be felt in the fifth left intercostal space just lateral to the sternum.
 - C. The right lung is collapsed.
 - D. The air pressure in the left pleural cavity is at atmospheric pressure.
 - E. The air has entered the left pleural cavity as the result of rupture of one of the emphysematous cysts of the left lung (left-sided pneumothorax).
 - F. The elastic recoil of the lung tissue caused the lung to collapse.

Answers and Explanations

- 1. **B** is the correct answer. The shrapnel had torn the suprapleural membrane, which normally prevents the cervical dome of the pleura from bulging up into the neck.
- 2. **B** is the correct answer. The intercostal nerve is located in the subcostal groove on the lower border of the rib (see text Fig. 3-4).
- 3. C is the correct answer. The lymphatic drainage of the skin of the back above the level of the iliac crests is upward and forward into the posterior axillary lymph nodes.
- 4. C is the correct answer. The chest wall of a child is very elastic, and fractures of ribs in children are rare.
- 5. **D** is the correct answer. The right dome of the diaphragm is normally higher than the left dome due to the large size of the right lobe of the underlying liver.
- 6. E is the correct answer. The lower trunk of the brachial plexus was cut by the knife. This would explain the loss of movement of the small muscles of the left hand. It would also explain the loss of skin sensation that occurred in the C8 and T1 dermatomes on the *medial*, not on the lateral, side of the left forearm and hand. The knife had also pierced the left dome of the cervical pleura, causing a left pneumothorax with left-sided diminished breath sounds and a deflection of the trachea to the left.
- 7. **D** is the correct answer. The skin over the sixth intercostal space is innervated by the lateral cutaneous branch as well as the anterior cutaneous branch of the sixth intercostal nerve.
- 8. E is the correct answer. The seventh to the eleventh intercostal nerves supply the muscles of the anterior abdominal wall.

- 9. E is the correct answer. The left recurrent laryngeal nerve ascends to the neck by passing under the arch of the aorta; it ascends in the groove between the trachea and the esophagus.
- 10. **B** is the correct answer. The trachea is a mobile, fibroelastic tube that can be kinked or compressed despite the presence of the cartilaginous rings.
- 11. **D** is the correct answer. Lung tissue and the visceral pleura are not innervated with pain fibers. The costal parietal pleura is innervated by the intercostal nerves, which have pain endings in the pleura.
- 12. C is the correct answer. The right principal (main) bronchus is the more vertical and wider of the two principal bronchi, and for this reason an inhaled foreign body passes down the trachea and tends to enter the right main bronchus, where it was lodged in this patient.
- 13. **B** is the correct answer. The parietal pleura in the midclavicular line only extends down as far as the eighth rib (see text Fig. 3-51).
- 14. C is the correct answer. The left lung collapsed immediately when air entered the left pleural cavity because the air pressures within the bronchial tree and in the pleural cavity were then equal.