Trachea

The trachea is a mobile cartilaginous and membranous tube (Fig. 3.9). It begins in the neck as a continuation of the larynx at the lower border of the cricoid cartilage at the level of the 6th cervical vertebra. It descends in the midline of the neck. In the thorax, the trachea ends below at the **carina** by dividing into right and left principal (main)

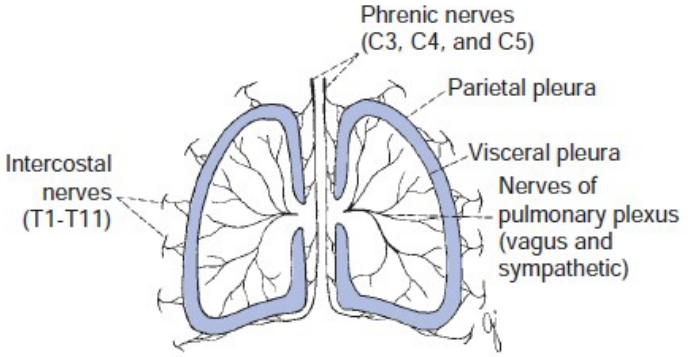

FIGURE 3.7 Diagram showing the innervation of the parietal and visceral layers of pleura.

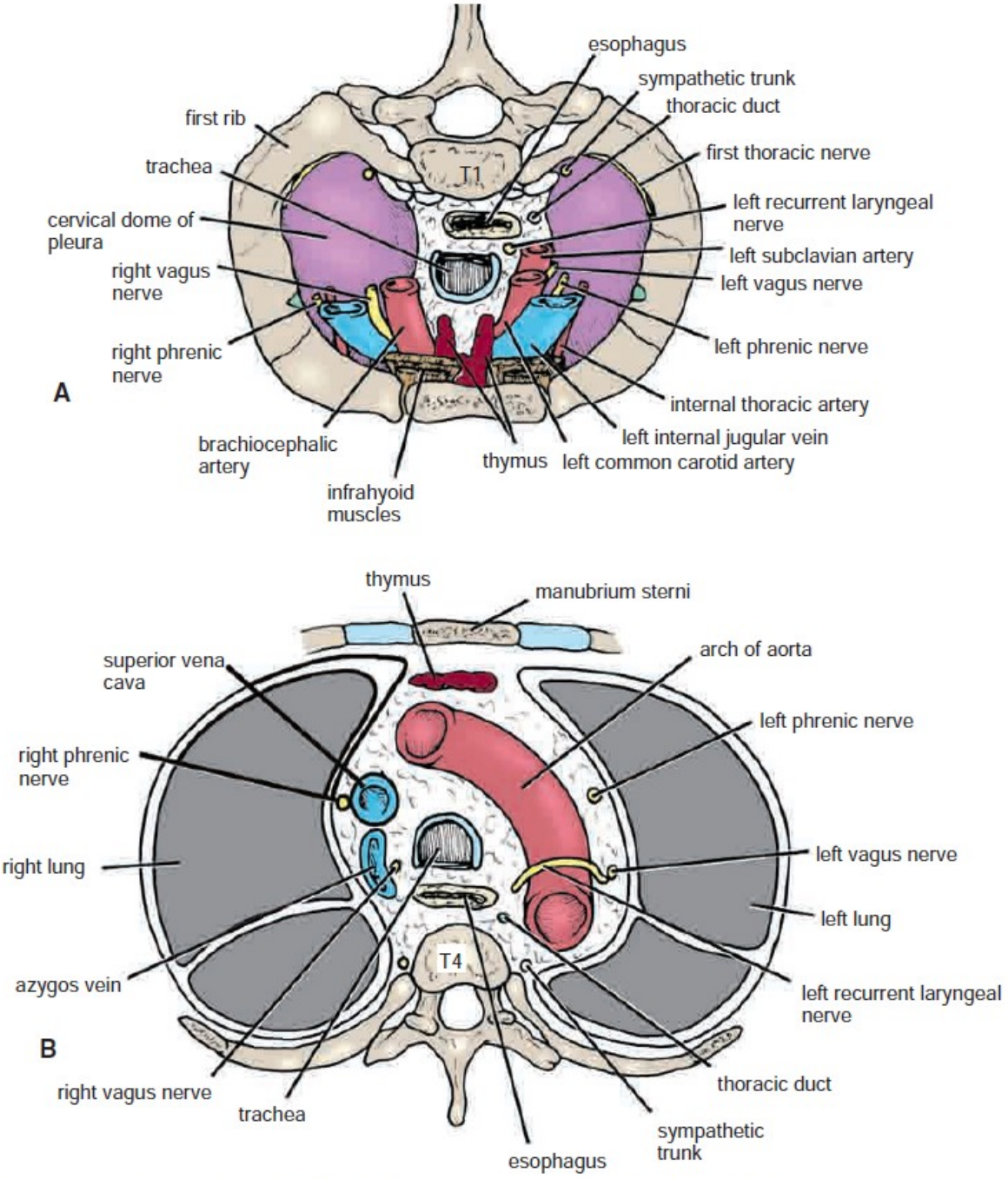

FIGURE 3.6 Cross section of the thorax. **A:** At the inlet, as seen from above. **B:** At the 4th thoracic vertebra, as seen from below.

CLINICAL NOTES

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 (Fig. 3.8).

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, Empyema, and Pleural Effusion

As the result of disease or injury (stab or gunshot wounds), air can enter the pleural cavity from the lungs or through the chest wall (pneumothorax). In the old treatment of tuberculosis, air was purposely injected into the pleural cavity to collapse and rest the lung. This was known as **artificial 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.

Stab wounds of the thoracic wall may pierce the parietal pleura so that the pleural cavity is open to the outside air. This condition is called **open pneumothorax.** Each time the patient inspires, it is possible to hear air under atmospheric pressure being sucked into the pleural cavity. Sometimes the clothing and the layers of the thoracic wall combine 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 toward the opposite side. In this situation, a collapsed lung is on the injured side and the opposite lung is compressed by the deflected mediastinum. This dangerous condition is called a **tension pneumothorax.**

Air in the pleural cavity associated with serous fluid is known as **hydropneumothorax,** associated with pus as **pyopneumothorax,** and associated with blood as **hemopneumothorax.** A collection of pus (without air) in the pleural cavity is called an **empyema.** The presence of serous fluid in the pleural cavity is referred to as a **pleural effusion** (Fig. 3.9). Fluid (serous, blood, or pus) can be drained from the pleural cavity through a wide-bore needle, as described on page 45.

In hemopneumothorax, blood enters the pleural cavity. It can be caused by stab or bullet wounds to the chest wall, resulting in bleeding from blood vessels in the chest wall, from vessels in the chest cavity, or from a lacerated lung.

bronchi at the level of the sternal angle (opposite the disc between the 4th and 5th thoracic vertebrae). During expiration, the bifurcation rises by about one vertebral level, and during deep inspiration may be lowered as far as the 6th thoracic vertebra.

In adults, the trachea is about 4 1/2 in. (11.25 cm) long and 1 in. (2.5 cm) in diameter (Fig. 3.9). The fibroelastic tube is kept patent by the presence of U-shaped bars (rings) of hyaline cartilage embedded in its wall. The posterior free ends of the cartilage are connected by smooth muscle, the **trachealis muscle.**

The relations of the trachea in the neck are described on page 651.

The relations of the trachea in the superior mediastinum of the thorax are as follows:

- **Anteriorly:** The sternum, the thymus, the left brachiocephalic vein, the origins of the brachiocephalic and left common carotid arteries, and the arch of the aorta (Figs. 3.6A, 3.9, and 3.30)
- **Posteriorly:** The esophagus and the left recurrent laryngeal nerve (Fig. 3.6A)
- **Right side:** The azygos vein, the right vagus nerve, and the pleura (Figs. 3.6, 3.15A, and 3.16)
- **Left side:** The arch of the aorta, the left common carotid and left subclavian arteries, the left vagus and left phrenic nerves, and the pleura (Figs. 3.6, 3.15B, and 3.17)

Blood Supply of the Trachea

The upper two thirds are supplied by the inferior thyroid arteries and the lower third is supplied by the bronchial arteries.

Lymph Drainage of the Trachea

The lymph drains into the pretracheal and paratracheal lymph nodes and the deep cervical nodes.

Nerve Supply of the Trachea

The sensory nerve supply is from the vagi and the recurrent laryngeal nerves. Sympathetic nerves supply the trachealis muscle.

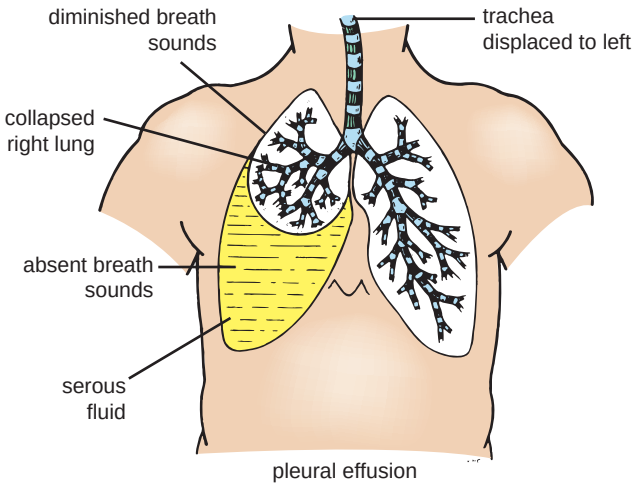

FIGURE 3.8 Case of right-sided pleural effusion. The mediastinum is displaced to the left, the right lung is compressed, and the bronchi are narrowed. Auscultation would reveal only faint breath sounds over the compressed lung and absent breath sounds over fluid in the pleural cavity.

The Bronchi

The trachea bifurcates behind the arch of the aorta into the **right and left principal (primary or main) bronchi** (Figs. 3.9, 3.18, and 3.19). The bronchi divide dichotomously, giving rise to several million terminal bronchioles that terminate in one or more respiratory bronchioles. Each respiratory bronchiole divides into 2 to 11 alveolar ducts that enter the alveolar sacs. The alveoli arise from the walls of the sacs as diverticula (see page 71).

Principal Bronchi

The right principal (main) bronchus (Fig. 3.11) is wider, shorter, and more vertical than the left (Figs. 3.9, 3.18, and 3.19) and is about 1 in. (2.5 cm) long. Before entering the hilum of the right lung, the principal bronchus gives off the **superior lobar bronchus.** On entering the hilum, it divides into a **middle** and an **inferior lobar bronchus**.

The left principal (main) bronchus is narrower, longer, and more horizontal than the right and is about 2 in. (5 cm) long. It passes to the left below the arch of the aorta and **in front of the esophagus.** On entering the hilum of the left lung, the principal bronchus divides into a **superior** and an **inferior lobar bronchus.**

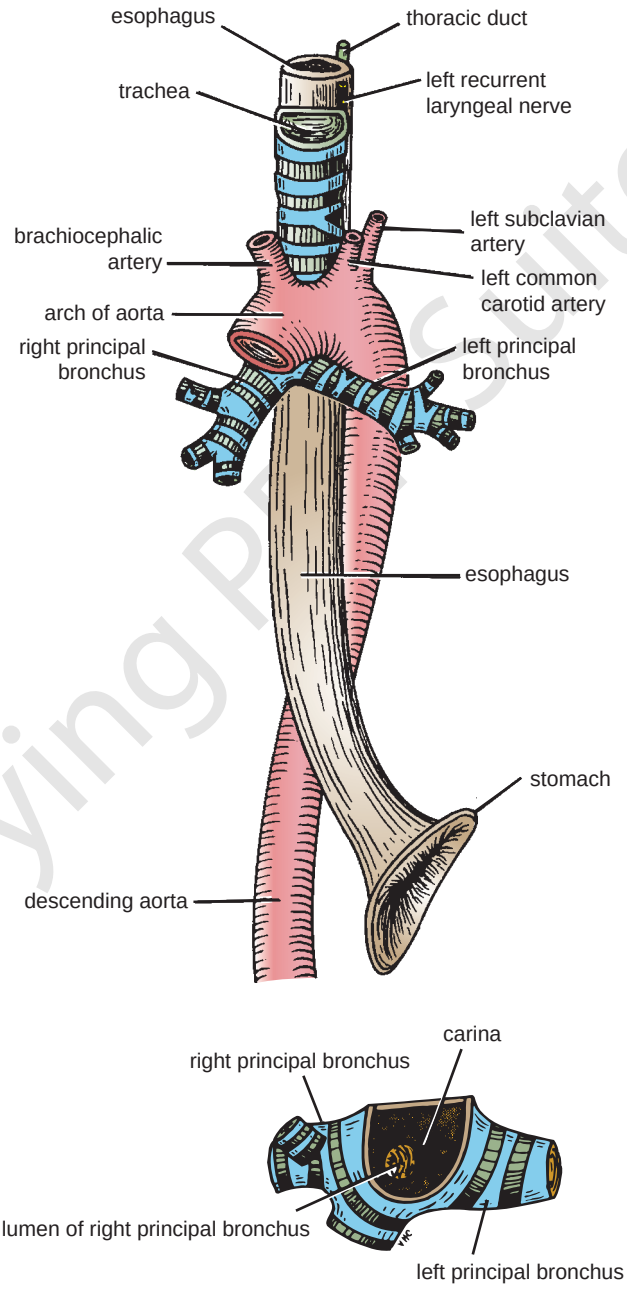

FIGURE 3.9 Thoracic part of the trachea. Note that the right principal bronchus is wider and has a more direct continuation of the trachea than the left. Bifurcation of the trachea viewed from above is also shown.

CLINICAL NOTES

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.

(continued)

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 (see page 224). 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 (Figs. 3.18 and 3.19), 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 (Figs. 3.12 and 3.13). 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 membrane and to remove inhaled foreign bodies (even an open safety pin).

Lodgment of a foreign body in the larynx or edema of the mucous membrane of the larynx secondary to infection or trauma may require immediate relief to prevent asphyxiation. A method commonly used to relieve complete obstruction is tracheostomy (see page 654).

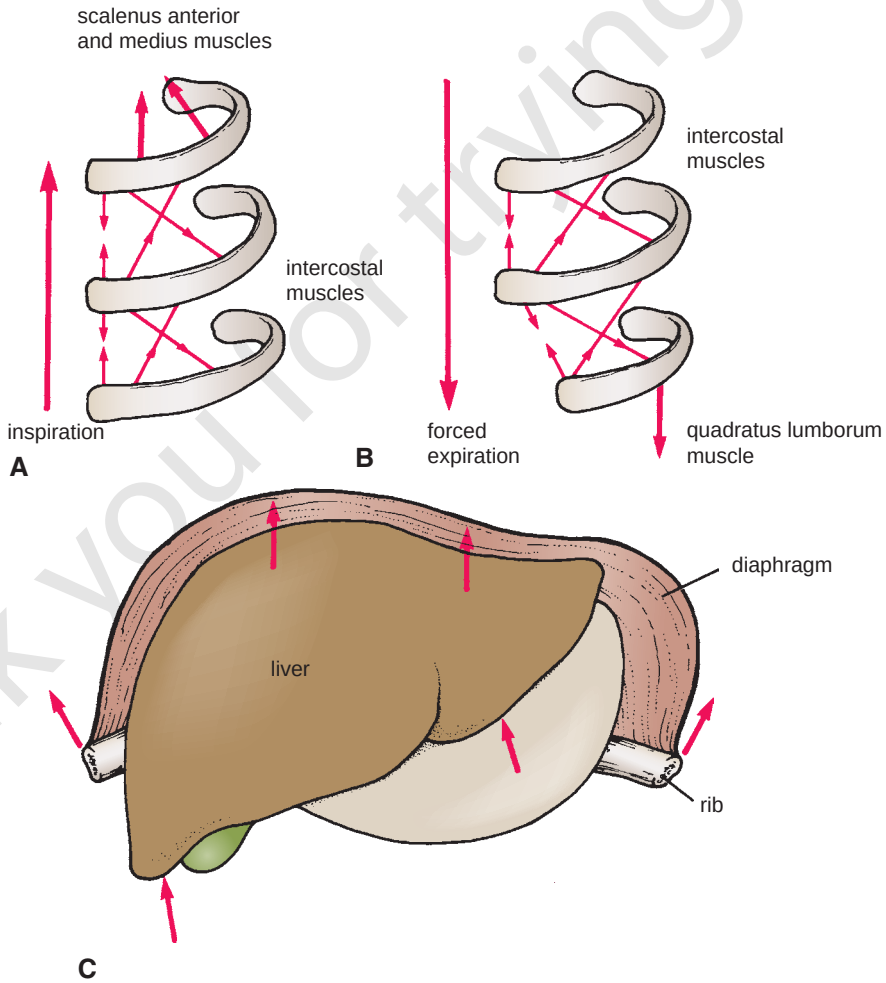

FIGURE 3.10 **A.** How the intercostal muscles raise the ribs during inspiration. Note that the scaleni muscles fix the 1st rib or, in forced inspiration, raise the 1st rib. **B.** How the intercostal muscles can be used in forced expiration, provided that the 12th rib is fixed or is made to descend by the abdominal muscles. **C.** How the liver provides the platform that enables the diaphragm to raise the lower ribs.

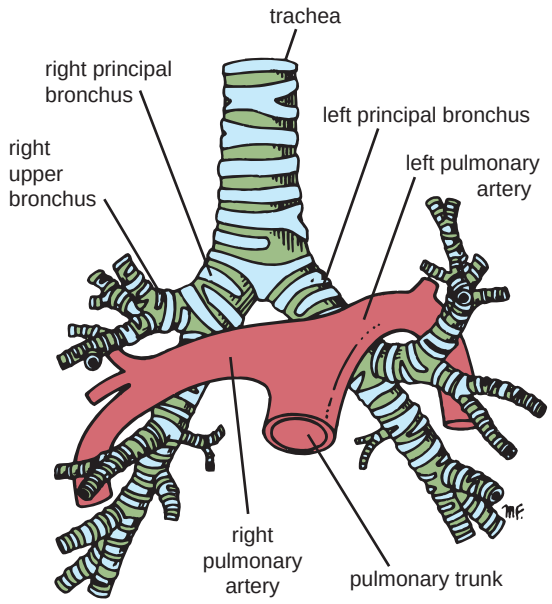

FIGURE 3.11 Relationship of the pulmonary arteries to the bronchial tree.

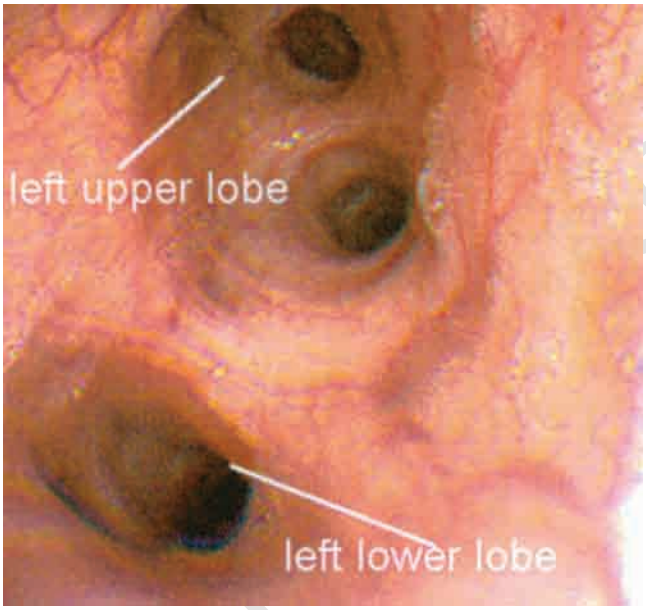

FIGURE 3.13 The interior of the left main bronchus as seen through an operating bronchoscope. The openings into the left upper lobe bronchus and its division and the left lower lobe bronchus are indicated. (Courtesy of E.D. Andersen.)

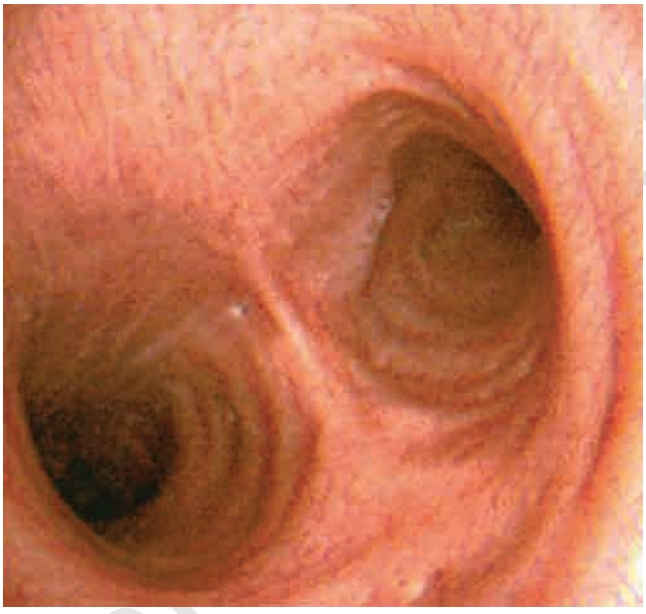

FIGURE 3.12 The bifurcation of the trachea as seen through an operating bronchoscope. Note the ridge of the carina in the center and the opening into the right main bronchus on the right, which is a more direct continuation of the trachea. (Courtesy of E.D. Andersen.)

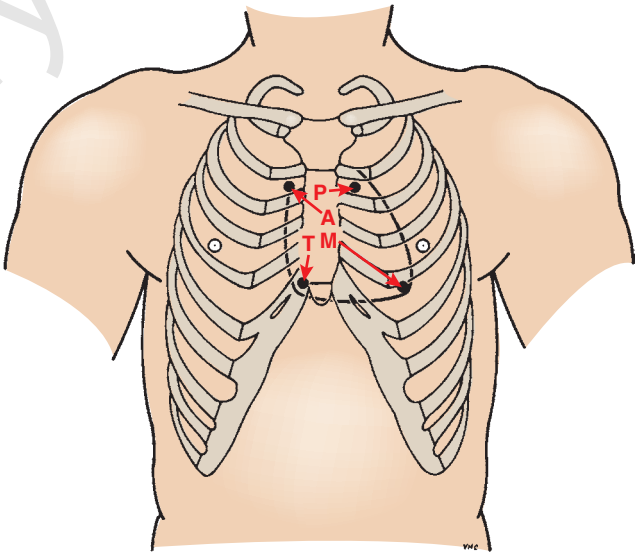

FIGURE 3.14 Position of the heart valves. P, pulmonary valve; A, aortic valve; M, mitral valve; T, tricuspid valve. *Arrows* indicate position where valves may be heard with least interference.