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1 Mediastinum

Gabriele A. Krombach

1.1 Anatomy

► **Location and divisions.** The mediastinum extends from the thoracic inlet to the diaphragm and is bounded laterally by mediastinal pleura. The mediastinum constitutes a single, coherent space that has no natural (fascial) barriers to the spread of tumors or inflammation. Nevertheless, it is useful conceptually to divide the mediastinum into parts because various diseases tend to occur at specific sites within the mediastinum, and the location of a pathologic process can be helpful in narrowing the diagnosis. The mediastinum is divided into anterior, middle, and posterior parts (► Fig. 1.1). The cervical fasciae communicate freely with the mediastinum, allowing inflammatory processes to spread contiguously from the neck into the mediastinum.

The mediastinum is further subdivided into the superior mediastinum and inferior mediastinum. The superior mediastinum extends downward from the thoracic inlet to the pericardium.

► **Radiographic landmarks.** ► Fig. 1.2 shows the mediastinal landmarks that appear on a standard chest radiograph.

Note

- The *anterior mediastinum* contains the thymus, lymph nodes, and fat. Its upper portion extends from the chest wall to the ascending aorta and superior vena cava, its lower portion from the retrosternal surface to the pericardium.
- The largest of the three compartments, the *middle mediastinum*, contains the heart, trachea, and large vessels arising from the aortic arch.
- The *posterior mediastinum* contains the esophagus, descending aorta, azygos and hemiazygos veins, and thoracic duct.

Caution

The pericardial reflection extends far in a cranial direction anteriorly and encloses almost the entire ascending aorta as far as the horizontal segment of the aortic arch.

► CT landmarks (► Fig. 1.3)

- The sternum and ascending aorta provide landmarks for the *thymic bed*, which is located between those structures.

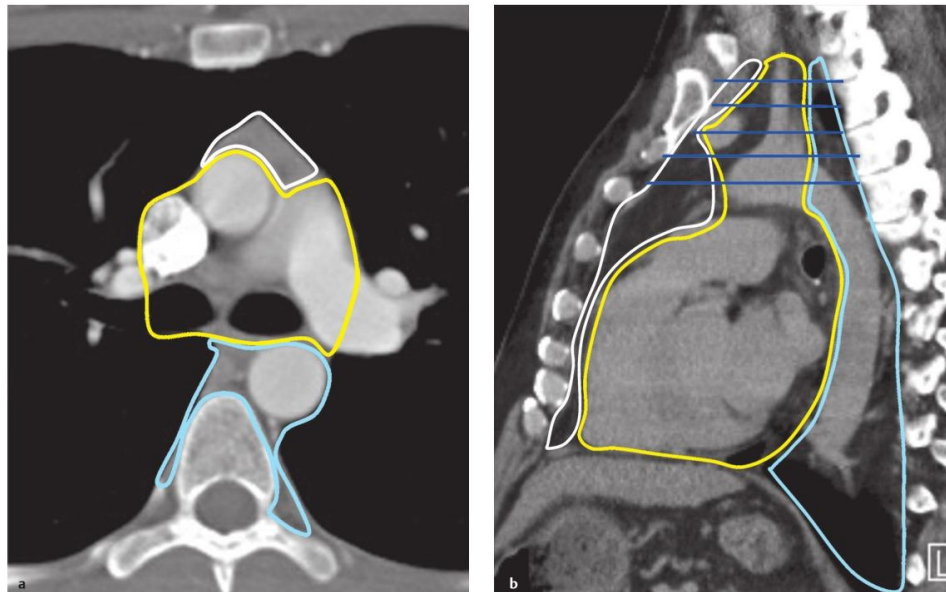


Fig. 1.1 Divisions of the mediastinum. (a) The divisions outlined in an axial CT scan. (b) The divisions outlined in a sagittal reformatted CT image. White indicates the anterior mediastinum (thymus, lymph nodes, and fatty tissue); yellow indicates the middle mediastinum (heart, aortic arch, pulmonary artery trunks, vena cava, trachea); light blue indicates the posterior mediastinum (descending aorta, esophagus, azygos and hemiazygos veins, thoracic duct); horizontal darker blue lines indicate the superior mediastinum (space above the pericardial reflection).

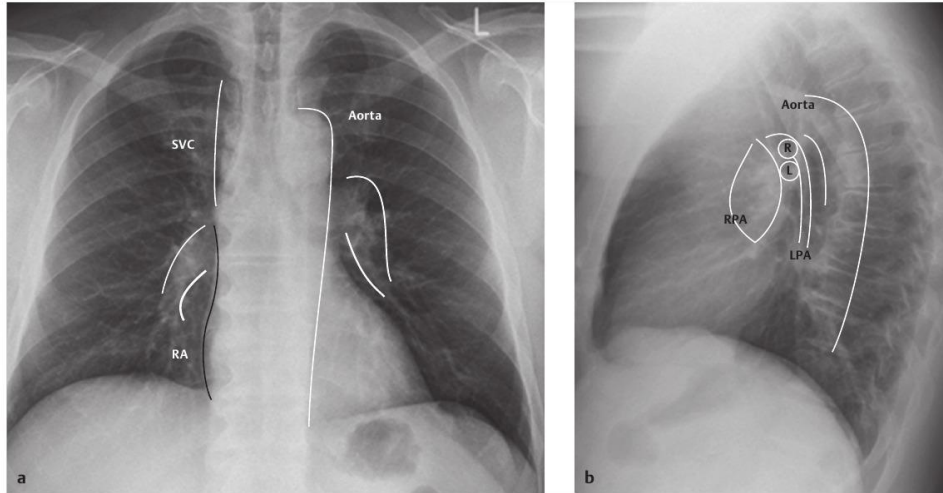


Fig. 1.2 Landmarks for mediastinal structures on chest radiographs. (a) PA view: the right mediastinal borders are formed by the superior vena cava (SVC), the pulmonary arteries in the hilum, and the right atrium (RA). The aortic contour is prominent on the left side. The left atrial appendage and left ventricle form the cardiac borders. The paravertebral line (black) is an edge-on projection of the pleura and immediate paravertebral soft tissues. (b) Lateral view: the left pulmonary artery (LPA) forms a cane-shaped figure that arches over the left main bronchus (L). The right pulmonary artery (RPA) runs for some distance across the mediastinum and appears end-on in the lateral view, creating an elliptical figure. The right main bronchus (R) runs just above it. The left main bronchus is projected below the right main bronchus. The aortopulmonary window is the gap between the left pulmonary artery and the aorta visible in the lateral projection.

- The most important landmarks in the superior mediastinum are the *supra-aortic branch vessels*. From right to left they are the brachiocephalic trunk, which branches into the right subclavian artery and common carotid artery; the left carotid artery; and the left subclavian artery (see ► Fig. 1.3a). The next vessel to the right is the superior vena cava. The trachea is located behind those vessels and is just anterior to the esophagus.
 - The *thoracic duct* ascends to the right of the aorta and opens into the junction of the left subclavian vein and left jugular vein. It collects lymphatic fluid from the lower extremities and abdominal organs in the upper left half of the body except for the left lower lobe of the lung. Its maximum diameter in the mediastinum is approximately 5 mm. The remaining areas on the right side are drained by the smaller right lymphatic duct.
 - The *vagus nerve* descends with the major vessels in the neck, entering the chest through the thoracic inlet. Below the level of the aortic arch it accompanies the esophagus in its descent through the mediastinum.
 - The right *recurrent laryngeal nerve* leaves the vagus nerve at the level of the subclavian artery, winds around that vessel, and ascends to the neck in the groove between the trachea and esophagus. The left recurrent laryngeal nerve is longer; it leaves the vagus nerve at the level of the aortic arch, passes behind the ductus arteriosus and around the aorta, and runs cephalad between the trachea and esophagus (► Fig. 1.4). Compression or infiltration of the nerve by a tumor leads to hoarseness.
 - The *phrenic nerve* arises from the C3–C5 nerve roots, leaves the brachial plexus, and accompanies the subclavian artery and vein through the thoracic inlet. It descends in the middle mediastinum along the pericardium to the diaphragm. Infiltration of the phrenic nerve by a mass leads to unilateral elevation of the diaphragm (► Fig. 1.5).
- **Selection of modalities.** The most common mediastinal diseases are masses. These present clinically with nonspecific complaints caused by the compression of surrounding structures. Typical presenting complaints are dyspnea, foreign-body sensation, and dysphagia. Chest radiographs in two planes are the imaging study of first choice in these cases; they can further narrow the diagnosis and may indicate a need for sectional imaging by CT or MRI. When mediastinal imaging is required in patients with a known disease entity or in cases where the history and symptoms are suspicious for a particular disease, CT is the modality of choice for defining the location and extent of the changes and for tumor staging. MRI should be added in selected cases where CT alone cannot detect or exclude conditions such as tumor infiltration of the pericardium or invasion of the spinal canal through the neural foramina. Ultrasound imaging has a minor role and may have limited applications in the anterior superior mediastinum. Transesophageal ultrasonography is needed to access the posterior mediastinum with ultrasound.

Mediastinum

1

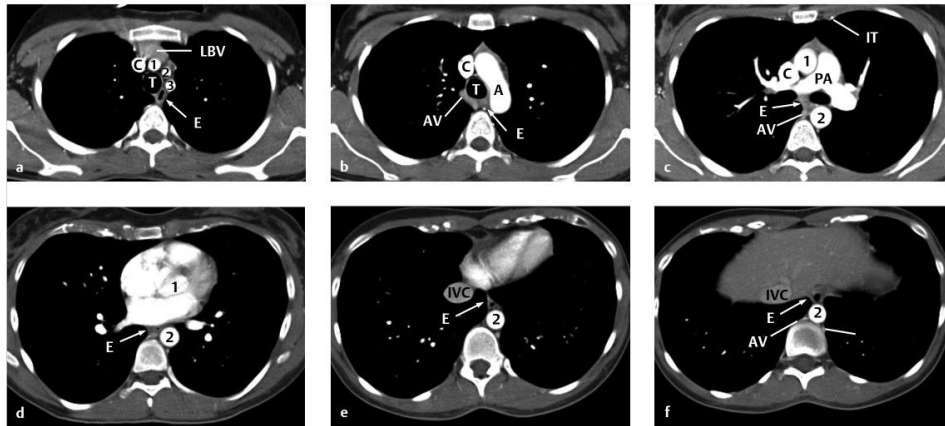


Fig. 1.3 Landmarks for mediastinal structures on axial CT. (a) Superior mediastinum, supra-aortic branches. Just posterior to the sternum is the left brachiocephalic vein (LBV). Just to the left of it are the vessels arising from the aortic arch, the brachiocephalic trunk (1), left common carotid artery (2), and left subclavian artery (3), which run anterior to the trachea (T). Just posterior to the trachea is the esophagus (E), whose small lumen can be traced through all the slices down to its passage through the diaphragm at the esophageal hiatus. The superior vena cava (C) can be traced through all slices from the union of both brachiocephalic veins to the right atrium. It occupies a right anterolateral position relative to the trachea and borders the brachiocephalic trunk on the right side. (b) At the level of the aortic arch (A), the azygos vein (AV) curves around the right main bronchus and opens into the superior vena cava (C). Additional landmarks for identifying the vessel are the spinal column and trachea (T). The azygos vein follows a right prevertebral path. (c) Below the aortic arch are the main trunk of the pulmonary artery and its division into the right and left pulmonary arteries, which forms a typical Y-shaped structure (PA). The left and right internal thoracic artery and vein, which arise from the subclavian artery and drain into the subclavian vein, respectively, follow a parasternal path on the inner chest wall. 1, ascending aorta; 2, descending aorta; C, superior vena cava; E, esophagus; IT, internal thoracic artery; AV, azygos vein. (d) The ascending aorta (1) arises from the middle of the heart. The descending aorta (2) occupies a left anterolateral position relative to the spinal column. E, esophagus. (e) The inferior vena cava (IVC) is identified at this level. 2, descending aorta; E, esophagus. (f) The hemiazygos vein ascends in a left prevertebral path to approximately the level of the T7 vertebral body, where it empties into the azygos vein (AV). 2, descending aorta; E, esophagus; IVC, inferior vena cava.

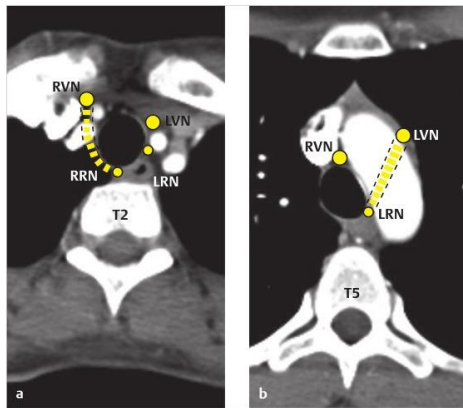


Fig. 1.4 The course of the vagus nerve and the recurrent laryngeal nerve. Axial scans demonstrate the course of the right vagus nerve (RVN) and left vagus nerve (LVN) and the right and left recurrent laryngeal nerve (RRN, LRN). The vagus nerve emerges from the skull base through the jugular foramen and runs behind the carotid artery in the carotid sheath. (a) The right recurrent laryngeal nerve leaves the vagus nerve at the level of the subclavian artery origin, loops around the vessel, and ascends to the larynx between the trachea and esophagus. (b) The left recurrent laryngeal nerve leaves the vagus nerve at the level of the aortic arch and runs below the aortic arch between the trachea and esophagus, where it ascends toward the head.

1.2 Evaluation of the Mediastinum on Conventional Radiographs

1.2.1 Silhouette Sign

When seen on conventional radiographs, soft tissues such as muscles, organs, and fluid are indistinguishable from one another in terms of their radiographic density. The radiographic phenomenon termed the silhouette sign may be helpful in determining the location of a mass.

- When organs of equal density border directly on one another, they form a composite silhouette of uniform density when viewed on a projection radiograph. This image resembles a paper cutout (the original “silhouette”) with one continuous outline and no internal gradations of shading or color (► Fig. 1.6).
- When two structures of equal density are located at different depths in the chest and are separated by a third structure of lower density, the two structures will appear sharply outlined relative to each other (► Fig. 1.7). They do not exhibit the silhouette sign.

1.2.2 Edge-on Effect

In conventional radiography, the edge-on effect describes the visualization of a very thin structure, such as the pleura, when

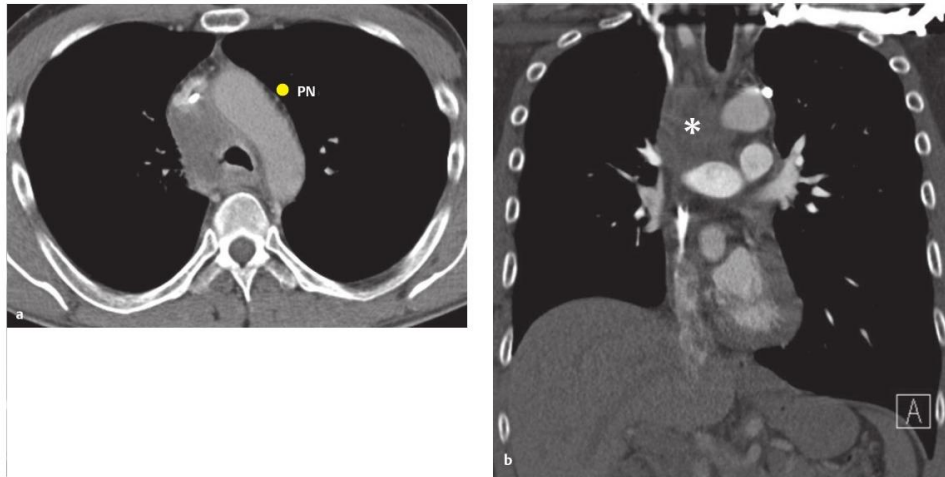


Fig. 1.5 Infiltration of the right phrenic nerve by a mediastinal metastasis (asterisk in [b]) has led to elevation of the diaphragm on the affected side. The location of the phrenic nerve (PN) is indicated in image (a). (a) Axial CT after IV injection of contrast medium. (b) Coronal reformatted image.

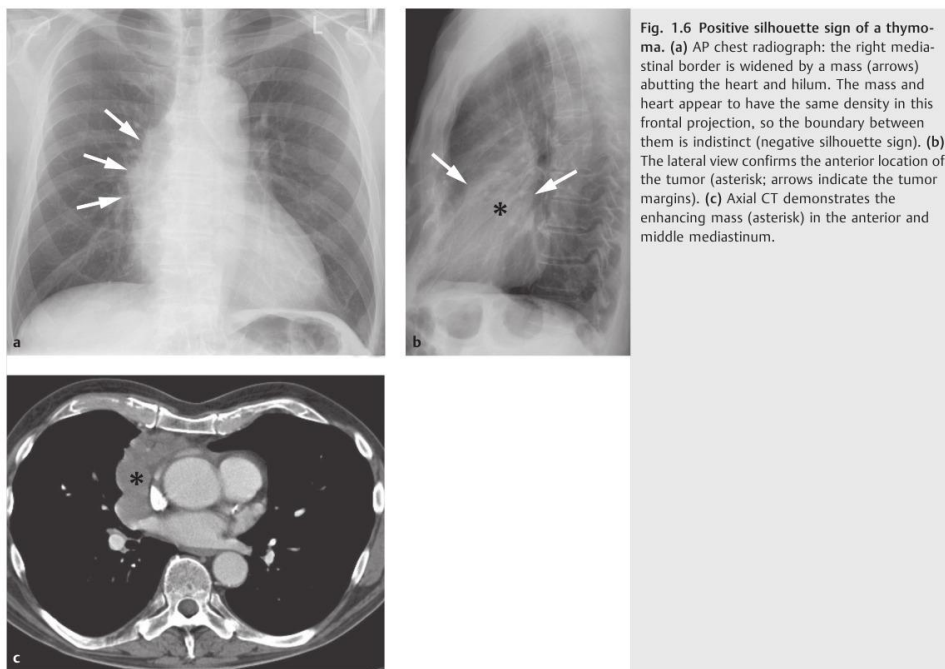


Fig. 1.6 Positive silhouette sign of a thymoma. (a) AP chest radiograph: the right mediastinal border is widened by a mass (arrows) abutting the heart and hilum. The mass and heart appear to have the same density in this frontal projection, so the boundary between them is indistinct (negative silhouette sign). (b) The lateral view confirms the anterior location of the tumor (asterisk; arrows indicate the tumor margins). (c) Axial CT demonstrates the enhancing mass (asterisk) in the anterior and middle mediastinum.

Mediastinum

1

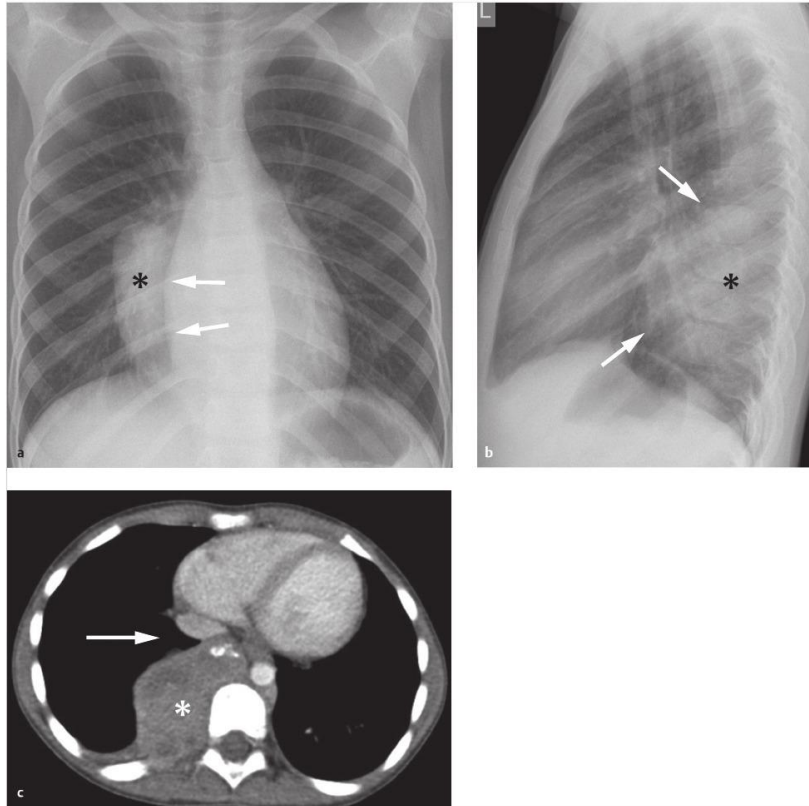


Fig. 1.7 Negative silhouette sign of neuroblastoma. (a) In the PA chest radiograph, a sharp line separates the cardiac border (arrows) from the mass (asterisk). This sign proves that a structure of different density—in this case aerated lung—is located between the cardiac border and mass and that both are in different planes. This radiographic sign is called a “negative silhouette sign”. (b) Lateral view: the tumor (asterisk; arrows indicate the tumor margins) is posterior to the heart and is not in direct contact with it. (c) Axial CT confirms the location of the mass (asterisk) in the posterior mediastinum. The arrow indicates lung tissue that is interposed between the heart and mass and is responsible for the positive silhouette sign.

several centimeters of that structure occupy a plane that is oriented “edge-on” relative to the detector. Another common example of this effect is the visualization of the pulmonary interlobar fissures in a lateral chest radiograph.

When the mediastinum is viewed in a PA chest radiograph, multiple lines can be seen due to the edge-on effect as well as the density difference between the soft tissues and lung. Lines visible in the anterior and middle mediastinum include the right paraesophageal line, the anterior pleural interface line, and the paracaval line (► Fig. 1.8). Lines visible in the posterior mediastinum include the paravertebral and para-aortic lines. The close proximity of masses or inflammatory processes may disrupt these lines (e.g., obliteration of the right paravertebral line [see ► Fig. 1.7]).

Note

It is important to realize that lines produced by an edge-on projection are visible in healthy subjects only if the structures in question are aligned in the plane of the detector. It is very rare for all the lines to be visualized in a healthy individual.

1.3 Diffuse Mediastinal Diseases**1.3.1 Acute Mediastinitis**

► **Brief definition.** Acute mediastinitis is a bacterial infection of the mediastinal fat and connective tissue that may be a mixed

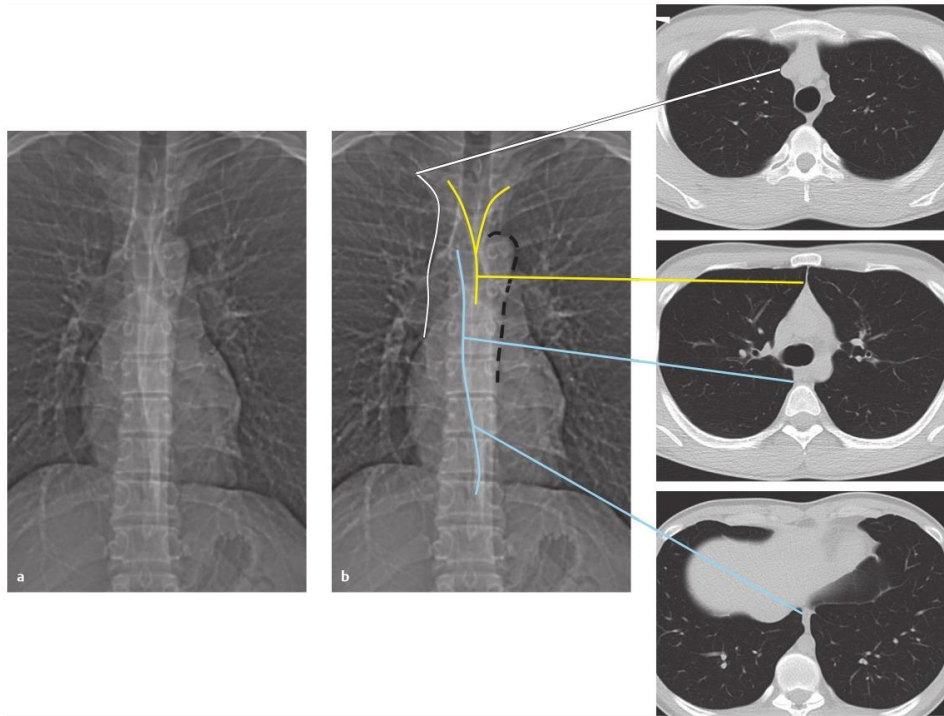


Fig. 1.8 Boundary lines in the anterior and middle mediastinum that are visible in the chest radiograph, with corresponding CT scans.

infection (type I) or may be caused by group A beta-hemolytic streptococci (type II). It may develop as a postoperative complication, after trauma including esophageal perforation, or in the form of descending necrotizing mediastinitis secondary to a deep soft tissue infection in the neck.¹ The majority of cases result from an esophageal perforation. The negative intrathoracic pressure generated by each inspiration promotes the contiguous spread of infectious organisms from the cervical soft tissues to the mediastinal connective tissue. This leads to a high tissue concentration of bacterial toxins, resulting in tissue necrosis. Predisposing factors are diabetes mellitus, obesity, and alcohol and nicotine abuse. If untreated, the necrotizing mediastinitis will lead to generalized sepsis and death. In recent decades the mortality rate of this disease has declined from 49% in the early 1900s to the current level of 11 to 15% as a result of prompt imaging evaluation combined with aggressive surgical and interventional therapy (excision of the necrotic tissue and drain insertion).²

► **Imaging signs**

• The chest radiograph shows widening of the mediastinum as a nonspecific sign. CT after IV administration of contrast medium is the modality of choice for confirming the diagnosis and planning treatment.

- Mediastinitis may present as a diffuse, suppurative inflammation of the mediastinal fat and connective tissue, or may lead to the formation of necrotic tracks and abscesses in the mediastinum. In diffuse mediastinitis, the mediastinal fat initially shows streaky infiltration followed later by homogeneous, diffusely increased density with positive attenuation values (► Fig. 1.9). Reactive lymphadenopathy is often present.
- If the mediastinitis results from an esophageal perforation, imaging may reveal small air inclusions or larger collections including mediastinal emphysema.
- Fluid collections are found in mediastinitis with abscess formation. Like abscesses elsewhere in the body, a mediastinal abscess may display an enhancing rim formed by inflammatory cells. This rim is not always initially defined in early acute cases, however, so the absence of enhancement in the tissue surrounding a fluid collection does not exclude mediastinitis.
- In very pronounced cases, mediastinitis may spread into the lung through the hila. This creates a streaky pattern of perihilar density.
- Mediastinal abscess may be complicated by perforation of the abscess into the esophagus or trachea.

► **Clinical features.** Acute mediastinitis presents as a highly acute, severe illness of sudden onset with rapid debilitation,