



The Mediastinal Visceral Space: The Central Pathway for the Spread of Mediastinal Disease

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Abstract

Keywords

- ▶ spread of disease
- ▶ mediastinal pathology
- ▶ compartments of the mediastinum
- ▶ perivisceral fascia

The connective tissue of the mediastinal visceral space extends from the neck through the chest and into the abdomen. This connective tissue encases the esophagus and tracheobronchial tree and is bounded by the perivisceral fascia. The continuous longitudinal and axial interconnection of the mediastinal visceral space accounts for commonly observed bidirectional pathways of disease through the chest. Disease patterns that seem counterintuitive when viewed through the lens of gross anatomy are more understandable in view of this knowledge. This article illustrates case examples of the spread of gas, fluid, fat and soft tissue mass through the mediastinal visceral space.

Introduction

Many methods have been used to classify images of the mediastinum for the diagnosis and management of disease.^{1–3} Initial classification systems were based on radiographic models, but a newer classification system with boundaries demonstrable by cross-sectional imaging has been developed by the International Thymic Malignancy Interest Research Group (ITMIG).⁴ The ITMIG system divides the mediastinum into prevascular, visceral, and paravertebral compartments, characterized by specific cross-sectional structures. Although one of the ITMIG compartments of the mediastinum is named the visceral compartment, the ITMIG visceral compartment does not specifically correspond to the mediastinal visceral space (MVS) surrounded by the perivisceral fascia as defined by Marchand.⁵ The ITMIG system is “designed to enable precise identification of mediastinal abnormalities at cross-sectional imaging by radiologists and consistent communication be-

tween health care providers.”⁴ It is not our intent to describe a competing cross-sectional imaging classification system, but rather to describe known and observable anatomic features that explain the pathway of spread of mediastinal disease.

While it is not unusual to see central mediastinal disease on cross-sectional imaging, factors influencing the spread of disease may not be immediately apparent. The spread of central mediastinal disease may appear random, in part because the underlying anatomic influences are subtle and often difficult to identify on modern cross-sectional imaging. The gross anatomy of the MVS and the surrounding perivisceral fascia that serve as the basic anatomic framework of the central mediastinum have been described.⁵ The thin perivisceral fascia is difficult to distinguish on chest computed tomography (CT), except for the thickened pretracheal fascia component. Radiologists reviewing chest CT are generally limited to observing the indirect effects of mediastinal disease spreading along the pathway of the MVS. A portion of

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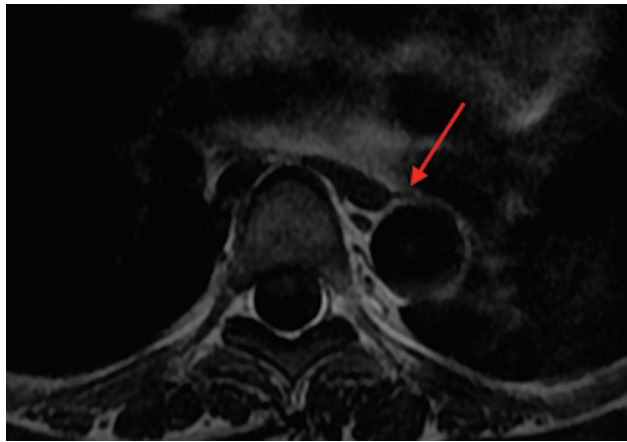


Fig. 1 Axial section of magnetic resonance imaging chest demonstrates aortoesophageal ligament (red arrow), a layer of connective tissue between esophagus and aorta.

the mediastinal visceral fascia, the aortoesophageal ligament, which courses from the anterior aspect of the aorta to the left lateral aspect of the esophagus, has been identified at magnetic resonance imaging (MRI)⁶ (→ Fig. 1).

The embryology of the perivisceral fascia and MVS is not well described. However, the formation of the mediastinum is understood.⁷ The splanchnic mesoderm unfolds from the midline and forms the primitive mesentery, suspending and containing the primitive gut. The primitive gut divides the primitive mesentery into dorsal and ventral mesenteries (→ Fig. 2). The subserous space is a continuous space made up of the splanchnic mesoderm and somatic mesoderm. This mesoderm evolves into connective tissue.^{8,9}

At approximately 4 weeks, a diverticulum forms from the ventral wall of the primitive foregut just caudal to the last pharyngeal pouch. This respiratory diverticulum remains connected by the subserosal splanchnic mesoderm to the primitive foregut. The ventral portion of the foregut will develop into the trachea, bronchi, and alveoli, while the dorsal portion will develop into the esophagus^{10,11} (→ Fig. 3).

The subserous splanchnic mesoderm connects the respiratory diverticulum to the esophagus and also extends continuously along the length of the gut and around the developing respiratory diverticulum into the lung anlage. The subserous splanchnic mesoderm remains continuous around the developing esophagus and the tracheobronchial tree (→ Fig. 4). It is separated by the mediastinal visceral fascia from the remaining mediastinum, thus forming the MVS. The continuity of the subserosal splanchnic mesoderm within the MVS forms the pathway for spread of mediastinal pathology.^{1,7}

Anatomy

The fascia surrounding the esophagus, tracheobronchial tree, and its extension define the pathway of the MVS. Marchand demonstrated the MVS by injecting radiopaque fluid beneath the fascia of the visceral compartment and analyzing radiographs with correlation to dissections.¹

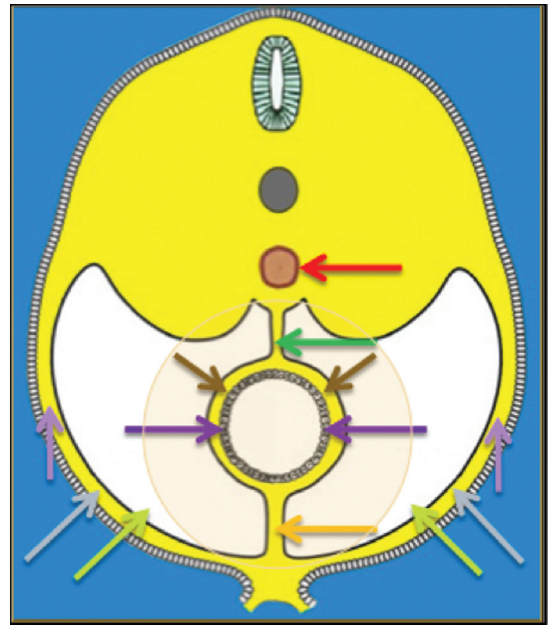


Fig. 2 Diagram transverse through 4-week embryo (inset focuses on splanchnic mesoderm) demonstrates serous membrane (gray arrows) outlining the coelomic cavity (light green arrows) and primitive mesentery. Splanchnic mesoderm (brown arrows) has unfolded from the midline and formed the primitive mesentery, suspending and containing the primitive gut (purple arrows). The primitive gut (purple arrows) divides the primitive mesentery into dorsal (green arrow) and ventral (orange arrow) mesenteries. The subserous space (yellow) is a continuous space made up of the splanchnic mesoderm (brown arrows) and somatic mesoderm (light purple arrows).

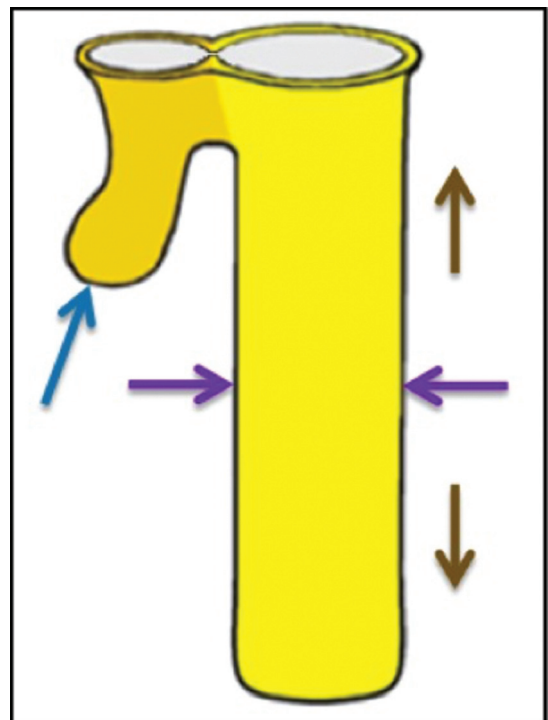


Fig. 3 Lung bud formation: continuity of the subserous splanchnic mesoderm. The subserous splanchnic mesoderm connects the respiratory diverticulum (blue arrow) to the esophagus (purple arrows) and also extends continuously along the length of the gut (brown arrows).

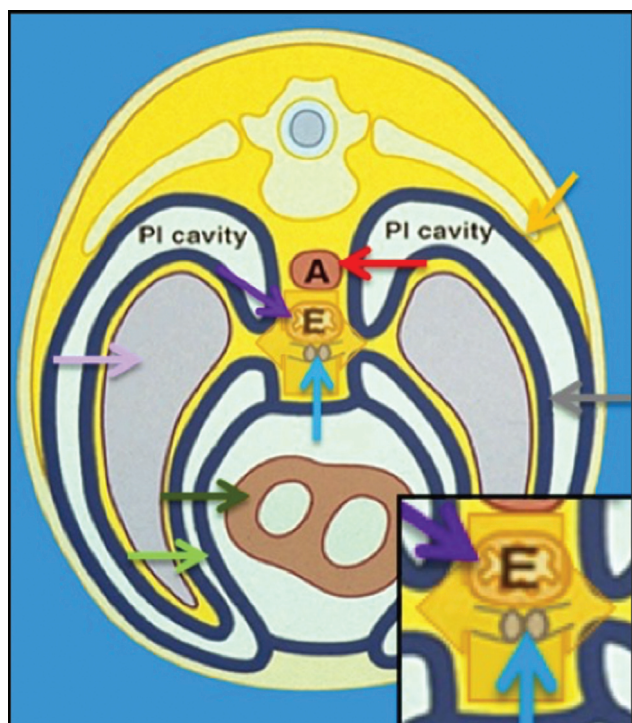


Fig. 4 Continuing differentiation of subserous mesoderm (inset focuses on splanchnic mesoderm). The subserous splanchnic mesoderm (tan shaded area) remains continuous around the developing esophagus and the respiratory system as both develop into their adult forms. Key: Aorta—red arrow, esophagus—purple arrow, carina—blue arrow, subserous splanchnic mesoderm—tan shaded area, future lung anlage—light purple arrow, parietal pleura—orange arrow, visceral pleura—light gray arrow, pericardium—light green arrow, heart—dark green arrow.

The perivisceral fascia defining the visceral space of the neck continues into the thorax as the perivisceral surrounding the trachea and esophagus. This continuity of the visceral space of the neck with the MVS forms the cervicothoracic continuum.¹² The pretracheal fascia courses downward from the thyroid gland anterior to the trachea and into the thorax, blending with the fascia surrounding the aorta and pericardium.¹ Posteriorly the visceral fascia fuses with prevertebral fascia. Anteriorly, below the carina, the perivisceral fascia fuses with the parietal pericardium. The perivisceral fascia continues laterally investing the left and right main bronchi and continues into the lungs surrounding the bronchi. Marchand describes the extension to the fourth bronchial division. This fascia contains the bronchial arteries and lymphatics.⁵ Thus, the MVS extends laterally from the mediastinum into the lungs.

Beneath the carina, the perivisceral fascia surrounds the periesophageal space and continues to the esophageal hiatus. The thoracoabdominal continuum is a continuation of the MVS deep to the periesophageal fascia as it passes through the esophageal hiatus to the gastrohepatic ligament into the abdomen.¹³

Pathology

The gossamer-thin structure of the mediastinal visceral fascia makes it very difficult to observe directly by current

imaging. This fascia is observed indirectly when it contains disease within the mediastinal visceral compartment. A disease process, whether it is gas, fluid, lipid, or soft tissue can be confined by the mediastinal visceral fascia, and its spread directed along the MVS pathway. The different imaging characteristics of these abnormal contents allow for the differential diagnosis of the disease process.

Pathologies that manifest as the spread of gas between the mediastinum and neck and abdomen include¹⁴

1. Loss of oral cavity or pharyngeal mucosal integrity including foreign body, trauma, and iatrogenic procedures.
2. Excessive coughing, sneezing, vomiting, and nose blowing.
3. Trauma to any of the air-containing structures such as paranasal sinuses or tracheal rupture.
4. Soft-tissue infections
5. Esophageal perforation
6. Hollow visceral perforation
7. Emphysematous infections in the abdomen
8. Residual air from retroperitoneal surgery

The pursuit by the radiologist in the searching for the underlying etiology of pneumomediastinum is complex since gas can enter any site in the MVS, as well as the neck and abdomen.¹⁴ The continuity of the MVS allows for the bidirectional spread of disease. An example of gas in the MVS is pulmonary interstitial emphysema from any etiology dissecting along the peribronchovascular space into the mediastinum, known as the Macklin effect¹⁵ (→ **Figs. 5 and 6**).

Pathologies that manifest as the spread of fluid between the mediastinum and neck and abdomen include

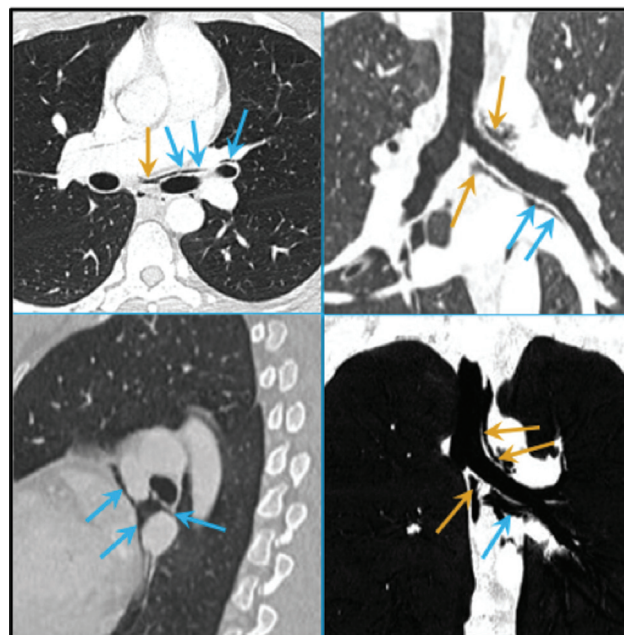


Fig. 5 A 22-year-old female with asthma and atypical pneumonia. Axial (top left), coronal (top right), sagittal (bottom left), and coronal MinIP (bottom right) chest computed tomographic images show peribronchovascular gas (blue arrows) dissecting along visceral space continuously from lungs to mediastinum (gold arrows). Esophagus is nondistended and fluid-filled. No visible pneumothorax.

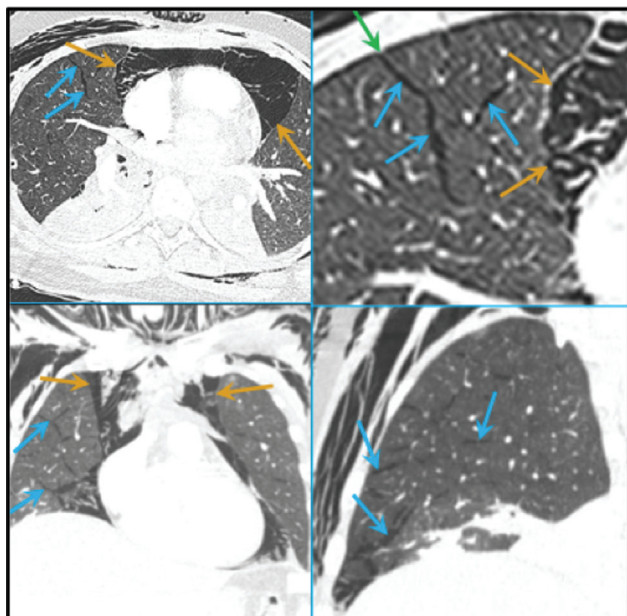


Fig. 6 A 28-year-old male patient with trauma. Axial (top left), cropped axial (top right), coronal (bottom left), and sagittal (bottom right) chest computed tomographic images show extensive pulmonary interstitial emphysema (blue arrows) dissecting along the peripheral peribronchial space. Trace right pneumothorax (green arrow). Note bulging mediastinal pleura (gold arrows), related to tension pneumomediastinum.

1. Spread of infection from deep neck or abdomen
2. Spread of fluid after esophageal perforation
3. Spread of hemorrhage

Fluid from any source can enter the MVS and spread bidirectionally. Below the carina the MVS continues as the periesophageal visceral space. Positive contrast material is often used in suspected esophageal perforation to demonstrate the pathway of disease spread in the MVS (►Fig. 7). Similarly, the MVS also can serve as a conduit for infection (►Figs. 8–10) and mediastinal hematoma (►Fig. 11).

Pathologies that manifest as the spread of soft tissue and fat between the mediastinum and neck and abdomen include

1. Fat lesions, for example lipoma
2. Soft tissues, for example thyroid mass and cysts
3. Metastatic tumor from the neck

Materials vary in their accommodation to the constraints of the MVS. As the MVS extends along the distal trachea, the space narrows. While gas can easily pass through this area, more viscous material, like a fluid-containing cyst, can be restricted (►Fig. 12).

Fatty lesions like a lipoma can outline the MVS, paralleling the tracheobronchial tree and esophagus. If a mediastinal lipoma develops, it can displace the tracheobronchial tree and esophagus. The lipoma contrasts with the soft tissue attenuation of the other mediastinal structures to highlight the MVS⁷ (►Fig. 13). The tracheobronchial tree and esophagus are pliable and a lipoma or soft tissue mass can deform them. However, the tracheoesophageal septum or aorto-esophageal ligament can serve as an axial barrier to disease

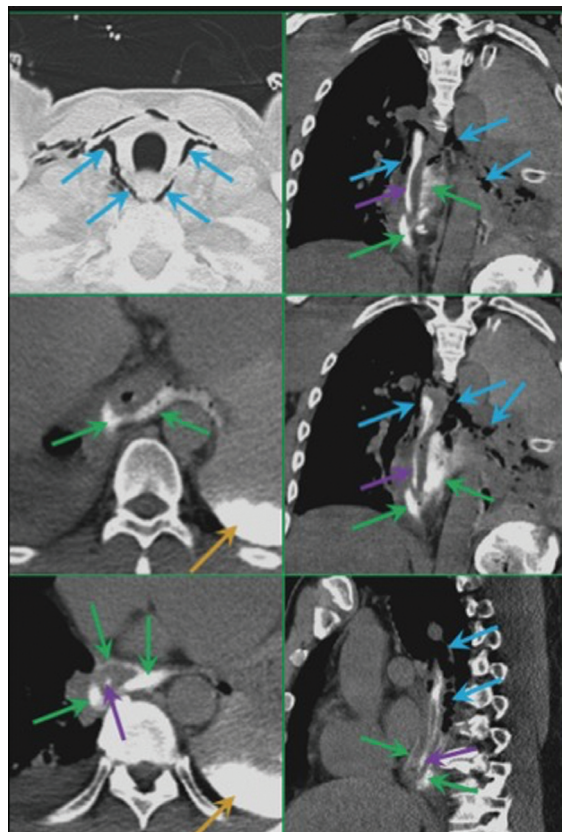


Fig. 7 A 54-year-old male patient with distal esophageal perforation. Axial neck (top left), axial chest (middle and bottom left), coronal chest (top and middle right), and sagittal (bottom right) images show gas (blue arrows) in the cervical and mediastinal visceral space. Contrast material occupies the periesophageal visceral space (green arrows) and dissects into the pleural space (orange arrow). Contrast material is also visible in the esophageal lumen (purple arrow).

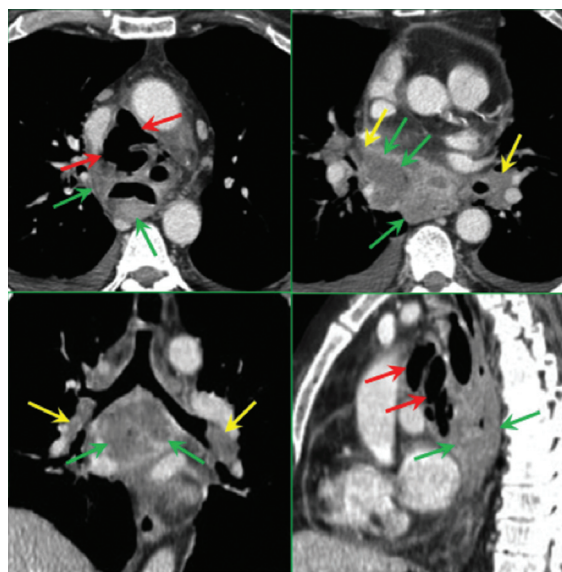


Fig. 8 A 64-year-old male patient with mediastinal abscess related to ruptured esophagus. Axial (top left and right), coronal (bottom left), and sagittal (bottom right) computed tomographic images show a mediastinal abscess, containing fluid (green arrows) and gas (red arrows) within the central mediastinal visceral space. Inflammatory changes extend along the peribronchial space (yellow arrows).

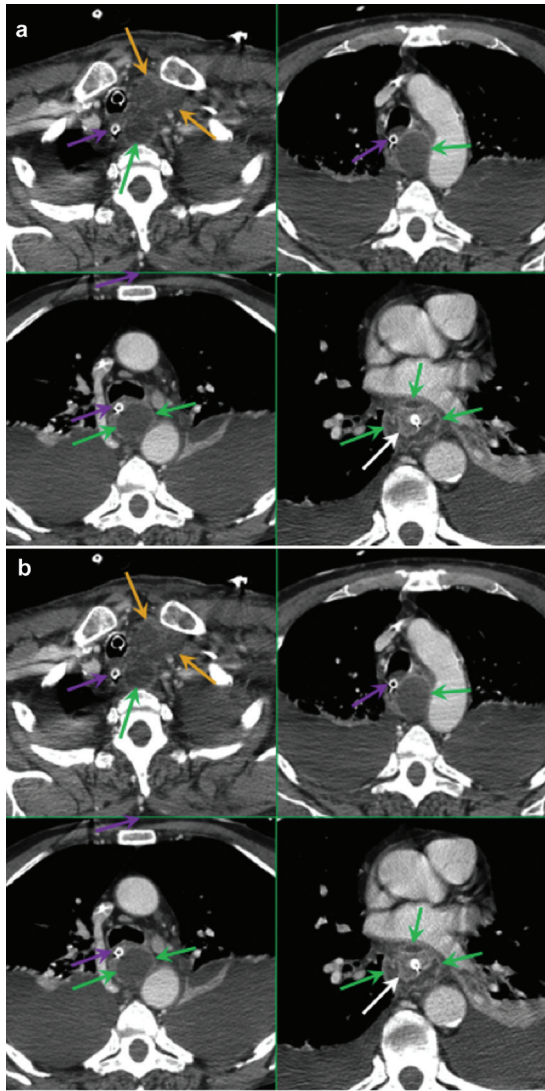


Fig. 9 A 65-year-old male patient with a history of alcohol abuse and pancreatitis of 1 month duration. (A) Axial section of computed tomography (CT) abdomen demonstrates pancreatitis with pseudocysts (red arrow). (B) Follow-up axial chest CT images show extension of mediastinal pseudocyst (green arrows) along enhancing esophagus (white arrow) within mediastinal visceral space. Pseudocyst extends into neck (gold arrows). Gastric tube is visible within esophagus (purple arrows).

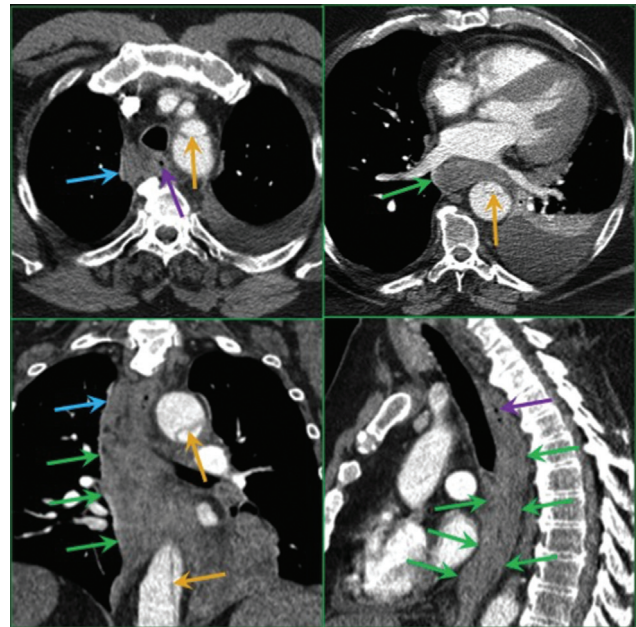


Fig. 11 A 44-year-old male patient with aortic dissection. Axial (top left and right), coronal (bottom left), and sagittal (bottom right) computed tomographic images show aortic dissection (orange arrows) with aortic rupture into the mediastinal visceral space. Hematoma (green arrows) infiltrates the fat in the mediastinal visceral space. Gas is present in the esophageal lumen (purple arrows). The hematoma within the mediastinal visceral space extends above the level of the aortic arch to the opposite side of the esophagus from the aorta (blue arrows).

spread within the MVS, directing its extension along a longitudinal pathway.² Solid masses such as mediastinal goiter and metastatic tumor can follow the pathway of the MVS from the neck to the mediastinum (► **Figs. 14** and **15**).

Concepts from Surgeon’s Perspective

Radiologists should understand the mediastinal anatomy that dictates surgical approaches and establishes the basis for the spread of disease. Surgeons conform with this anatomic approach for dissection and surgical drainage. For example, in mediastinoscopy the mediastinoscope is inserted beneath the pretracheal fascia into the pretracheal

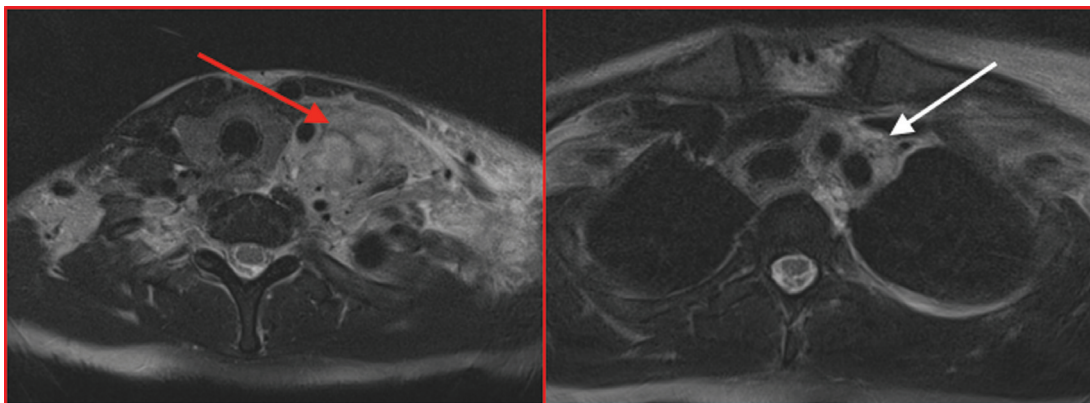


Fig. 10 A 52-year-old female patient with neck abscess extending into mediastinum. Axial magnetic resonance imaging T2-weighted images of neck at the level of thyroid shows multiloculated abscess within the left lower neck (red arrow) that is extending into the superior mediastinum (white arrow).

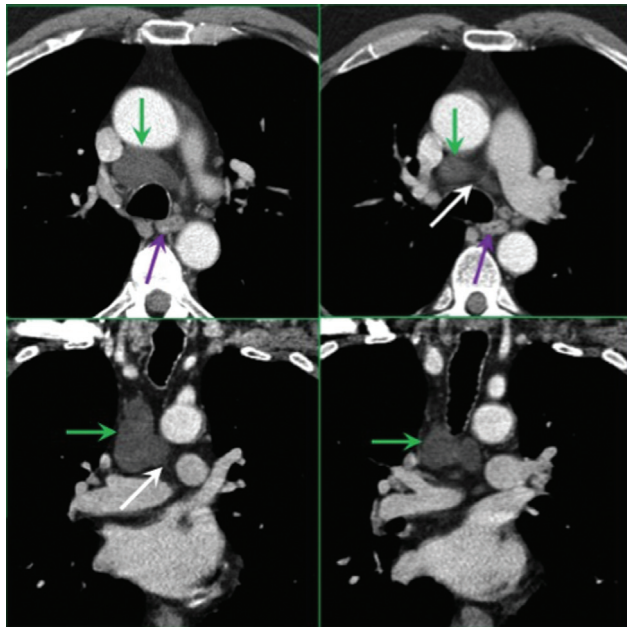


Fig. 12 A 70-year-old male patient with bronchogenic cyst. Axial chest computed tomographic (CT) images (top left and right) and coronal CT images (bottom left and right) show extension of bronchogenic cyst (green arrows) along the right lower mediastinal visceral space and anterior to the carina. The lower mediastinal visceral space narrows at this point (white arrows) and deforms the soft bronchogenic cyst, esophagus (purple arrow).

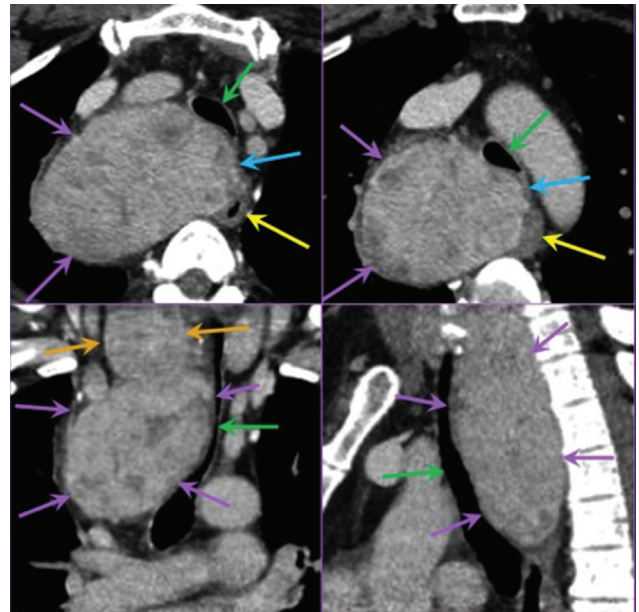


Fig. 14 A 51-year-old male patient with shortness of breath. Axial (upper left and right), coronal (lower left), and sagittal (lower right) contrast-enhanced chest computed tomographic images. Goiter (purple arrows) originating from right lobe of thyroid gland (gold arrows) extends from neck along right mediastinal visceral space. Mediastinal goiter deforms and displaces trachea (green arrows) and esophagus (yellow arrows), while paralleling right tracheoesophageal groove. Tracheoesophageal septum (blue arrows) bars extension of mass from right mediastinal visceral space to left.

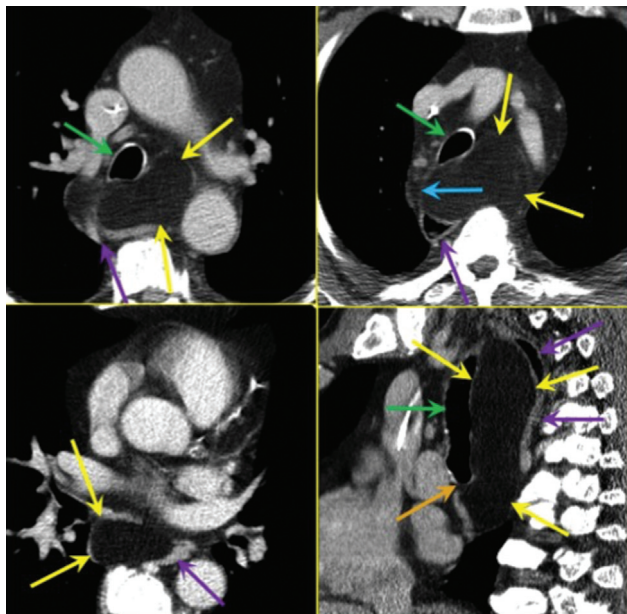


Fig. 13 A 69-year-old male patient with mediastinal lipoma. Axial (upper left and right, lower left) and sagittal (lower right) contrast-enhanced chest computed tomographic images show lipoma (yellow arrows) extending along the left mediastinal visceral space, displacing the trachea (green arrows) and esophagus (purple arrows). Lipoma bows tracheoesophageal septum (blue arrow) rightward and deforms the trachea and esophagus. Lipoma continues inferiorly below carina (gold arrow). Below the level of the tracheoesophageal septum the lipoma extends to the right of the esophagus, bowing the esophagus to left.

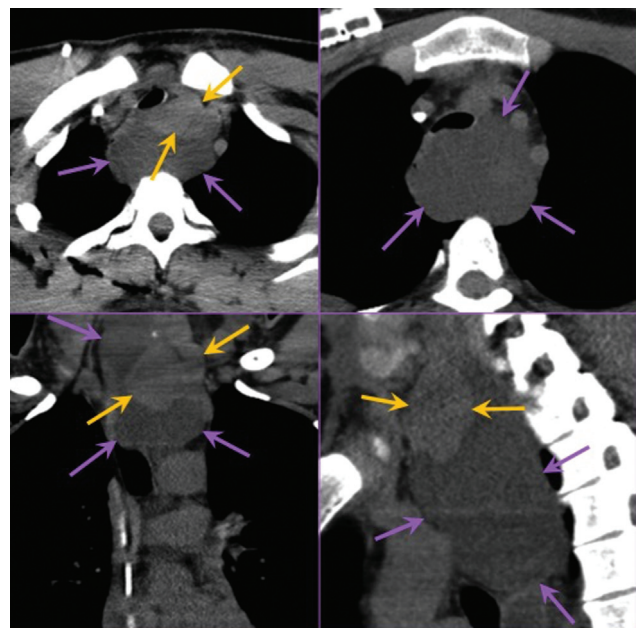


Fig. 15 A 22-year-old male patient with neck sarcoma growing within the cervical visceral compartment to the upper mediastinal visceral space (MVS). Axial (upper left and right), coronal (lower left), and sagittal (lower right) unenhanced chest computed tomographic images. Partially necrotic mass (purple arrows) extends across the cervicothoracic continuum from the neck into the upper MVS. More solid component is present (gold arrows) within the tumor.

space, allowing access to a substantial portion of the MVS. During esophagectomy, surgical dissection follows the planes of the perivisceral fascia. After surgery on structures within the MVS, drains are placed along the MVS to prevent fluid collections. Radiologists should inform surgeons of accumulating postoperative fluid collections that do not communicate freely with the natural drainage pathway of the MVS.

Conclusion

The MVS extends continuously from the neck through the central portion of the mediastinum into the lungs and the abdomen. The connective tissue surrounding the esophagus and tracheobronchial tree is bounded by the perivisceral fascia to form the MVS. This space forms a potential pathway for the bidirectional spread of disease. Disease patterns that seem counterintuitive are understandable in view of this knowledge.

Conflict of Interest

None of the authors have any potential conflict of interest to disclose.

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