Imaging of the Anterior/ Prevascular Mediastinum

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KEYWORDS

• Prevascular mediastinum • Thymic hyperplasia • Thymic cyst • Thymic epithelial neoplasm • Thymoma • Thymic carcinoid • Germ cell neoplasm

KEY POINTS

- Various neoplastic and non-neoplastic entities may affect the prevascular mediastinum.
- Most prevascular mediastinal masses are discovered incidentally and are characterized further with contrast-enhanced chest computed tomography.
- Correlation of specific imaging features with demographic and clinical information may allow radiologists to provide a focused differential or a specific diagnosis.
- By distinguishing surgical from nonsurgical lesions, radiologists play a crucial role in the multidisciplinary approach to the management of prevascular mediastinal pathologies.

INTRODUCTION

The mediastinum contains many organs, structures, and tissues. A wide variety of entities may arise primarily from these structures or secondarily involve this region, including neoplasms, glandular enlargement, congenital and vascular abnormalities, lymphadenopathy, and mesenchymal lesions. Localization of mediastinal masses to specific compartments, together with demographic and clinical information, allows formulation of a focused differential diagnosis and helps guide further evaluation and management. Anterior, middle, and posterior mediastinal compartments have been used for decades in radiographic interpretation.[1] The International Thymic Malignancy Interest Group recently redefined the mediastinal compartments based on cross-sectional imaging, separating the mediastinum into prevascular, visceral, and paravertebral compartments. Contents of the prevascular compartment include the thymus, fat, lymph nodes, left brachiocephalic vein, small vessels, nerves, and lymphatic channels. The most common pathologies that occur in this compartment include thymic lesions, germ cell neoplasms (GCNs), lymphoma, lymphatic malformations, metastatic disease, and glandular lesions.[2]

Mediastinal masses are uncommon. They typically are discovered on radiography and are characterized further with computed tomography (CT) and/or MR imaging. More than half of all mediastinal masses arise from the prevascular compartment.[3] When classic imaging features are present, a specific diagnosis may be suggested based solely on CT imaging features. The appearances of prevascular mediastinal lesions may overlap, however, and additional imaging studies, laboratory tests, and tissue sampling often are required for a definitive diagnosis.

The true incidence of prevascular mediastinal masses is difficult to determine largely due to historical variability in clinical and radiologic classification systems of mediastinal compartments in published studies, which may or may not include congenital and nonsurgical lesions and due to variability regarding the inclusion of lymphoma.[4] The most common tumors of the prevascular mediastinum are thymic epithelial neoplasms and lymphoma. Other neoplasms include neuroendocrine tumors, GCNs, and a variety of thymic neoplasms. The most common non-neoplastic masses are

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cystic lesions, which may be congenital or acquired. Vascular abnormalities, lymphatic malformations, mediastinal thyroid and parathyroid tissue, and thymic enlargement also may occur.

IMAGING OF THE PREVASCULAR MEDIASTINUM

Radiography

Chest radiography is the imaging study performed most commonly and often is the first imaging modality to demonstrate a mediastinal abnormality. A systematic approach to radiographic analysis and knowledge of normal mediastinal lines, stripes, and interfaces allow radiologists to identify and localize mediastinal lesions. Although small mediastinal lesions may produce normal or subtle findings, large lesions typically produce contour abnormalities or distortion of the aforementioned lines, stripes, and interfaces on posteroanterior (PA) radiography (**Fig. 1**). The lateral radiograph then is used to localize the lesion to the anterior mediastinum. Identification of the hilum overlay sign allows differentiation of an anterior mediastinal lesion from a hilar mass.[1]

Computed Tomography

Contrast-enhanced CT is the modality of choice for evaluating mediastinal masses and is equal to or superior to MR imaging in diagnosing most lesions, with the exception of thymic cysts.[5] CT analysis of a prevascular mediastinal lesion should be systematic and should address multiple characteristics, including (1) location, size, morphology, and margins; (2) density/attenuation and enhancement characteristics; (3) internal composition, including soft tissue, fat, fluid, and calcification; (4) relationship with adjacent structures, including mass effect and/or invasion; and (5) presence or absence of lymphadenopathy.[4]

MR Imaging

MR imaging is not performed routinely for the assessment of mediastinal masses but is the optimal imaging modality for distinguishing cystic from solid lesions, identifying cystic and/or necrotic lesion components, characterizing cystic lesions as to the presence of septations and mural nodularity, and distinguishing normal or hyperplastic thymic tissue from neoplasia.[6]

Fluorodeoxyglucose PET/Computed Tomography

^{18}F-fluorodeoxyglucose (FDG) PET/CT has a limited role in the evaluation of mediastinal masses and often is nonspecific given that many infectious and inflammatory processes result in increased FDG uptake, which can be mistaken for malignancy. Although FDG PET/CT has been used to distinguish between low-grade thymoma, high-grade thymoma, and thymic carcinoma,[7,8] there is significant overlap between FDG-avid neoplasms, including high-grade thymic epithelial neoplasms, lymphoma, paraganglioma, and nonseminomatous malignant GCNs.[9] FDG PET/CT, however, is the imaging modality of choice for staging and restaging lymphoma. The overall consensus suggests that FDG PET/CT may have an ancillary role in the diagnostic workup of prevascular mediastinal masses, but accuracy and

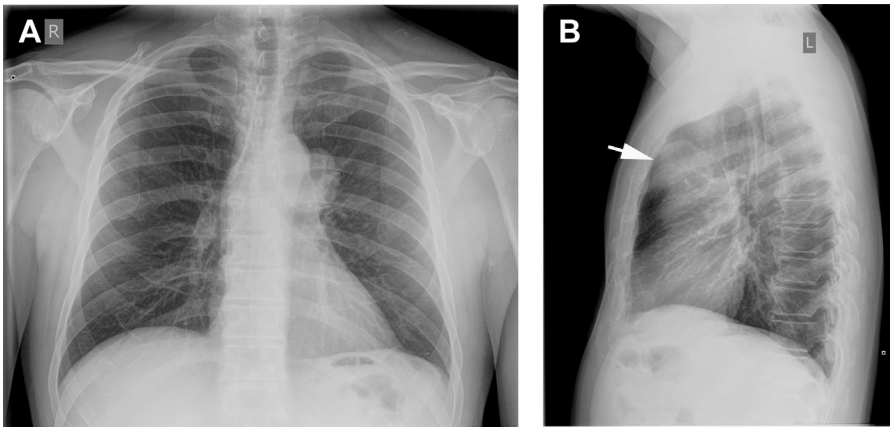

Fig. 1. Anterior mediastinal mass. (*A*) PA chest radiograph shows a left mediastinal mass that demonstrates the hilum overlay sign. (*B*) Lateral chest radiograph allows localization of the mass to the anterior mediastinum (*arrow*). Thymoma subsequently was diagnosed.

specificity are limited, with significant overlap between different mediastinal pathologies.[9–11]

THYMIC HYPERPLASIA

Normal thymic tissue typically is identified in the prevascular mediastinum of young patients and gradually decreases with age, with fatty replacement usually complete by age 40. When uniform thymic enlargement with a bilobed morphology and intercalated fat is present, thymic hyperplasia is the leading consideration. Rebound hyperplasia is defined as an increase in thymic volume by greater than 50% compared with baseline and typically occurs after chemotherapy, radiation therapy, prolonged corticosteroid treatment, or after physiologic stress from severe injuries or burns. Thymic hyperplasia, specifically lymphoid (follicular) hyperplasia, is characterized by thymic lymphoid follicles with or without concurrent increase in glandular size. It typically occurs in patients with underlying systemic disorders, such as myasthenia gravis, collagen vascular disease, systemic lupus erythematosus, human immunodeficiency virus infection, and hyperthyroidism[12] (**Fig. 2**A).

Thymic hyperplasia may manifest on CT as a diffuse, focal, or asymmetric nodular or masslike heterogeneous soft tissue lesion with lobular margins and may mimic a mediastinal neoplasm. If suspicion for thymic hyperplasia is high, short-term interval follow-up CT can be obtained, with an expected decrease in size. Alternatively, chemical-shift MR imaging may be performed to confirm intralesional fat, an expected finding in thymic hyperplasia (**Fig. 2**B), or suggest the diagnosis of thymic neoplasia.[13]

THYMIC EPITHELIAL NEOPLASMS

Thymic epithelial neoplasms are rare and account for 0.2% to 1.5% of all malignancies in the United States, but are the most common nonlymphomatous primary neoplasm of the prevascular mediastinum.[14,15] These tumors include thymomas and thymic carcinomas. Complete resection when possible is the treatment of choice for these neoplasms. Neoadjuvant and/or adjuvant systemic therapy and radiation often are utilized for invasive lesions.[16,17]

Thymoma

Thymoma is the most common primary neoplasm of the prevascular mediastinum and is the most common thymic epithelial neoplasm, with a reported 0.15 cases per 100,000 persons, accounting for 20% of prevascular mediastinal masses in adults.[18,19] The highest incidence occurs in middle-aged patients, typically between 40 years and 60 years, without gender predilection.[12,20] These generally are slow-growing encapsulated neoplasms but may invade vascular structures and/or involve the pleura and pericardium. Distant metastases are rare.[14,21] Affected patients may be asymptomatic, may have symptoms related to mass effect or local invasion, or may present with a paraneoplastic syndrome. Such parathymic syndromes include myasthenia gravis, pure red cell aplasia/Diamond-Blackfan syndrome, aplastic

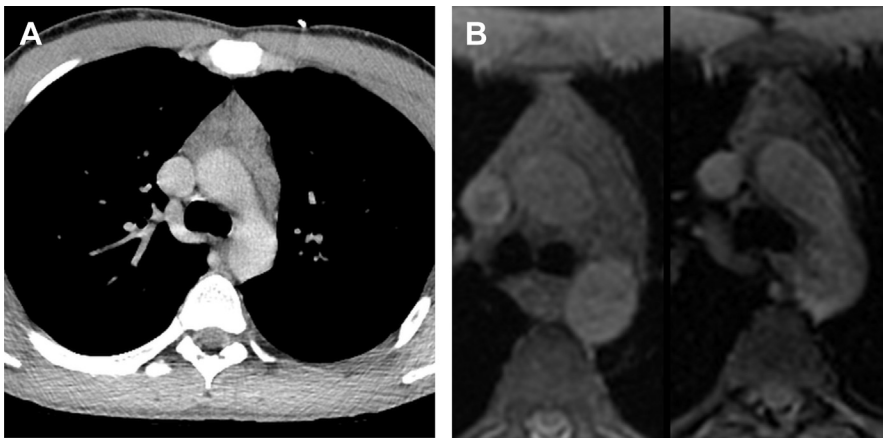

Fig. 2. Thymic hyperplasia secondary to Graves disease. (*A*) Contrast-enhanced axial CT shows diffuse thymic enlargement with soft tissue attenuation and intercalated fat. (*B*) Composite image of chemical-shift MR imaging shows in-phase homogeneous high signal intensity in the thymus (*left*) and signal drop on out-of-phase imaging (*right*), consistent with thymic hyperplasia. Follicular hyperplasia was suspected, given associated hyperthyroidism.

anemia, and hypogammaglobulinemia. Thymomas are also associated with autoimmune disorders such as Hashimoto's thyroiditis, systemic lupus erythematosus, polymyositis, and rheumatoid arthritis.[22–24] The most common symptoms reported at presentation are chest pain, dyspnea, cough, dysphagia, diaphragmatic paralysis, and superior vena cava (SVC) syndrome.

More than 80% of thymomas are diagnosed accurately on CT or MR imaging.[5] CT of suspected thymoma should be performed with contrast for more accurate identification of invasive features. Thymoma should be the leading diagnostic consideration when a homogeneous or slightly heterogeneous rounded or lobular prevascular mediastinal mass is present in a patient over the age of 40. A tissue plane between the mass and adjacent structures may be visible in encapsulated lesions (**Fig. 3**). Heterogeneity within the mass due to internal cystic or necrotic foci, irregular lobular contours, and intrinsic calcifications suggest invasive thymoma[25,26] (**Figs. 4** and **5**). Invasive lesions may exhibit infiltration of the mediastinal fat, vascular encasement or frank invasion, and/or pleural and pericardial metastases. Lymphadenopathy typically is absent. The presence of local invasion, lymphadenopathy, pleural effusion, or distant metastases should raise concern for more aggressive neoplasms, such as thymic carcinoma or carcinoid (**Fig. 6**).

Thymic Carcinoma

Thymic carcinomas are uncommon but represent approximately 20% of thymic epithelial neoplasms, and affected patients are often symptomatic. The mean age at presentation is 50 years.[14] Imaging features may be indistinguishable from those of thymoma, but thymic carcinoma typically exhibits aggressive features, such as invasion of adjacent structures, lymphadenopathy, pleural/pericardial effusions, and distant metastases (**Fig. 7**). Approximately 50% to 65% of patients have distant metastases at the time of diagnosis.[14] In contrast to thymoma, paraneoplastic syndromes rarely are associated with thymic carcinoma.

THYMIC NEUROENDOCRINE NEOPLASMS

Thymic neuroendocrine neoplasms are the least common primary thymic tumors, comprising 2% to 5% of these lesions, and most frequently are carcinoids, specifically atypical carcinoids.[27] The reported median age at presentation is 57 years, with a 3:1 male-to-female ratio.[28] Approximately 25% develop in patients with multiple endocrine neoplasia (MEN) type 1.[29] Most patients are symptomatic at diagnosis secondary to local invasion and mass effect and may present with paraneoplastic syndromes, most commonly Cushing syndrome, due to ectopic production of

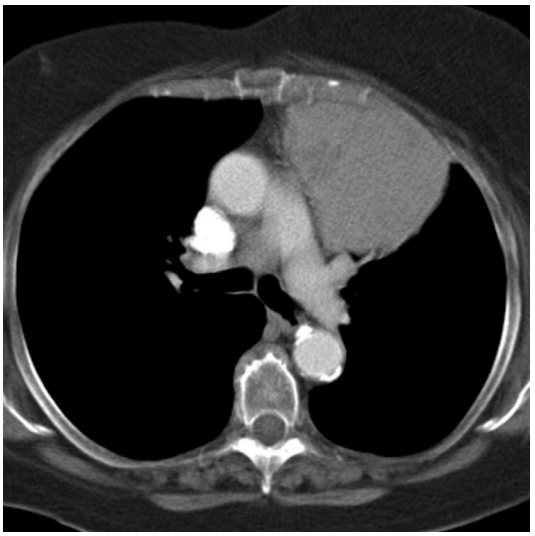

Fig. 3. Thymoma. Contrast-enhanced axial CT shows an enhancing left prevascular mass with a distinct tissue plane separating the mass from the adjacent pulmonary trunk. Surgical excision showed a thymoma with microscopic invasion of the adjacent mediastinal fat.

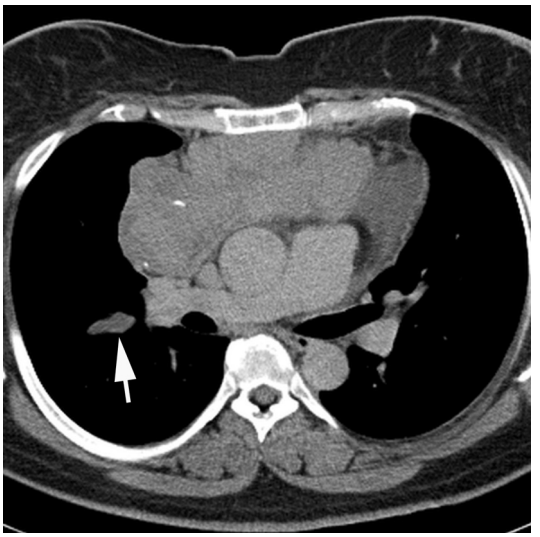

Fig. 4. Invasive thymoma. Contrast-enhanced axial CT shows a large, lobulated, heterogeneously enhancing, prevascular mediastinal mass with intrinsic calcification and absence of a tissue plane between it and the pericardium, concerning for invasion. Note right pleural metastasis along the major fissure (*arrow*).

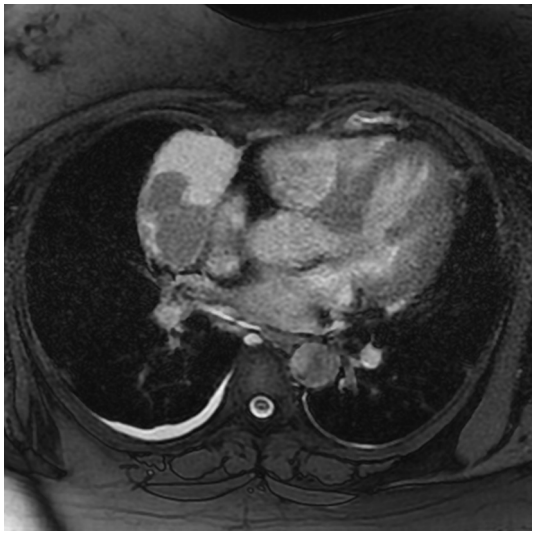

Fig. 5. Cystic thymoma. Axial T2-weighted MR image with fat suppression shows a large, right prevascular mediastinal cystic mass with T2 hyperintense signal corresponding to fluid in the lesion as well as eccentric soft tissue nodules.

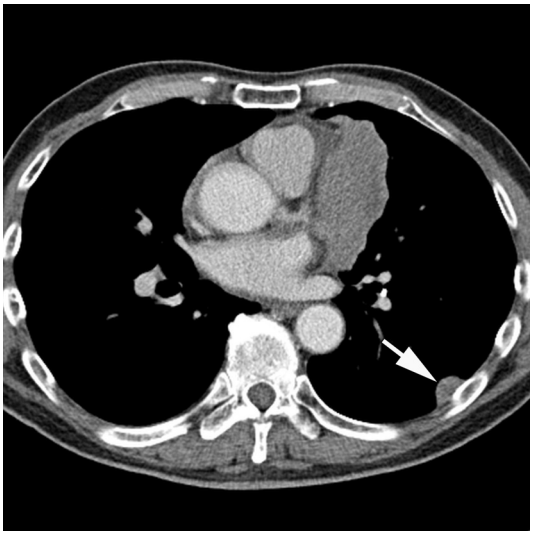

Fig. 6. Invasive thymoma. Contrast-enhanced axial CT shows a heterogeneously enhancing left prevascular mediastinal mass with pericardial invasion and a left pleural metastasis (*arrow*).

adrenocorticotropic hormone. Other paraneoplastic syndrome of inappropriate secretion of antidiuretic hormone (SIADH), and rarely carcinoid syndrome.[14] Approximately one-third of affected patients are asymptomatic and may be diagnosed incidentally or during surveillance for MEN 1.[27]

On imaging, these typically are aggressive, prevascular mediastinal soft tissue masses that may invade surrounding structures and often are associated with mediastinal lymphadenopathy[30] (**Fig. 8**). Surgical resection is the treatment of choice, with or without adjuvant or neoadjuvant systemic therapy and/or radiation therapy.

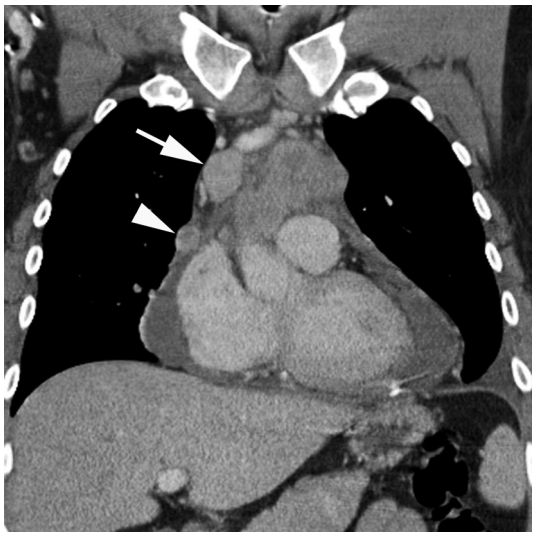

Fig. 7. Thymic carcinoma. Contrast-enhanced coronal CT shows a heterogeneously enhancing, necrotic prevascular mediastinal mass with lymphadenopathy (*arrow*), solid pericardial metastasis (*arrowhead*), and a pericardial effusion.

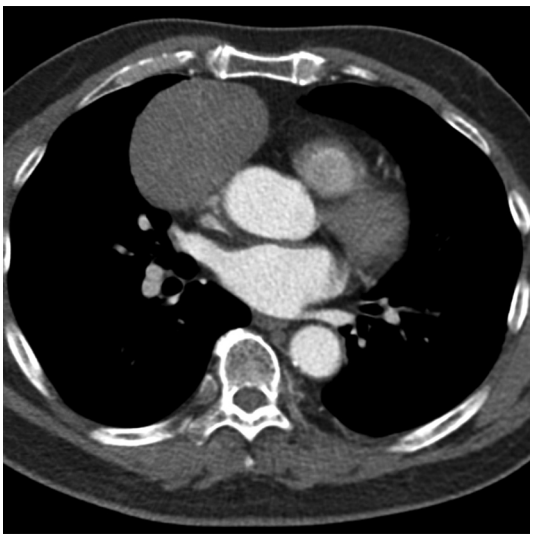

Fig. 8. Thymic carcinoid. Contrast-enhanced axial CT demonstrates a homogenous right prevascular mediastinal mass abutting the pericardium. Atypical carcinoid tumor was confirmed after surgery.

LYMPHOMA

Lymphomas are heterogeneous neoplasms with frequent intrathoracic involvement and account for 4.9% of newly diagnosed malignancies. Lymphoma may arise primarily in the mediastinum or secondarily may involve it. A diagnosis of lymphoma should be favored over thymoma in younger patients and in those with a mediastinal mass and associated lymphadenopathy. Primary mediastinal lymphomas are rare, comprising approximately 1% of all lymphomas.[31] Diagnosis of primary mediastinal lymphoma necessitates involvement of mediastinal lymph nodes, the thymus, or both, without evidence of extranodal or systemic disease at presentation. The most common cell types to primarily or secondarily involve the mediastinum are diffuse large B-cell lymphoma and Hodgkin lymphoma. Less common cell types include primary mediastinal (thymic) B-cell lymphoma, gray zone lymphoma (GZL), T-cell lymphoblastic lymphoma (TCLL), mucosa-associated lymphoid tissue (MALT) lymphoma, and peripheral T-cell lymphoma (PTCL).[31,32]

Lymphoma should be considered when large, lobular, soft tissue masses and/or enlarged lymph nodes are identified in the prevascular mediastinum, particularly if there is involvement of other mediastinal compartments and lymph node stations or infiltration between or encasement of vascular structures, with or without mass effect or local invasion (**Fig. 9**A). Systemic B symptoms, such as fever, night sweats, and weight loss, in combination with typical imaging features, are highly suggestive of the diagnosis. More aggressive subtypes, such as GZL and TCLL, often exhibit increased heterogeneity and invasion of adjacent structures.[31]

FDG PET/CT is the imaging modality of choice for initial staging and ongoing surveillance of patients with lymphoma. Studies have shown increased accuracy of FDG PET/CT in detecting lymph node involvement and identifying intranodal and extranodal disease throughout the body as compared with CT. FDG PET/CT may identify occult lesions in the spleen, gastrointestinal tract, and bones. FDG PET/CT also can be used to guide tissue sampling, with the goal of sampling the most FDG-avid foci and avoid necrotic or uninvolved tissue (**Fig. 9**B). Low-grade lymphomas, such as MALT lymphoma and PTCL, often demonstrate minimal to no FDG uptake on PET/CT.[33]

GERM CELL NEOPLASMS

GCNs are a heterogenous group of tumors that comprise 10% to 15% of adult prevascular mediastinal masses and are thought to originate from primitive germ cells aberrantly placed in the mediastinum during embryogenesis. The prevascular mediastinum is the most common extragonadal site for these tumors, which are histologically identical to their gonadal counterparts, and encompass teratomas, seminomas, and nonseminomatous malignant GCNs. GCNs may mimic other prevascular mediastinal masses, and demographic information, clinical history, and serology often help suggest the correct diagnosis.

Teratoma

Teratomas are the most common mediastinal GCNs and are composed of tissues derived from

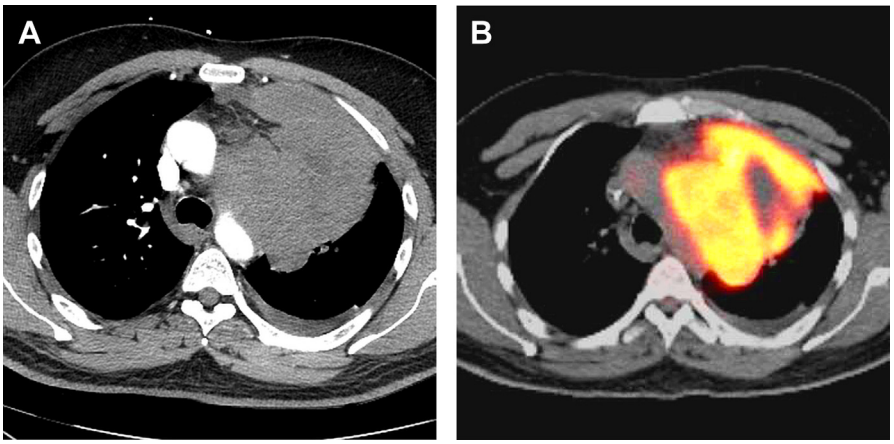

Fig. 9. Diffuse large B-cell lymphoma. (*A*) Contrast-enhanced axial CT shows a heterogeneously enhancing mass involving the left prevascular mediastinum extending into the visceral compartment and compressing and/or invading adjacent vessels and the left lung. (*B*) Fused axial FDG PET/CT shows extensive FDG avidity in the mass with low uptake foci representing necrosis.

more than 1 of the 3 primitive germ cell layers. These tumors can contain ectodermal (teeth, skin, and hair), mesodermal (cartilage and bone), and endodermal derivatives (bronchial, intestinal, and pancreatic tissue). A vast majority are mature teratomas and are histologically well differentiated and benign. Immature teratomas are rare variants that contain fetal tissue, are considered malignant, and carry a good prognosis when diagnosed in children but may recur locally or metastasize in adults. Rarely, teratomas may contain intrinsic foci of carcinoma, sarcoma, or malignant GCN, in which case they are referred to as *malignant teratoma* or *teratocarcinoma*.[34]

Mature teratomas represent 60% to 70% of mediastinal GCNs and typically affect children and young adults without gender predilection. Affected patients often are asymptomatic. Symptoms, when present, usually are due to large lesions that produce mass effect and compression of surrounding structures and include chest pain, dyspnea, cough, and dysphagia. If the tumors contain ectopic intestinal mucosal or exocrine pancreatic tissue, secreted enzymes may result in rupture into the tracheobronchial tree, pleura, pericardium, or lung. Expectoration of hair (trichoptysis) or sebum is rare but pathognomonic for ruptured mediastinal teratoma.[34,35]

On cross-sectional imaging, these tumors are unilateral well-defined encapsulated lesions with rounded or lobular margins and intrinsic heterogeneity, including cystic foci and solid components, that may include soft tissue and calcification. Many mature teratomas exhibit predominantly or entirely unilocular or multilocular thin-walled cystic morphology, with internal septations of variable thickness and contrast enhancement, in which case they may be referred to as *cystic teratomas*. Fat occurs in 75% of lesions and may be adipose tissue or lipid within a cystic component. Rarely, intrinsic bone or teeth may be visible on imaging. A combination of fluid, soft tissue, calcium, and/or fat attenuation in a well-defined prevascular mediastinal mass is highly specific for mature teratoma (**Fig. 10**). Intrinsic fat-fluid levels are rare but diagnostic findings. Surgical resection is curative.[35]

Seminoma

Seminomas represent approximately 40% of malignant GCNs of a single histology and occur almost exclusively in young men between the ages of 20 years to 40 years. Although some patients are asymptomatic, most have symptoms related to large tumor size resulting in compression of adjacent structures.

On cross-sectional imaging, these tumors usually manifest as a large, prevascular, mediastinal homogenous or slightly heterogeneous mass with lobulated contours that may involve other compartments or exhibit associated lymphadenopathy and thus mimic lymphoma. Invasion of adjacent structures and obliteration of intervening tissue planes may occur. Calcification is exceedingly rare. Metastases to regional lymph nodes and distant sites (in particular, osseous metastases) occasionally occur[20,34] (**Fig. 11**).

Curative therapy may consist of a combination of adjuvant or neoadjuvant chemotherapy, chemoradiation, and surgical resection, with excellent long-term survival.[12,34,36]

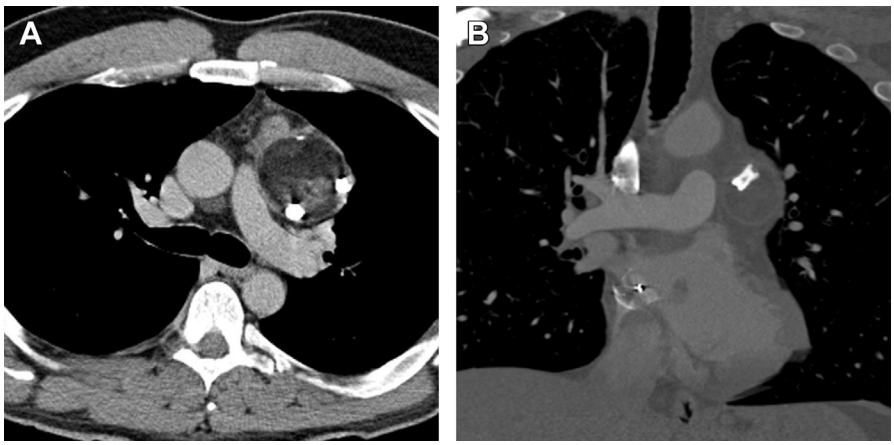

Fig. 10. Mature teratoma. (*A*) Contrast-enhanced axial CT shows a well-defined left prevascular mediastinal mass with intrinsic fat, soft tissue, and densely calcified/ossified components. (*B*) Contrast-enhanced coronal CT (bone window) shows a calcified structure within the mass that represented a well-formed tooth.

Nonseminomatous Malignant Germ Cell Neoplasm

Nonseminomatous malignant germ cell neoplasms (NSGCNs) include embryonal carcinoma, yolk-sac (endodermal sinus) tumor, choriocarcinoma, mixed germ cell tumors composed of multiple histologic types, and immature and malignant teratomas. NSGCNs almost exclusively affect young adult men, with a mean age of 30 years at presentation. Affected patients have an increased risk for developing hematologic malignancies, and approximately 20% have Klinefelter syndrome.[37–39] Patients typically are symptomatic at presentation due to compression or invasion of mediastinal structures, and the severity of symptoms correlates with tumor size. On serology, elevated α-fetoprotein and β-human chorionic gonadotropin hormone levels occur in more than 50% of patients.[40] Serum lactate dehydrogenase is elevated in more than 50% of patients and tends to correlate with tumor burden rather than tumor histology.

On cross-sectional imaging, these tumors usually manifest as large, well-circumscribed or poorly-defined prevascular mediastinal masses, with extensive intrinsic heterogeneity due to necrosis, hemorrhage, and cystic change, with peripheral enhancing frondlike soft tissue.[34] These lesions frequently affect both sides of midline, with obliteration of tissue planes, and mass effect and/or invasion of adjacent structures. Pleural and pericardial metastases are common. Regional lymph node and distal metastases also occur[20,34,41–44] (**Fig. 12**).

NSGCNs tend to respond well to systemic chemotherapy, which usually is followed by surgical resection.[40] Serum biomarkers are helpful for ongoing disease surveillance. Affected patients have an average 5-year survival rate of 50%.[20] Patients with mediastinal NSGCNs have a poorer prognosis that those with primary gonadal tumors of the same histology.[12,36,45]

CYSTS

Thymic Cyst

Thymic cysts are rare, represent approximately 3% of all prevascular mediastinal masses, and may be congenital or acquired.[34,46–48] Congenital thymic cysts may be found anywhere along the embryologic course of the thymus as it descends from the neck into the prevascular mediastinum. Approximately 50% of congenital thymic cysts are discovered incidentally in the first 2 decades of life. Acquired thymic cysts usually are postinflammatory and may be associated with mediastinal malignancy, surgery, chemotherapy, radiation therapy, or trauma.[46–48]

Congenital thymic cysts typically are smaller than 6 cm, spherical, unilocular, and thin-walled. Acquired cysts may range in size from

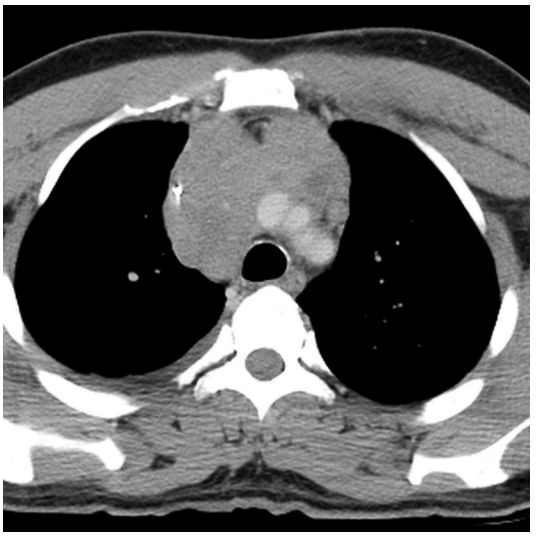

Fig. 11. Seminoma. Contrast-enhanced axial CT shows a locally invasive, relatively homogeneous prevascular mediastinal soft tissue mass that extends into the visceral mediastinum and obliterates the brachiocephalic veins and upper superior vena cava.

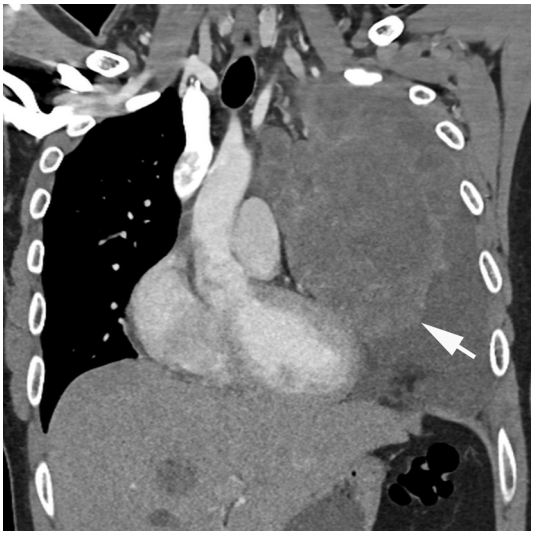

Fig. 12. Nonseminomatous malignant GCN. Contrast-enhanced coronal CT shows a heterogeneous, left prevascular mediastinal mass with predominantly central low attenuation corresponding to necrosis, and frondlike peripheral enhancement (*arrow*). Note mass effect on the mediastinum, left pleural effusion, and hepatic metastases. Tissue sampling confirmed yolk-sac tumor.

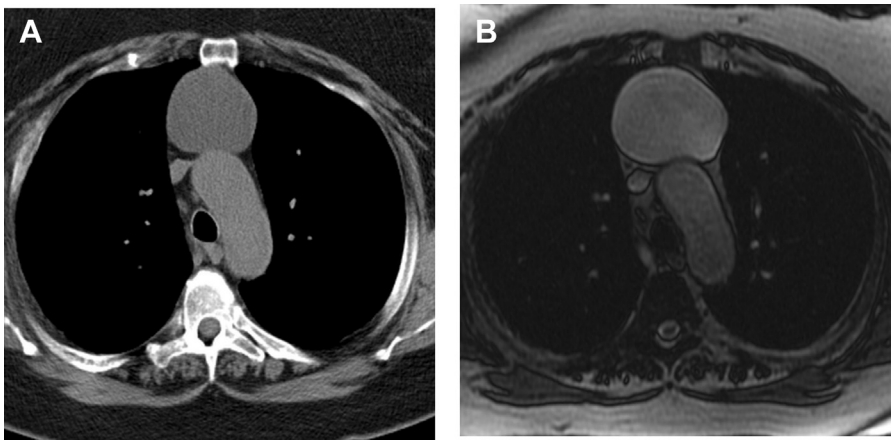

Fig. 13. Thymic cyst. (*A*) Unenhanced axial CT shows a large water attenuation mass in the prevascular mediastinum. (*B*) Axial T2-weighted MR image shows a thin-walled cyst with homogeneous high signal intensity throughout the lesion, consistent with a simple thymic cyst.

3 cm to 17 cm and usually are multilocular with variable wall thickness, enhancement, and/or calcification. When thymic cysts occur in the absence of symptoms and exhibit a unilocular morphology with simple fluid attenuation on CT, no further follow-up is needed (**Fig. 13**). When areas of high attenuation are present secondary to hemorrhage or proteinaceous material, internal septa, wall thickening, or mural nodularity, further characterization with MR imaging should be performed to help differentiate a complex thymic cyst from a cystic neoplasm. Surgical excision is curative in symptomatic patients or in patients in whom imaging features are equivocal.[6]

Pericardial Cyst

Pericardial cysts are benign, non-neoplastic, congenital cysts that arise from aberrant embryologic development of the somatic or coelomic cavities. Patients typically are asymptomatic, with most cases diagnosed incidentally on imaging. Pericardial cysts typically manifest as well-circumscribed unilocular cysts of variable size and simple fluid attenuation with an imperceptible wall and are located at one of the cardiophrenic angles, more commonly the right. They may occur anywhere along the pericardium and may be located as high as the superior pericardial reflection at the aortic root and pulmonary trunk (**Fig. 14**). When imaging findings are characteristic, no imaging follow-up or treatment is needed in the absence of complications, such as superimposed infection.[45]

LYMPHATIC AND VASCULAR LESIONS

Mediastinal Lymphangioma

Mediastinal lymphangioma is a benign proliferation of lymphatic channels and sacs that typically occurs in very young children, with 50% present at birth and 90% discovered by 2 years of age. Rarely, lymphangiomas may manifest as primary mediastinal tumors in adults.[34]

These lesions typically occur in the superior portion of the prevascular mediastinum and usually are contiguous with cervical and/or axillary components. They may manifest as rounded,

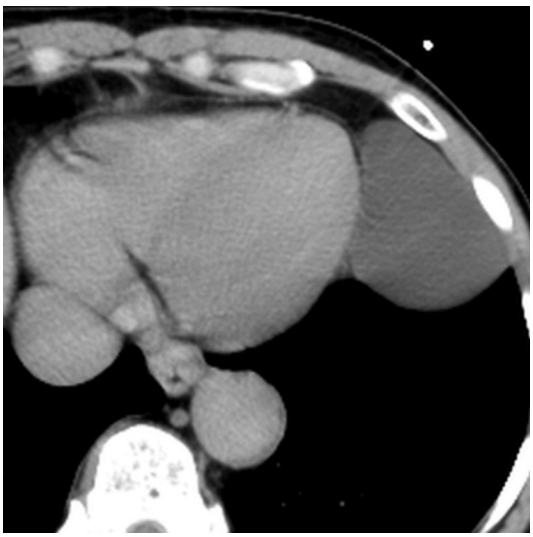

Fig. 14. Pericardial cyst. Contrast-enhanced axial CT shows a homogenous water attenuation cyst in the left cardiophrenic angle with an imperceptible wall.

lobulated, and multilocular cystic masses that may grow to large sizes and may infiltrate between mediastinal structures. Cystic foci correspond to dilated lymphatic channels and range from 1-2 mm in size to several centimeters. The fluid within the cystic spaces typically is of simple water attenuation, and septa may vary in thickness, sometimes with mild contrast enhancement. MR imaging is useful for further evaluating and characterizing these lesions (**Fig. 15**). Complete surgical resection often is challenging owing to their complex infiltrative nature; therefore, postsurgical surveillance often is necessary to monitor for recurrence.[34] Percutaneous sclerotherapy with injectable sclerosing agents is a potential nonsurgical treatment option for some patients.[49,50]

Mediastinal Hemangioma

Hemangiomas are rare mediastinal tumors, which typically occur in young patients, with approximately 75% manifesting in patients under the age of 35. Up to 50% of affected patients are asymptomatic.

Mediastinal hemangiomas may occur within any mediastinal compartment and may involve more than 1 compartment, with a reported incidence of 43% to 68% in the prevascular mediastinum. These are well-circumscribed heterogeneous masses, with variable contrast enhancement patterns. Punctate calcifications, and less commonly calcified phleboliths, may be identified.[51,52]

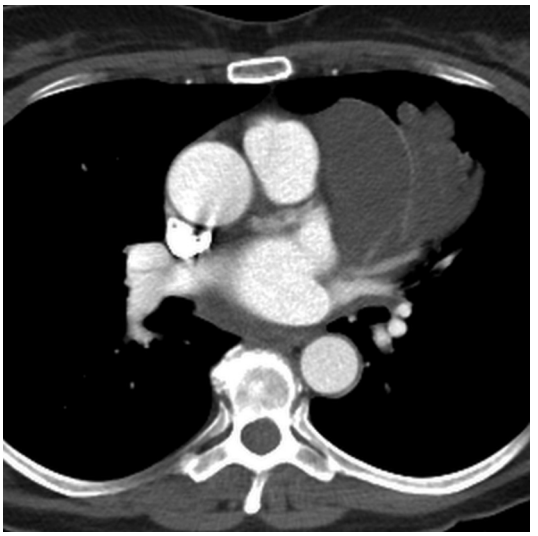

Fig. 15. Lymphangioma. Contrast-enhanced axial CT shows a left prevascular mediastinal multilocular cystic lesion with intrinsic septation. The lesion encases the left tracheobronchial tree and extends into the adjacent left upper lobe.

Dynamic contrast-enhanced (DCE) MR imaging may be utilized for further characterization.[53] Surgical excision can be both diagnostic and therapeutic.[52]

THYMOLIPOMA

Thymolipomas are rare, benign, slow-growing thymic tumors that typically occur in young adults (mean age 27 years) but may affect patients over a wide age range, without gender predilection. Approximately 50% of patients are asymptomatic. When symptoms occur, they usually are secondary to compression of mediastinal structures.[54,55]

Thymolipomas usually are large, encapsulated, and composed of adipose and thymic tissue. On imaging, these tumors often manifest as large, prevascular mediastinal masses, most commonly in the inferior aspect of the mediastinum, and may be unilateral or bilateral. These tumors are soft and malleable, conform to the shape of adjacent structures, and may mimic cardiomegaly or diaphragmatic elevation on radiography. CT and MR imaging help establish a lesion's connection to the anatomic location of the thymus and demonstrate an admixture of fat and soft tissue components with a characteristic swirling morphology (**Fig. 16**). The fat component may be dominant, and such lesions may be indistinguishable from primary fat-containing neoplasms, such as lipomas. Complete surgical excision is curative.[54,55]

LIPOMA AND LIPOSARCOMA

Lipomas are rare, benign, prevascular, mediastinal tumors comprising approximately 2% of all primary mediastinal neoplasms. On imaging, they typically manifest as well-circumscribed encapsulated lesions predominantly composed of fat, with a small amount of intrinsic soft tissue components and vascularity.[55]

Liposarcomas are even rarer and usually can be differentiated from lipomas due to a larger amount of intrinsic soft tissue and aggressive features, such as local invasion, mediastinal and/or hilar lymphadenopathy, or distant metastases (**Fig. 17**). Low-grade liposarcomas often are less heterogeneous in appearance and can be difficult to differentiate from lipomas.[56–58]

MEDIASTINAL GOITER

Mediastinal goiter is one of the most frequently encountered mediastinal masses in clinical practice, with approximately 20% of thyroid goiters extending inferiorly into the mediastinum.[34] Although they typically affect asymptomatic

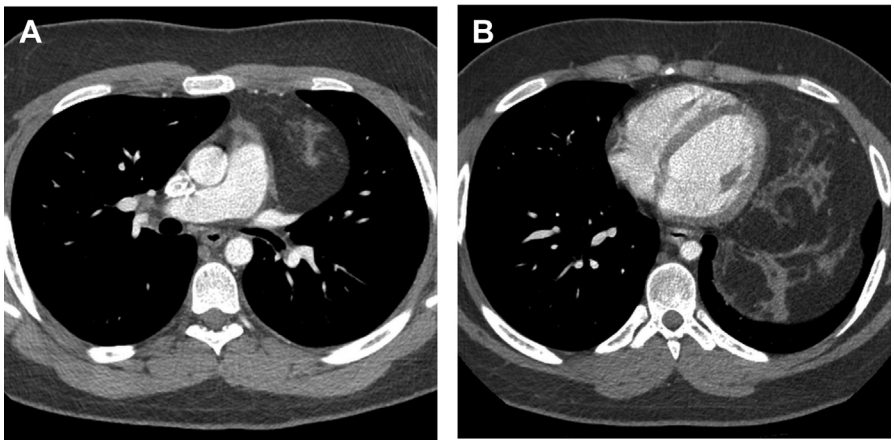

Fig. 16. Thymolipoma (*A, B*). Contrast-enhanced axial CT of the same patient at a more superior (*A*) and more inferior (*B*) level of the mediastinum shows a large heterogeneous mass in the left prevascular mediastinum that exhibits fat and soft tissue attenuation, corresponding to adipose and thymic tissue, respectively. Note the anatomic connection of the mass to the thymic bed (*A*), which strongly supports the diagnosis of thymolipoma.

women with palpable cervical goiters, they may produce symptoms of compression or pain.

Mediastinal goiters traditionally have been considered anterior mediastinal masses based on radiographic classification systems but may either descend into the prevascular mediastinal compartment or along the trachea into the visceral mediastinum. Primary intrathoracic or ectopic thyroid goiters without a cervical component are rare.[34]

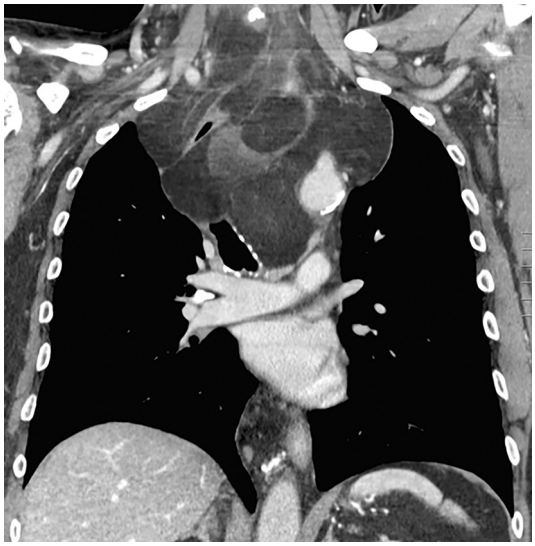

Fig. 17. Liposarcoma. Contrast-enhanced coronal CT shows a large, predominantly fat attenuation mass involving the prevascular and visceral mediastinal compartments with intrinsic soft tissue components, exerting mass effect on surrounding structures, and extending into the neck. Tissue sampling confirmed liposarcoma.

On radiography, mediastinal goiters frequently manifest with upper mediastinal widening and the characteristic cervicothoracic sign, which describes obscuration of the lesion's contours as it extends cephalad above the clavicle. This continuity between the cervical and mediastinal portions of the lesion is recognized easily on CT or MR imaging with multiplanar imaging. These usually are encapsulated, lobulated, and heterogenous masses with low attenuation foci that correspond to cyst formation and usually exhibit high attenuation due to iodine-containing portions of the gland. Calcifications are common and may be coarse, punctate, or ringlike. On contrast-enhanced CT, there is intense and sustained contrast enhancement[45] (**Fig. 18**). Nuclear scintigraphy with radioactive ^{123}I and ^{131}I can be diagnostic when functional thyroid tissue is present. Symptomatic patients and those with tumors of increasing heterogeneity or features suspicious for malignancy undergo surgical excision, with or without adjuvant or neoadjuvant ^{131}I ablation in the setting of malignancy.

MEDIASTINAL PARATHYROID ADENOMA

Parathyroid adenomas are benign functioning neoplasms that occur most commonly in the neck; however, approximately 10% are ectopic. Approximately 10% of all ectopic parathyroid adenomas occur in the prevascular mediastinum, usually near or within the thymus. These lesions most frequently affect older women, during the fifth to seventh decades of life, who often present with

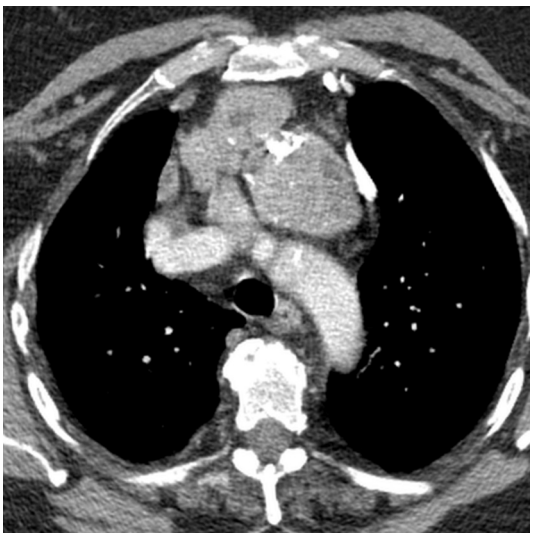

Fig. 18. Mediastinal goiter. Contrast-enhanced axial CT shows a large, lobulated, prevascular mediastinal goiter that demonstrates intense and sustained enhancement, cystic changes, and coarse calcifications. Multiplanar imaging (not shown) documented continuity with an enlarged cervical thyroid.

clinical hyperparathyroidism that persists after cervical parathyroidectomy.[59]

Parathyroid adenomas usually are small and encapsulated and measure less than 3 cm. On unenhanced CT, they are indistinguishable from lymph nodes. Approximately 25% demonstrate contrast enhancement on contrast-enhanced CT[34] (**Fig. 19**). Ultrasound in combination with 99mTc sestamibi single-photon emission CT have been the modalities of choice for diagnosis and preoperative localization. Four-dimensional (4-D) CT acquiring images in 4 different phases (noncontrast, arterial, venous, and delayed), however, has shown higher sensitivity and accuracy for localization, characterization, and preoperative planning in ectopic adenomas. Multiplanar reformatted images and 3-dimensional volume-rendered images are reconstructed for optimal anatomic depiction. These lesions demonstrate intense enhancement in the arterial phase (peak enhancement at 25–60 seconds), with washout of contrast in the delayed phase; 4-D MR imaging, including unenhanced sequences and DCE, also is reliable for localization of parathyroid adenomas.[59,60]

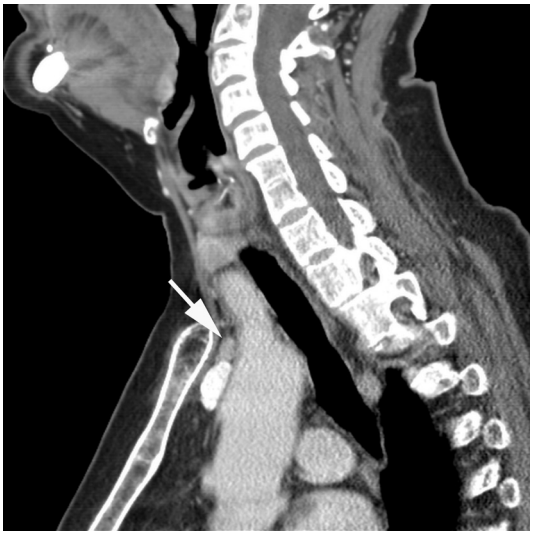

Fig. 19. Ectopic parathyroid adenoma. Contrast-enhanced 4-D sagittal CT (arterial phase) of a patient with primary hyperparathyroidism shows a small homogeneously enhancing soft tissue nodule (*arrow*) in the prevascular mediastinum which demonstrated uptake on Technetium-99m (99mTc) sestamibi scintigraphy (not shown), confirming parathyroid adenoma.

SUMMARY

Prevascular mediastinal masses include a wide range of benign and malignant entities. Although many mediastinal masses are discovered incidentally, affected patients may present with thoracic symptoms and/or with systemic effects of paraneoplastic syndromes or hormonal aberrations. Although the appearance of some prevascular mediastinal masses can be characteristic and diagnostic on CT, correlation with demographic information, clinical history, laboratory findings, and in some cases additional tests, such as MR imaging, FDG PET/CT, and nuclear scintigraphy, allows the formulation of a focused differential diagnosis and, in some cases, a specific diagnosis. Radiologists may use these methods to distinguish surgical from nonsurgical entities and thus inform appropriate patient management and impact outcomes. Treatment of choice varies based on the pathology, ranging from no intervention or serial imaging follow-up to surgical excision, chemotherapy, and/or radiation therapy.

CLINIC CARE POINTS

- When classic imaging features are present, a specific diagnosis may be suggested based solely on CT imaging features.
- Since appearance of various mediastinal lesions may overlap, additional imaging studies, laboratory tests, and tissue sampling often are required for a definitive diagnosis.
- Imaging cannot reliably definitively differentiate between thymomas, thymic carcinomas, and thymic neuroendocrine tumors.

DISCLOSURE

The authors have nothing to disclose.

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