The Thymus: A Comprehensive Review\textsuperscript{1}

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Since first being described as such by Galen of Pergamum (130–200 AD), the thymus has remained an “organ of mystery” throughout the 2000-year history of medicine. The thymus reaches its maximum weight in puberty and subsequently undergoes involution, and thus is hardly an eye-catching structure on imaging studies performed in healthy adults. However, once there has been involvement of the thymus by a disease process, the gland demonstrates a variety of clinical and radiologic manifestations that require comprehensive understanding of each entity. Furthermore, it is important for radiologists to be familiar with the current World Health Organization histologic classification scheme for thymic epithelial tumors and to understand its clinical-pathologic, radiologic, and prognostic features.

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Introduction

The word *thymus* comes from the Latin derivation of the Greek word *thymos*, meaning “warty excrescence.” Because *thymos* also means “soul” or “spirit,” the thymus was misrepresented as the seat of the soul by the ancient Greeks (1–3). Galen of Pergamum (130–200 AD), who first noted that the thymus was proportionally largest during infancy (4), referred to the thymus as an “organ of mystery,” a moniker that remained fairly accurate for almost two millennia.

In this article, we discuss and illustrate the embryologic and histologic features and the function of the thymus; medical conditions associated with thymic disease; and a wide spectrum of thymic diseases, with emphasis on the current World Health Organization (WHO) histologic classification scheme for thymic epithelial tumors. The aim of this article is to provide radiologists with a comprehensive understanding of the thymus and thymic diseases, and to enhance awareness of the current WHO classification scheme with radiologic-pathologic correlation.

Embryologic Features of the Thymus

The thymus arises bilaterally from the third and fourth branchial pouches and contains elements derived from all three germinal layers (5–7). Development begins in the 6th gestational week. Migration of tissue occurs during the 8th week, leading to a fusion of the bilateral lobes, with the thymus occupying its final position in the anterosuperior mediastinum. In the course of its development, until the 9th gestational week, the thymus remains purely epithelial. By the 10th week, small lymphoid cells migrate from fetal liver and bone marrow, leading to lobulation of the gland. Further differentiation into cortex and medulla is completed by 14–16 weeks. Thereafter, the thymus grows rapidly and attains its greatest weight in relation to body weight before birth (average, 15 g) (5).

Because the thymus migrates from the third and fourth branchial pouches to the anterior mediastinum during its course of development, ectopic thymic tissue or ectopic thymoma can occur anywhere along this pathway. Often manifesting as a neck mass, these entities are sometimes examined with computed tomography (CT) or magnetic resonance (MR) imaging (8,9). Thus, knowledge of the embryologic features of the thymus is important in recognizing these entities.

Histologic Features of the Thymus

The cortex is composed primarily of lymphocytes (thymocytes), with a few epithelial and mesenchymal cells (Fig 1), whereas the medulla is composed of more epithelial cells but fewer lymphocytes. Epithelial cells compose the framework of the thymus; they are functionally essential for the maturation of T lymphocytes and thus are called “nurse cells” (5). Hassall corpuscles are the char-
characteristic structures of the thymus and are found exclusively in the medulla (Fig 1). These entities are round, keratinized formations with mature epithelial cells and undergo marked cystic change into multilocular thymic cysts (5). In addition to epithelial cells and lymphocytes, the thymus contains a variety of other types of cells, including macrophages and myoid cells. Myoid cells are of great interest because of their potential role in the pathogenesis of myasthenia gravis (discussed later) (5). A basic knowledge of the histologic features of the thymus is essential for understanding the various pathologic conditions that affect this gland, including thymic epithelial tumors. Familiarity with the current WHO classification scheme, which is based on histologic features, is also essential (5).

**Function of the Thymus**

In ancient times, the thymus was believed to be the seat of the soul or the organ of purification of the nervous system (1–4). Later, the thymus was thought to be a protective thoracic cushion (10) or the regulator of fetal and neonatal pulmonary function (1,11). In 1832, Sir Astley Cooper suggested that this organ must perform some important function (12); however, the exact nature of this “important function” was not yet understood. What is currently known about thymic function is that the thymus is one of the central lymphoid organs and plays an important role in cellular immunity by generating circulating T lymphocytes. Although the need for the thymus to generate a continuous supply of T cells decreases with advancing age, the thymus continues to serve as the site of T-cell differentiation and maturation throughout life (5,13). One of the major functions of the thymus, the maturation of thymocytes, has been studied extensively with molecular and cellular biology. It is now known that various inductive, hormonal, and proliferative signals from epithelial cells contribute to the maturation of thymocytes (5). Of note, T-cell antigen receptors of thymocytes interact with epithelial major histocompatibility complex antigens in the process of thymocyte maturation (5).

**Definition of “Normal Thymus” in Adults**

What constitutes a normal thymus is another important issue. Because the thymus demonstrates unique changes over time, differentiation of a normal thymus from a thymic disorder can sometimes be problematic for radiologists.

As was mentioned earlier, Galen was the first to note that the thymus is proportionally largest during infancy (1,4). This observation was verified in 1777 by William Hewson, who studied the evolution of thymic size during fetal and infant life (1,11). After reaching its greatest weight in proportion to body weight before birth, the thymus continues to grow, reaching its maximum absolute weight at puberty. The thymus subsequently undergoes a process called involution, which is defined as a decrease in the size and weight of the gland with advancing age. This process starts at puberty, when the thymus is at its maximum absolute weight. During involution, the epithelial component atrophies, resulting in scattered small lymphocytes in abundant adipose tissue (5).

At CT, the thymus appears as a bilobed triangular structure located in the anterior mediastinum, most commonly anterior to the proximal ascending aorta, the pulmonary outflow tract, and the distal superior vena cava before it enters the right atrium (Fig 2) (14). Differentiation of the thymus from other mediastinal structures, such as lymph nodes or the superior sinus of the pericardium, may be difficult. Therefore, it is important to be familiar with the location, shape, and size of the normal thymus.

The size of a normal thymus has been extensively studied with CT and MR imaging (14–17). Baron et al (14) analyzed 154 mediastinal CT scans and reported that the mean thickness of a normal thymus decreased with advancing age from 1.1 cm (standard deviation, 0.4 cm) for the 6–19-year age group to 0.5 cm (standard deviation, 0.27 cm) for patients over age 50 years. The
maximum thickness was 1.8 cm in patients under age 20 years and 1.3 cm in patients over age 20 years. However, the thickness is greater at MR imaging (15–20 mm between ages 20 and 70 years), which may be due to better detection of (a) thymic tissue partially replaced by fat and (b) the margins of the thymus with this modality (17).

**Medical Conditions Associated with Thymic Disease**

A variety of pathologic conditions are known to be associated with thymic lesions, including thymoma and thymic hyperplasia.

**Diseases Associated with Thymoma**

A variety of diseases are seen in association with thymoma (Table 1) (5,18,19). Among these diseases, myasthenia gravis is the most common and has the most well established association with thymoma. The other diseases, including pure red cell aplasia, hypogammaglobulinemia, SLE, rheumatoid arthritis, and nonthymic cancers, occur less frequently than myasthenia gravis but are relatively well recognized associated conditions (5,18). The causal relationship between thymoma and most of these diseases is not well understood.

Myasthenia gravis affects one-third to one-half of all thymoma patients, whereas 10%–20% of myasthenia gravis patients have thymoma (Fig 3) (20). In spite of the frequent association between thymoma and myasthenia gravis, the mechanism of the association is not fully understood. However, it is known that myasthenia gravis is an autoimmune disease affecting the nicotinic acetylcholine receptor at the neuromuscular junction, and production of autoantibodies against the acetylcholine receptor α subunit is assumed to cause myasthenia gravis (21). The source of acetylcholine receptors in the thymus is considered to be myoid cells, which are in very close contact with antigen-presenting interdigitating cells (5). Thymectomy improves myasthenia gravis in some patients regardless of whether thymoma is present (18).

Several hematologic disorders are known to be associated with thymoma; however, these disorders occur less frequently than myasthenia gravis and have been studied less. Pure red cell aplasia occurs in only 5% of thymoma patients, whereas thymomas are found in 50% of patients with pure red cell aplasia (22). The role of thymoma in the occurrence of pure red cell aplasia is not known at present. Suggested explanations include the following: (a) thymoma shares an antigen in common with cells of the erythroid series; (b) thymoma overproduces suppressor T cells, at times resulting in not only pure red cell aplasia but also hypogammaglobulinemia; and (c) both thymoma and pure red cell aplasia occur through the action of a common causative agent (23).

**Medical Conditions Associated with Thymic Hyperplasia**

There are two distinct histologic types of thymic hyperplasia: true thymic hyperplasia and lymphoid hyperplasia. These two types are associated with different groups of pathologic conditions.
Both true thymic hyperplasia and lymphoid hyperplasia manifest as diffuse symmetric enlargement of the thymus, so that it is difficult to distinguish between the two types on the basis of imaging findings alone (24).

True thymic hyperplasia is defined as enlargement of the thymus, which remains normally organized, beyond the upper limit of normal for a given patient age. This disease entity is seen when a patient is recovering from some recent stress, such as chemotherapy for neoplasm, corticosteroid therapy, irradiation, or thermal burns (5,18,24). Under such conditions, the thymus may respond by becoming atrophic; however, it grows back to its original size after cessation of the stress. The thymus sometimes grows to an even larger size after such stress, a phenomenon known as rebound hyperplasia (18). In a series of 29 patients, Choyke et al (25) demonstrated that rebound hyperplasia, defined as a greater than 50% increase in thymic volume over baseline, was noted in 25% of patients several months (range, 3–8 months; mean, 4.2 months) after cessation of chemotherapy.

Lymphoid hyperplasia of the thymus refers to the presence of an increased number of lymphoid follicles (5). This condition is most commonly associated with myasthenia gravis, being seen in up to 65% of cases (24). Lymphoid hyperplasia of the thymus is observed in a number of immunologically mediated disorders, including SLE, rheumatoid arthritis, scleroderma, vasculitis, thyrotoxicosis, and Graves disease (Fig 4).

Table 2

<table>
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<th>Diseases Associated with Thymic Hyperplasia</th>
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<tr>
<td>True thymic hyperplasia</td>
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<tr>
<td>SLE</td>
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<tr>
<td>Rheumatoid arthritis</td>
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<td>Scleroderma</td>
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<tr>
<td>Polyarthritis nodosa</td>
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<td>Behçet disease</td>
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<tr>
<td>Hashimoto thyroiditis</td>
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<tr>
<td>Addison disease</td>
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<tr>
<td>Autoimmune hemolytic anemia</td>
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<tr>
<td>Thyrotoxicosis</td>
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<tr>
<td>Graves disease</td>
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<tr>
<td>Lymphoid hyperplasia</td>
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<tr>
<td>Rebound hyperplasia secondary to chemotherapy, radiation therapy, corticosteroid therapy, thermal burns, treatment for Cushing syndrome, or some other severe systemic stress</td>
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It is important that radiologists be able to distinguish thymic hyperplasia from neoplasm. Diffuse symmetric enlargement of the gland is the key morphologic feature of hyperplasia, whereas neoplasm tends to manifest as a focal mass, as in thymoma (24). However, differentiation may be difficult on the basis of morphologic features alone. Several new imaging approaches have been attempted, including chemical shift MR imaging and fluorine 18 fluorodeoxyglucose (FDG) positron emission tomography (PET) (26,27).

Chemical shift imaging was recently used in an attempt to distinguish normal thymus from thymic hyperplasia, with the latter demonstrating
homogeneously decreased signal intensity on opposed-phase images. This finding suggests that chemical shift imaging may potentially be used to differentiate normal and hyperplastic thymus from neoplastic involvement of the thymus (26). However, further investigation with a larger study population will be needed.

FDG PET is often performed in patients with malignancy; however, differentiation between thymic hyperplasia and thymic involvement by malignancy is difficult because the thymus demonstrates normal physiologic uptake. In questionable cases, correlation with morphologic findings obtained at CT or MR imaging is appropriate (27).

Thymic Neoplasms with Radiologic-Pathologic Correlation

There are a variety of pathologic entities of the thymus. Of note, a variety of subtypes of thymic epithelial tumors with a broad spectrum of biologic and morphologic features exist, reflecting the unique histologic background of the thymus. Recently, several reports described specific CT, MR imaging, and FDG PET features of thymic epithelial tumors that reflect the WHO histologic subtypes (28–32). In this section, we discuss (a) thymic epithelial tumors and their classification, (b) imaging features of thymic epithelial tumors correlated with histologic subtypes, and (c) uncommon thymic neoplasms.

Thymic Epithelial Tumors and Their Classification

Thymic epithelial tumors, which include thymoma and thymic carcinoma, arise from thymic epithelium and demonstrate various histologic features and biologic behaviors (29). Thymoma is often divided into “noninvasive” and “invasive” types. Noninvasive thymoma manifests as a completely encapsulated tumor without microscopic evidence of growth outside the tumor capsule, whereas invasive thymoma demonstrates microscopic evidence of such growth, occasionally showing pleural implants and, rarely, hematogenous and lymphatic metastasis (5). It is impossible to differentiate between the two types solely on the basis of histologic features, and invasive thymoma may lack histologic features of malignancy. Therefore, the terms noninvasive and invasive are preferred over “benign” and “malignant” (5,18,33).

Several classification schemes and staging systems for thymic epithelial tumors have been proposed. Although there is some correlation between these various approaches and the invasiveness and clinical course of the tumor, most of them fail to provide consistent prognostic significance (30,34–47). The Masaoka clinical-pathologic staging system is based on surgical findings, including the presence of invasion or metastasis, and tumors are classified as follows: stage I, macroscopically encapsulated tumor with no microscopic evidence of capsular invasion; stage II, macroscopic invasion of the surrounding fatty tissue of the mediastinal pleura or microscopic evidence of capsular invasion; stage III, macroscopic invasion of a neighboring organ; stage IVa, pleural or pericardial dissemination; and stage IVb, lymphogenous or hematogenous metastasis (48). This staging system correlates with 5-year survival rates (48). The WHO proposed a consensus classification scheme for thymic epithelial tumors in 1999 that is based on histologic features (Table 3) (49). This histologic classification scheme reflects both the clinical and functional behaviors of thymic epithelial tumors and contributes to the clinical treatment of patients (50–52).

The WHO classification scheme correlates with invasiveness: Types A and AB are usually clinically benign and encapsulated (stage I), type B has a greater likelihood of invasiveness (especially type B3), and type C is almost always invasive. This scheme has been shown to reflect the clinical features of thymic epithelial tumors and to correlate with prognosis (52). Preoperative predictions based on WHO histologic subtypes of thymic epithelial tumors may help determine if tumors can be treated with surgical resection alone or if they require pre- or postoperative adjuvant treatment (30). However, most clinicians and radiologists are unfamiliar with this complicated classification scheme. In addition, poor interobserver reproducibility has been reported in the various WHO histologic subtypes (53).

<table>
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<th>Tumor Type</th>
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<tr>
<td>A</td>
<td>Medullary</td>
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<tr>
<td>AB</td>
<td>Mixed</td>
</tr>
<tr>
<td>B1</td>
<td>Lymphocyte rich, predominantly cortical</td>
</tr>
<tr>
<td>B2</td>
<td>Cortical</td>
</tr>
<tr>
<td>B3</td>
<td>Epithelial (well-differentiated thymic carcinoma)</td>
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<tr>
<td>C</td>
<td>Thymic carcinoma</td>
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Several proposals to simplify the classification scheme according to similar prognostic appearance have been made to facilitate clinical-pathologic understanding of thymic epithelial tumors. Rieker et al (53) proposed a simplified classification scheme consisting of three subtypes: types A, AB, B1, and B2 as one group; type B3; and type C. However, the survival rates for patients with type B2 tumors are lower than those for patients with type A, AB, or B1 tumors (52,54). In addition, a large-scale report of thymic epithelial tumors stated that overall survival rates for patients with type B2 tumors are lower than those for patients with type A, AB, or B1 tumors (52,54). In addition, a large-scale report of thymic epithelial tumors stated that overall survival rates for patients with type B2 or B3 tumors were higher than those for patients with type B2 or B3 tumors (54). Jeong et al (30) simplified the WHO histologic classification scheme into three subgroups—low-risk thymomas (types A, AB, and B1), high-risk thymomas (types B2 and B3), and thymic carcinomas (type C)—and correlated CT findings in the three tumor subgroups with prognosis.

In summary, the Masaoka clinical-pathologic staging system is based on invasiveness of the tumor at surgery, and the system correlates with 5-year survival rates. The WHO classification scheme is relatively new and is based on histologic features. This scheme has been shown to correlate with the invasiveness and clinical behavior of tumors and with prognosis, has important preoperative implications for treatment strategy, and will be a standard classification scheme for thymic epithelial tumors.

**Imaging Features of Thymic Epithelial Tumors Correlated with Histologic Subtypes**

**Computed Tomography.**—Thymic epithelial tumors most frequently manifest as soft-tissue masses in the anterior mediastinum, vary in size, and can have smooth and lobulated borders. Because of their embryologic background and anatomic location, they can occur adjacent to the junction of the great vessels and the pericardium; less commonly, in the cardiophrenic angles or adjacent cardiac borders; and, rarely, in the neck or other mediastinal compartments (5,18). Conventional radiography may help detect relatively large lesions, especially on lateral projections as an opacity in the retrosternal area; however, this finding is often indeterminate, and smaller lesions may go undetected (18).

CT, of course, has a much higher sensitivity for detecting thymic epithelial tumors, and also allows evaluation of (a) invasion of the surrounding mediastinal fat, vascular structures, and adjacent lung; and (b) the presence of pleural and extrapleural seeding. On CT scans, thymic epithelial tumors usually appear as homogeneous, oval, rounded or lobulated soft-tissue masses in the anterior mediastinum (Fig 5) (18).
invasive thymoma or thymic carcinoma, invasion of the mediastinal fat or adjacent structures as well as pleural seeding may be seen.

With the increased prevalence of advanced CT technology, detailed characterization of thymic epithelial tumors at CT has become possible; therefore, the correlation of radiologic findings with WHO classifications, clinical behaviors, and prognosis has also been investigated (28–30). Because the current WHO classification scheme correlates with the oncologic behavior of thymic epithelial tumors and affects treatment strategy, familiarity with the imaging features that suggest specific histologic subtypes is important for radiologists, allowing them to contribute to the clinical treatment of affected patients.

Tomiyama et al (28) assessed the CT features of various subtypes of thymic epithelial tumors in 53 patients and reported that smooth contours and a round shape are most suggestive of type A tumors, irregular contours are most suggestive of type C tumors, and calcification is suggestive of type B tumors. Jeong et al (30) reviewed the CT findings in 91 patients who had undergone resection of thymic epithelial tumors and correlated these findings with their simplified classification scheme and with prognosis.

According to these investigators, CT findings that are more common in high-risk thymomas and thymic carcinomas include lobulated contour, mediastinal fat invasion, and great vessel invasion (Figs 6, 7; Table 4). Findings associated with significantly more frequent recurrence and metastasis include lobulated or irregular contour, oval shape, mediastinal fat invasion or great vessel invasion, and pleural seeding (Fig 8, Table 4). In the diagnosis of thymic tumors, radiologists should look carefully at the CT findings, which may serve as predictors of tumor invasiveness and of postoperative recurrence or metastasis.

Table 4
CT Findings in Thymic Epithelial Tumors

| Findings more common in high-risk thymomas and thymic carcinomas |
| Lobulated contour |
| Mediastinal fat invasion |
| Great vessel invasion |
| Findings associated with a significantly greater prevalence of recurrence and metastasis |
| Lobulated or irregular contour |
| Oval shape |
| Mediastinal fat invasion or great vessel invasion |
| Pleural seeding |
Figure 7. Incidentally noted thymic carcinoma in a 79-year-old man who presented with bronchiectasis and cough. (a) Unenhanced chest CT scan shows an anterior mediastinal mass with a somewhat lobulated contour. (b) On a sagittal reformatted image, the mass is closely attached to the pericardium with loss of the fat plane (arrow) between the two entities, findings that suggest pericardial involvement. Pericardial effusion is also noted. At surgery, pericardial invasion was noted, and pathologic analysis showed squamous cell thymic carcinoma.

Figure 8. Pleural seeding from a WHO type B2 (cortical) thymoma in a 40-year-old woman who presented with myasthenia gravis. (a) Contrast-enhanced CT scan shows a lobulated anterior mediastinal mass. (b) Contrast-enhanced CT scan obtained at the level of the upper abdomen shows an enhancing pleura-based nodule (arrow), a finding that represents pleural seeding. Pathologic analysis showed a predominance of lymphoid cells (type B2 tumor).
**MR Imaging.**—At MR imaging, thymoma has a signal intensity similar to that of muscle or normal thymic tissue on T1-weighted images and appears heterogeneous on T2-weighted images (Fig 9) (18,29,31). MR imaging may also be useful in differentiating between thymoma and thymic cysts that demonstrate increased CT attenuation due to hemorrhage or high mucinous content (Fig 10). T2-weighted and contrast-enhanced MR images also help detect solid components of cystic lesions, a finding that raises the possibility of cystic thymoma (Fig 11).

**FDG PET.**—FDG PET is another powerful diagnostic tool for the diagnosis, staging, and restaging of neoplasms in general. In thymic neoplasms, FDG PET may be useful in differentiating thymic carcinoma from other thymic neoplasms, thymic hyperplasia, and normal physiologic uptake (27). Sasaki et al (32) reported that the standardized uptake value (SUV) for thymic carcinoma was significantly greater than that for invasive or noninvasive thymoma. With an SUV cutoff point of 5.0, thymic carcinoma can be differentiated from thymoma with reasonably high sensitivity (84.6%), specificity (92.3%), and accuracy (88.5%). There was no statistically significant difference in SUV between invasive and noninvasive thymomas. It is speculated that FDG PET will prove to be effective in differentiating thymic carcinoma from other thymic diseases but far less so in differentiating between invasive and noninvasive thymoma (27).

**Uncommon Thymic Neoplasms**

**Thymolipoma.**—Thymolipoma is a rare, benign, slow-growing tumor that accounts for 2%–9% of all thymic neoplasms. It occurs most frequently in young adults and has no sex predilection. Thymolipoma is usually asymptomatic and manifests as a large anterior mediastinal mass. At histologic analysis, it is composed of mature fat and thymic tissue (5). Because of its soft and pliable nature, thymolipoma typically drapes itself around the heart and adjacent mediastinal structures, often becoming quite large before
coming to clinical attention. It is usually detected incidentally at routine chest radiography and may occasionally mimic cardiac enlargement or an elevated hemidiaphragm (55). At CT and MR imaging, thymolipoma manifests as a fatty mass with fibrous septa (18). Association with myasthenia gravis, Graves disease, aplastic anemia, and other hematologic disorders has been reported (56–58).

**Thymic Carcinoid.**—Thymic carcinoid is a rare primary malignant thymic neoplasm that occurs over a wide patient age range (median age, 43 years) and has a male predilection of 3:1. One-third of these tumors are functionally active, causing endocrinologic disorders such as Cushing syndrome (33%–40% of cases) or multiple endocrine neoplasia, specifically type 1 (19%–25%) (5,18,59–62). At imaging, a thymic carcinoid usually manifests as a large anterior mediastinal mass, often with invasion of adjacent structures and metastasis. Differentiation between thymic carcinoids and invasive thymic epithelial tumors may be difficult on the basis of imaging findings.

**Figure 10.** Thymic cyst in a 66-year-old woman. (a) Contrast-enhanced CT scan shows an incidentally noted anterior mediastinal lesion (arrow) with well-circumscribed borders and soft-tissue attenuation. The lesion is indistinguishable from a solid mass. (b) On a T2-weighted MR image, the lesion (arrow) is hyperintense and contains a fluid level, findings that indicate a hemorrhagic or mucin-containing cystic lesion. The lesion was surgically removed, and pathologic analysis demonstrated a thymic cyst.

**Figure 11.** Cystic thymoma in a 48-year-old woman. Axial short inversion time inversion-recovery MR image shows hyperintense cystic lesions in the mediastinum abutting the pericardium. Note the hypointense nodular lesion (arrow), a finding that suggests the presence of a solid component. The nodule demonstrated enhancement after contrast material administration. Surgery was performed, and pathologic analysis helped confirm a cystic type AB thymoma.
alone (Fig 12) (18). Thymic carcinoid has a poor prognosis due to a high prevalence of recurrence and metastasis.

**Lymphoma.**—Lymphoma may involve the thymus as part of disseminated disease or sometimes as an isolated site. Hodgkin disease accounts for the majority of thymic lymphomas, with nodular sclerosis being the most common histologic finding identified in the thymus (18,24). The major imaging findings include thymic enlargement, sometimes with single or multiple masses. In general, it is difficult to distinguish lymphoma from other thymic masses, especially thymoma, on the basis of imaging findings alone. Distinguishing prominent but normal thymus in young patients and thymic hyperplasia from lymphomatous involvement of the thymus is also problematic (18,24). Use of chemical shift MR imaging and FDG PET in this setting have been described previously; however, further study will be needed to determine their utility (26,27).

**Conclusions**

Knowledge of the embryologic, histologic, and normal morphologic features of the thymus is essential for comprehensive understanding of the normal thymus and thymic diseases. Familiarity with the classification schemes for thymic epithelial tumors, especially the current WHO classification scheme, and awareness of the correlation between these classification schemes and radiologic findings are necessary if the radiologist is to contribute to the clinical treatment of affected patients.

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**References**


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