State of the Art
MR Imaging of Thymoma

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KEYWORDS

• Thymus • Thymoma • Mediastinum • Anterior • Staging • MR imaging

KEY POINTS

- Although thymoma is a rare tumor, it is the most common primary malignancy of the anterior mediastinum.
- MR imaging is an excellent tool for characterizing anterior mediastinal masses and elegantly distinguishes normal thymus and thymic hyperplasia from malignant neoplasms involving the thymus.
- Thoracic MR imaging may be used to stage patients in whom allergy to intravenous contrast and/or renal failure precludes evaluation with contrast-enhanced chest computed tomography (CT).

INTRODUCTION

Thymoma is the most common primary malignancy of the anterior mediastinum, but it is a rare tumor that constitutes less than 1% of adult malignancies.[1] Thmyoma is the most common thymic epithelial neoplasm, a group that also includes thymic carcinoma and thymic carcinoid. Because of the rarity of thymoma, it has not been evaluated thoroughly and many of the studies regarding imaging characteristics of the tumor were single-institution studies spanning multiple decades. Increased interest in thymic malignancies and greater international collaboration over the past 5 years has ultimately resulted in the formation of the International Thymic Malignancy Interest Group (ITMIG), an organization that provides infrastructure for the study of these lesions. With the formation of an international thymic malignancy database, it is hoped that large-scale multiinstitutional studies will overcome the smaller ones of the past and advance the knowledge in the detection, staging, and treatment of this disease. CT is currently the imaging modality of choice for distinguishing thymoma from other anterior mediastinal masses, characterizing the primary tumor, and staging the disease. However, MR imaging is also effective in evaluating and characterizing anterior mediastinal masses and staging thymoma in patients with contrast allergy and/or renal failure, which preclude evaluation with contrast-material-enhanced CT. This review focuses on the characterization, classification, and staging of thymoma based on various morphologic features that may be identified on MR imaging and the impact of imaging findings on therapy and management.

EPIDEMIOLOGIC AND CLINICAL FEATURES

The incidence of thymoma is 1 to 5 cases per million individuals per year in the United States, and it is higher in African Americans and Asians. Men and women are affected equally.[2,3] The incidence of thymoma increases with age, and the condition is most common in patients older than 40 years, but decreases in incidence after 60 years of age. Children are only rarely affected.

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The most common clinical symptoms reported at the time of diagnosis include chest pain, dyspnea, and cough.[4] These symptoms are present in up to one-third of patients and typically secondary to compression and/or invasion of mediastinal structures. Dysphagia, diaphragmatic paralysis, and superior vena cava syndrome may also be present. One-third of patients present with systemic symptoms and paraneoplastic syndromes because of the presence of hormones, antibodies, and cytokines released by the tumor. The most common paraneoplastic syndrome associated with thymoma is myasthenia gravis, which is present in 30% to 50% of patients and is more common in women than in men.[5] Other paraneoplastic syndromes include hypogammaglobulinemia and pure red cell aplasia, which are present in 10% and 5% of cases, respectively.[6] Autoimmune disorders such as systemic lupus erythematosus, polymyositis, and myocarditis may be associated with thymoma.[7] Patients may be asymptomatic, and the increased utilization of CT for the diagnosis and follow-up of benign and malignant diseases has increased the detection of incidental thymomas.[8]

HISTOLOGY AND CLASSIFICATION

Thymomas are typically solid, encapsulated tumors that are restricted to the thymus. One-third of thymomas demonstrate necrosis, hemorrhage, or cystic components, and one-third of tumors invade the capsule and adjacent structures.[9] Although thymomas are typically slow-growing malignancies, aggressive features such as invasion of surrounding structures and involvement of the pleura and pericardium may be present. However, compared with thymic carcinoma and other malignancies of the anterior mediastinum, distant metastases are rare.[9]

The histologic classification of thymoma is complex and has been the source of controversy. Histologically, thymomas are composed of neoplastic epithelial cells and nonneoplastic lymphocytes, and most tumors are heterogeneous in composition. The first histologic classification scheme developed by the World Health Organization (WHO) Consensus Committee was released in 1999 and classified thymomas into 6 separate subtypes (A, AB, B1, B2, B3, and C) based on morphologic features of the neoplastic epithelial cells and the lymphocyte:epithelial cell ratio. A revised WHO classification scheme was published in 2004 and moved type C (thymic carcinoma) to a separate category.[10] However, there are inherent limitations in this classification system. Because thymomas are typically heterogeneous tumors, many different subtypes may coexist within the same lesion.[11] In addition, when diagnosis is made from tissue obtained via needle biopsy, the sample obtained may not be representative of the predominant subtype of the tumor.[10] For histologic classification to be useful, it should correlate with prognosis so that therapy could be selected according to the classification. The WHO classification schemes of 1999 and 2004 lacked intraobserver and interobserver reproducibility and clinical predictive value.[12] At present, the most important feature of the histologic classification of thymic epithelial malignancies is differentiation of thymic carcinoma from thymoma, because thymic carcinoma is the most distinct group histologically and clinically with worse outcomes.[13] However, worse clinical outcomes have also been shown for subtype B3 when compared with the other histologic subtypes combined.[10,14]

STAGING

Many staging systems for thymoma have been proposed.[15–18] However, the Masaoka system (**Table 1**) and a variant of it, the Masaoka-Koga staging system,[16,17] are the most commonly used systems. The Masaoka-Koga staging system is the one recommended by the ITMIG[19] because of its correlation with patient survival as documented in several studies (**Table 2**).[20] The Masaoka-Koga staging system is based on the gross and microscopic features of thymoma. Tumors are designated as stage I when completely encapsulated; stage II in the setting of microscopic invasion through the capsule (IIa) or macroscopic invasion of the surrounding fat (IIb); stage III when invasion of an adjacent structure such as the great vessels, pericardium, or lung is present; and stage IV in the setting of pleural or pericardial dissemination (IVa)

Table 1
Masaoka staging system for thymoma

Stage	Descriptors
I	Complete encapsulation of tumor and no microscopic invasion of capsule
II	Macroscopic invasion into surrounding fat or mediastinal pleura Microscopic invasion into capsule
III	Invasion of pericardium, great vessels, or lung
IVa	Pleural or pericardial dissemination
IVb	Lymphatic/hematogenous metastasis

Adapted from Masaoka A, Monden Y, Nakahara K, et al. Follow-up study of thymomas with special reference to their clinical stages. Cancer 1981;48(11):2485–92; with permission.