Standard Report Terms for Chest Computed Tomography Reports of Anterior Mediastinal Masses Suspicious for Thymoma

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Abstract

With the formation of The International Thymic Malignancy Interest Group (ITMIG) there has been a collaborative effort to develop standard outcome measures, increase awareness of thymic malignancies, and identify preoperative prognostic factors with the purpose of improving individualized care for patients with thymoma. There is a growing demand for structured reporting in radiology and for the formulation of standard terms to be used by clinicians and radiologists alike. The following guidelines describe the imaging findings that should be included in CT reports of patients with anterior mediastinal masses in whom thymoma is considered in the differential diagnosis. These were discussed and adopted by ITMIG in the multidisciplinary standard workgroup meeting that took place in November 2010. We hope that consistent use of these descriptors will help establish a common reporting language that will be used and accepted by clinicians as they make management decisions regarding their patients with thymoma.

Key words:
Thymoma, Computed Tomography, Structured Reporting, Staging

Introduction

There is a growing demand for structured reporting in radiology and for the formulation of standard terms to be used by clinicians and radiologists alike. A study focusing on CT reporting of lung nodules found inconsistency of the reporting of their margins and presence of calcifications. Another study, comparing imaging terms listed in the Fleischner Society Glossary to their use in medical lexicons including the ICD-9-CM (International Classification of Diseases: 9th revision, Clinical Modification, Center of Medicare and Medicaid services, Washington DC), SNOMED-RT (College of American Pathologists, Northfield, IL), and the Unified Medical Language System (UMLS, National Library of Medicine, Bethesda, MD), found low rates of utilization of Fleischner terms ranging from 3-36%. On the other hand, when standardized reporting is implemented for imaging a specific disease, such as seen in the screening for breast cancer, this leads to improved patient care. It is expected that the creation of a standardized terminology for the description of an anterior mediastinal mass suspicious for thymoma and the promotion of its use will result in improved communication between the clinician and the radiologist and will ultimately positively impact patient care.

In addition to finding a common language, including pertinent information in the radiologic report that will influence therapy requires knowledge of the disease and is often disease specific. Because of this, standardized reporting has been created for specific diseases in a few organs and has been proven useful. The American College of Radiology developed the Breast Imaging Reporting and Data System (BI-RADS) to characterize breast lesions seen on mammography and breast ultrasound in a standardized manner that correlates with the underlying
histologic findings. The BI-RADS assigns a percentage probability of malignancy to each category and has gained worldwide acceptance in its use for guiding clinical management. A similar system has been developed for the ultrasound evaluation of thyroid nodules, stratifying them into those with imaging findings more likely to be malignant and those less likely to be malignant with suggestions for appropriate clinical management, called Thyroid Imaging and Reporting Data System (TIRADS).

While there is preliminary evidence to suggest that certain imaging findings in thymoma are important for staging or prognosis, further validation will require the prospective acquisition of data, which will be facilitated by the creation of a structured radiology report. The following guidelines contain descriptors that should be included in CT reports of patients with anterior mediastinal masses in whom thymoma is considered in the differential diagnosis. Corresponding representative images are included for clarity and consistency. Pertinent negatives with regards to these descriptors are just as important. Consistent use of these descriptors will help establish a common reporting language that will be used and accepted by clinicians as they make management decisions regarding their patients with thymoma and facilitate further research.

Methods

The process used in development of this document was designed to represent a broad consensus within the community of clinicians and researchers interested in thymic diseases. A core workgroup (Edith M. Marom, Melissa L. Rosado-de-Christenson, John F. Bruzzi, Masaki Hara, Joshua R. Sonett, and Loren Ketai) reviewed the existing literature as well as existing standards for chest radiology that applied or could be adapted to achieving consistency in reporting imaging findings in anterior mediastinal masses. This group drafted proposed standard report terms and definitions. After discussion at an ITMIG Definition and Terminology workshop on November 16, 2010 and distribution to all ITMIG members for comment, the final document was approved and adopted by ITMIG members in February, 2011 (obviously some of this has not yet happened).

Review of Existing Studies

The Masaoka staging system and its variants have been shown to strongly correlate with prognosis yet staging is often only established post-operatively. Patients with locally advanced thymoma may receive neoadjuvant chemotherapy to enable effective resection as complete resection, even of advanced disease, improves survival. Currently, it is recommended that patients with stage III and IV thymoma should receive neoadjuvant therapy.

Historically, mediastinal imaging has been considered to have limited value in the staging of patients with thymoma. This may have been due to the limitations of older imaging techniques and to the rarity of thymoma. These factors likely influenced scientific publication and limited the number of published case studies on the imaging of thymoma which in turn decreased the statistical power of these studies.

CT is currently considered the preferred imaging modality for the initial assessment and follow-up of patients with thymoma. In the last decade, CT technique has improved dramatically resulting in routine rapid acquisition of thin section slices enabling high quality image reformations in multiple planes. This resulted in improved visualization of these tumors, allowing assessment of internal lesion characteristics as well as detailed visualization of the tumor's relationship to surrounding structures.

Promising studies have been published in the last decade, taking advantage of modern CT imaging techniques. These studies have shown that some CT characteristics correlate with aggressive tumor behavior and higher stage. To the best of our knowledge, only two have
correlated the CT appearance of thymoma with Masaoka staging.\textsuperscript{20, 21} One study assessed 50 patients with thymoma\textsuperscript{21} and found that invasive thymomas were more likely to be larger, and to have low attenuation regions, calcifications, and lobulated and irregular contours when compared to low stage thymomas. A later study, assessed 99 patients with thymoma\textsuperscript{20} and found multiple factors associated with advanced disease (stage III and IV): large size, lobulated contours, heterogeneous attenuation, calcifications, infiltration of surrounding mediastinal fat, tumor abutting \( \geq 50\% \) of a mediastinal structure, adjacent lung abnormalities, and pleural effusion. However, after performing multivariate analysis, larger tumor size, lobulated contours, and fatty infiltration surrounding the tumor, were the only imaging findings that were likely to correlate with higher stage disease, that is stage III or IV.\textsuperscript{20}

Thymomas are classified histologically by the WHO classification. Although the WHO classification was found to lack adequate reproducibility and clinical predictive value,\textsuperscript{10} several CT studies have correlated CT appearance with the WHO histologic classification. Two studies that evaluated 45 and 76 patients with thymoma\textsuperscript{22, 23} found that lobulated and irregular tumor contours were associated with more aggressive disease, although this was not confirmed by a third study\textsuperscript{24} that evaluated 48 patients with thymoma.

The above imaging studies are promising. In fact, some clinicians already use large tumor size, tumor heterogeneity and tumor lobulation to help identify patients that should receive neoadjuvant therapy prior to attempted resection. However, much larger studies correlating the relationship of imaging findings of thymoma with its biologic behavior are needed. Such studies will have to be performed on an international basis as despite thymoma being the most common primary neoplasm of the anterior mediastinum, it only accounts for less than 1\% of all adult malignancies.\textsuperscript{25}

**Recommendations**

We believe that each CT report of a mediastinal mass suspicious for thymoma or of newly diagnosed thymoma should include the following data about the primary mass and its surrounding structures: lesion location and size in the x, y, and z axis, description of the lesion contour (smooth or lobulated), presence or absence of heterogeneous attenuation, calcifications, infiltration of surrounding mediastinal fat, and tumor abutting \( \geq 50\% \) of an adjacent mediastinal structure and direct invasion into a vessel lumen. The following information regarding the surrounding structures must also be included: diaphragmatic elevation (consistent with phrenic nerve involvement), adjacent lung abnormalities, pleural effusion, pleural nodule or nodules, lymph node enlargement, and findings suggestive of distant metastatic disease (i.e. lung, liver, adrenal or peritoneal nodules). If these variables are prospectively and consistently recorded, they can be used to create a table or drop down menu to be used in future structured reports (Tables 1 and 2). In addition, if all these data are routinely captured in radiologic reports of cases of thymoma, retrospective studies could be performed using the information contained in these reports.

**Definitions of Thymoma Report Terms**

**Primary tumor size:** We recommend documenting the three axes of tumor size to mirror information that is consistently contained in pathology reports of excised thymomas. The axial slice chosen for measurement is that which demonstrates the longest tumor dimension. The short axis is perpendicular to the long axis on that same slice (Figure 1). Because tumor orientation does not always conform to strict sagittal or coronal reformats, the superior-inferior dimension of the tumor should be obtained by subtracting the lowest from the highest bed position in which the primary tumor is seen (Figure 1).
Location: It is expected that most of these lesions will be located in the prevascular anterior mediastinum. Some of these lesions are unilateral while others cross the midline involving both sides of the mediastinum.

Contour: A lesion contour is considered smooth in the absence of spiculation, ill-defined borders or lobulation. Smooth lesions are typically spherical or ovoid in shape, but lesion contours may also conform to the shape of the adjacent mediastinum. A lobulated contour is one that exhibits one or more lobulations, characterized as convex tumor contours with adjacent notches between tumor lobules (Figure 2).

Attenuation: Thymomas may demonstrate homogeneous or heterogeneous attenuation. Heterogeneous attenuation often manifests as areas of low attenuation within the tumor and should be assessed on soft tissue or mediastinal windows. Administration of contrast will help demonstrate tumor heterogeneity and is recommended if not contraindicated (Figure 3). Cystic thymomas exhibit intrinsic low attenuation manifesting as homogeneous water attenuation surrounded by the soft tissue tumor capsule. These lesions may also exhibit internal soft tissue septa. The presence of mural soft tissue nodules in a cystic anterior mediastinal mass is one of the characteristic manifestations of cystic thymoma.

Calcifications: Calcifications of any pattern, including curvilinear, punctate or coarse have been associated with more advanced disease and should be described and characterized. Viewing the same image at a different window level, such as with bone window may accentuate the differences between intravascular contrast and tumor calcification (Figure 4).

Infiltration of surrounding mediastinal fat: For a tumor to be characterized as infiltrating the surrounding fat, it need only infiltrate the fat in one location, and not necessarily along its entire circumference. Such neoplasms may exhibit irregular borders. Tumors that abut the mediastinal vessels without an intervening fat plane are not considered as infiltrating of surrounding fat, as the mediastinal fat that typically surrounds the vessel cannot be evaluated for infiltration if it cannot be visualized (Figure 5).

Tumor abutting ≥ 50% of mediastinal structure: To maintain consistency in imaging reports, vessel abutment should be described as the percentage of the vessel circumference that is touched by the adjacent tumor without an intervening tissue plane (Figure 6).

Direct vascular invasion: Vascular invasion is rarely seen but may manifest as direct extension of the tumor into a vessel lumen (Figure 7). When present, any appreciable narrowing or deformity of the vessel lumen should be described as well.

Mediastinal lymph node enlargement: The presence and nodal stations of mediastinal lymph node enlargement should be noted in the report, as removal of any enlarged lymph nodes at surgery is recommended. The definition of mediastinal lymph node enlargement is a short axis diameter of a lymph node greater than 1cm on an axial image (Figure 8).

Adjacent lung abnormalities: Adjacent lung abnormalities such as intrapulmonary extension of tumor are rarely appreciated on CT, and are usually detected intraoperatively. The most common pulmonary abnormality seen on chest CT is compressive atelectasis by the adjacent tumor but this may be difficult to differentiate from direct extension of tumor into lung (Figure 9).

Pleural effusion: Pleural effusions are not common in patients with thymoma. However, presence or absence of pleural effusions should be documented on the report as they are more frequently associated with thymic carcinoma and metastatic pleural involvement by primary neoplasms other than thymoma (Figure 9).

Diaphragmatic elevation: Inclusion of the phrenic nerve in the resection may compromise pulmonary function and may lead to serious postoperative complications. Preoperative documentation of phrenic nerve involvement is of utmost importance as affected patients may receive preoperative chemotherapy prior to surgery to allow complete tumor resection of disease without resection of the phrenic nerve, thus leading to a favorable functional and survival benefit. Therefore, elevation of the hemidiaphragm should be documented in the
In addition, tumor abutting the anatomic location of the course of the phrenic nerve should also be mentioned. The phrenic nerve courses over the brachiocephalic artery, posterior to the subclavian vein, and then crosses anterior to the hilum, over the pericardium covering the right atrium (right phrenic nerve) or left ventricle (left phrenic nerve) to the diaphragm, where it divides into branches which pierce that muscle and are distributed to its under surface (Figure 10).

Pleural nodules: Metastatic thymoma typically involves the pleura, and manifests as soft tissue pleural nodules that range from small lentil-shaped nodules to large pleural masses and can progress to circumferential nodular pleural thickening with involvement of the interlobar fissures. Solid pleural metastases (Stage IVa) should be distinguished from pulmonary parenchymal metastases (Stage IVb). Pleural nodules are disposed along the anatomic location of the pleural surfaces and are best assessed on the lung window in cases of early disease. Intraparenchymal pulmonary nodules are completely surrounded by lung parenchyma (Figure 11).

Distant metastases: Distant metastases are uncommon at presentation and constitute stage IVb disease. The most common site is the lung followed by the liver, lymph nodes, and bone.

Conclusion

This paper provides a lexicon of terms that should be consistently used for describing mediastinal masses suspected of representing a thymoma. Knowledge of the imaging features of high stage thymomas as well as the correct use of these terms will add value to the CT report, will facilitate communication between clinicians and radiologists and will allow the radiologist to play an important role in helping the clinician make management decisions for their patients with thymoma including the use of preoperative therapy. Documentation of the above imaging features of thymoma provides the basis for structured reporting, and for a database for collected newly diagnosed thymoma cases that permits further research.
Table 1. Documentation of primary tumor characteristics

<table>
<thead>
<tr>
<th>VARIABLE</th>
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<tr>
<td>Size (cm)</td>
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<tr>
<td></td>
<td>Y-axis</td>
</tr>
<tr>
<td></td>
<td>Z-axis</td>
</tr>
<tr>
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<td>Smooth</td>
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<tr>
<td></td>
<td>Cystic</td>
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<tr>
<td>Calcification</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Infiltration of surrounding fat</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Abutment of ≥50% of mediastinal structure</td>
<td>Yes (list which structure/s)</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Additional mediastinal structures tumor abuts</td>
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</tr>
<tr>
<td></td>
<td>No</td>
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<tr>
<td>Direct vascular endoluminal invasion</td>
<td>Yes (list vessel name)</td>
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Table 2. Documentation of involvement of surrounding structures

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<td>Abnormalities in adjacent lung parenchyma</td>
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<td></td>
<td>Bilateral</td>
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<tr>
<td>Presence of a pleural nodule</td>
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<td>1</td>
</tr>
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<td></td>
<td>2-5</td>
</tr>
<tr>
<td></td>
<td>&gt;5/diffuse</td>
</tr>
<tr>
<td>Mediastinal lymph node enlargement (&gt; 1 cm in short axis on an axial image)</td>
<td>Yes (location according to node map&lt;sup&gt;31&lt;/sup&gt;)</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Abutment of expected location of phrenic nerve</td>
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<td></td>
<td>No</td>
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<tr>
<td>Elevated hemidiaphragm</td>
<td>Yes</td>
</tr>
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<td></td>
<td>No</td>
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<tr>
<td>Presence of a pulmonary nodule</td>
<td>Yes</td>
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<td></td>
<td>No</td>
</tr>
<tr>
<td>Extrathoracic suspected metastases</td>
<td>Yes (location)</td>
</tr>
<tr>
<td></td>
<td>No</td>
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Figure Legends

**Figure 1: Tumor Size Measurement.**
The measurement is obtained on the axial slice that demonstrates the tumor’s largest diameter; in this case, the largest diameter is 4 cm. The short axis, perpendicular to it is 3.5 cm. Tumor ranged in superior to inferior orientation from bed position 197 to 149 (197-149 = 48 mm) and thus the superior to inferior dimension is 4.8 cm. Thus, tumor size should be reported as: 4.0 x 3.5 x 4.8 cm, with the last measurement representing the superior to inferior dimension.

**Figure 2: Schematic and CT Examples of Contour.**
A) Smooth contour. B) Smooth contour conforming to the mediastinal structure the lesion abuts without evidence of lobulation. C) Contrast-enhanced chest CT (soft tissue window) showing a tumor that conforms to the mediastinal structure it abuts. D) Lobulated contour, with single sharp notch. E) Contrast-enhanced chest CT (soft tissue window) showing lobulated tumor due to the lateral sharp notch (white arrow) while medially the contour is smooth and conforms to the shape of the adjacent mediastinum (black arrowheads). F) Lobulated contour with multiple lobulations. G) CT image of a multilobulated tumor extending into lung parenchyma (white arrows point at lobulations).

**Figure 3: Attenuation**
Contrast-enhanced chest CT (soft tissue window) of a heterogeneous thymoma at the level of the pulmonary trunk. Arrows point to two of the many small low attenuation regions within the mass.

**Figure 4: Calcification**
Contrast-enhanced chest CT (soft tissue window) at levels set between bone and mediastinal window. Curvilinear high density regions (black arrows) are due to calcifications as they do not conform to the expected morphology of an opacified blood vessel, and most are of higher attenuation than opacified blood in the left atrium (LA) and ascending aorta (Ao).

**Figure 5: Infiltration of Mediastinal Fat**
Coronal oblique reformatted contrast-enhanced chest CT (soft tissue window) shows the thymoma (T) with infiltration of surrounding mediastinal fat (black arrows). Notice that the attenuation of the mediastinal fat further away from the tumor (arrowheads) is lower than that immediately adjacent to the lesion.

**Figure 6: Abutment of Vessels**
Contrast-enhanced chest CT (soft tissue window) demonstrates the thymoma (T) nearly completely encasing the right brachiocephalic vein (white arrow), whereas only abutting about 30% of the aorta (A) circumference. Arrowhead: contrast filled collateral vein.

**Figure 7: Vessel Invasion**
Contrast-enhanced chest CT (soft tissue window) at the level of the pulmonary trunk (PT) demonstrates a thymoma in the anterior mediastinum (arrowhead) with direct invasion (seen on a more superior slice) into the superior vena cava (white arrow). Note soft tissue attenuation of the intracaval mass similar to that of the primary tumor.

**Figure 8: Lymph Node Enlargement**
Contrast-enhanced chest CT (soft tissue window) at the level of the aortic arch (A) demonstrates the thymoma (T) and adjacent mildly enlarged ipsilateral mediastinal lymph nodes (white arrows). At surgery no malignancy was found within these lymph nodes.
**Figure 9: Pulmonary Parenchymal Involvement**
Contrast-enhanced chest CT (soft tissue window), at the level of the right pulmonary artery (rp) shows a thymoma (T) compressing the middle lobe bronchus with resultant atelectasis of the middle lobe. The atelectatic middle lobe is seen between the tumor edge (black arrowheads) and the right major fissure (white arrows). It is difficult to determine whether there is direct tumor invasion into the lung parenchyma at this site. Note the associated right pleural effusion (e).

**Figure 10: Phrenic Nerve Involvement**
PA chest radiograph of newly diagnosed thymoma demonstrates a large mediastinal mass (M) with associated elevation of the left hemidiaphragm (arrowhead). Contrast-enhanced chest CT (soft tissue window) at the level of the left pulmonary artery (L) demonstrates the thymoma (M) abutting the entire left side of the mediastinum anterior to the hilum, this location is in the expected course of the left phrenic nerve.

**Figure 11: Pleural and Pulmonary Metastasis**
Contrast-enhanced chest CT (lung window) demonstrates the thymoma (T) abutting the pulmonary trunk (*). There is a pleural metastasis within the left major fissure (PM), a left pleural effusion (e), and a pulmonary nodule (black arrow) surrounded by lung.
References