Thoracic imaging is important in the management of patients with lung cancer, mediastinal neoplasms, and mesothelioma. Imaging is used in these patients to determine anatomic extent of disease and appropriate therapeutic management. This chapter reviews the use of conventional anatomic imaging and newer thoracic imaging techniques such as positron emission tomography (PET) in staging, assessing treatment response, and monitoring for tumor recurrence after treatment of lung cancer, mediastinal neoplasms, and mesothelioma.

**LUNG CANCER**

**Staging Non–Small-Cell Lung Cancer**

Because most patients with lung cancer have advanced disease at presentation, diagnosis is usually not difficult. However, treatment and prognosis, both dependent on the anatomic extent of disease, can be more difficult to determine. Comprehensive patient evaluation, including imaging, is usually performed to define disease extent in patients with non–small-cell lung cancer (NSCLC). The International System for Staging Lung Cancer describes the anatomic extent of disease in a traditional TMN system that enables a standardized description of NSCLC in terms of the primary tumor (T), lymph nodes (N) and metastases (M). The primary tumor is described according to its size, location, and extent of local invasion. Computed tomography (CT) is more accurate than chest radiographs in assessing these parameters, and is typically used to further evaluate the patient after initial radiographic diagnosis because it is more readily available and less expensive than magnetic resonance imaging (MRI). Additionally, the higher spatial resolution of CT compared to MRI allows more optimal evaluation of the lungs and the detection of small lung metastases. CT and MRI are both useful in confirming gross chest wall (Figure 36c-1) or mediastinal invasion but are inaccurate in differentiating between anatomic contiguity and subtle invasion. MRI can be a useful adjunct to CT in showing the extent of great vessel, pericardial or cardiac involvement, particularly if there is a contraindication to the intravenous administration of iodinated contrast. Additionally, because of its superior soft-tissue contrast resolution and multiplanar ability, MRI is particularly useful in the evaluation of patients with superior sulcus tumors (Figure 36c-2).

The presence of nodal metastases and their location are important in determining management and prognosis in patients with NSCLC. Size is the only criterion used to diagnose nodal metastases, with nodes greater than 10 mm in short-axis diameter considered abnormal. Chest radiographs are not sensitive or specific in evaluating nodal metastases (Figure 36c-3). CT and MRI are better in this regard, but because enlarged nodes can be hyperplastic and small nodes may contain metastases, the accuracy of CT and MRI in the detection of metastases to hilar and mediastinal nodes is not optimal. PET using a radioactive glucose analog, 2-(18F)-fluoro-deoxy-D-glucose (FDG) can be used to improve the accuracy of CT and MRI in the detection of nodal metastases.

Although patients with NSCLC commonly have metastases to the adrenal glands, kidneys, liver, brain, bones, and lymph nodes at presentation, the role of imaging in the detection of these metastases is not clearly defined. Because the combination of a normal clinical examination and normal laboratory tests has a negative predictive value greater than 95% for extrathoracic metastatic disease, it has been suggested that routine radiologic evaluation for occult extrathoracic may not be required. However, routine imaging of the abdomen is still performed in most patients with NSCLC because clinical and laboratory findings are unreliable in the detection of adrenal, renal, hepatic, and abdominal nodal metastases.

Figure 36c-2 Superior sulcus tumor with invasion of the chest wall and brachial plexus. A, Chest CT shows mass (M) in the apex of the left hemithorax with focal destruction (black arrow) of the adjacent vertebral body. B, Sagittal T1-weighted MR image shows mass (M) in the apex of the left hemithorax with encasement of the left subclavian artery (white arrow) and C8, T1, and T2 roots of the brachial plexus. Note that the tumor extends to the intervertebral neural foramina.

Figure 36c-1 Non–small-cell lung cancer and vertebral body invasion. Chest CT shows mass (M) in the right upper lobe with destruction (black arrow) of the adjacent vertebral body.
of the central nervous system has also been advocated because up to 18% of patients with NSCLC have brain metastases at presentation. However, these metastases are usually associated with neurologic signs and symptoms, and if the patient is asymptomatic, imaging of the brain is frequently not performed. Similarly, imaging rarely reveals occult skeletal metastases and therefore bone radiographs, technetium 99mTc (technetium)-labeled methylene diphosphonate bone scintigraphy, and MRI are usually only performed if the patient has focal bone pain or an elevated alkaline phosphatase level.

Because staging of NSCLC performed on the basis of symptoms, laboratory findings and conventional radiologic imaging can be inaccurate, whole-body imaging with FDG-PET is being used to improve the accuracy of staging (Figure 36c-6). FDG-PET has a higher sensitivity and specificity than CT in detecting metastases to the adrenal glands, bones, and extrathoracic lymph nodes. Whole-body PET permits staging of intra- and extrathoracic disease with a single study, reveals occult extrathoracic metastases in patients selected for curative resection, and alters management in up to 40% of patients.

Small-Cell Lung Cancer

Small-cell lung cancer (SCLC) is generally staged as limited disease (malignancy confined to a hemithorax and regional lymph nodes) or extensive disease (malignancy with noncontiguous metastases to the contralateral lung or distant metastases). Most patients with SCLC have extensive disease at presentation and common sites of metastatic disease include the liver, bones, bone marrow, brain, and retroperitoneal lymph nodes (Figure 36c-7). There is no consensus regarding the imaging studies and invasive procedures that should be performed in the staging evaluation of SCLC, but evaluation for extrathoracic metastatic disease is usually directed at the common sites of metastases. Unlike NSCLC, central nervous system metastases are common at presentation in patients with SCLC. Because most of these patients are asymptomatic, CT or MRI of the brain is often routinely performed in patients with SCLC. Similarly, routine CT or MRI of the abdomen is performed because metastases to the liver and abdominal nodes are common at presentation and these patients are often asymptomatic. Although patients with SCLC with bone and bone marrow metastases are also often asymptomatic and frequently have normal blood alkaline phosphatase levels, isolated bone and bone marrow metastases are
radiologic images. Tumors are usually measured on chest radiographs or CT images and treatment response, largely determined by using a single measurement of the largest tumor diameter, is determined using uniform criteria known as the Response Evaluation Criteria in Solid Tumors (RECIST).43 Because there can be marked inconsistency in the measurement of lung lesions when using radiographs and CT scans, it has been suggested that the measurement of tumor volume may allow an earlier and more accurate assessment of tumor response.44–46

The accurate assessment of treatment response is further complicated by the recent development of treatment regimens where the antitumor effect is cytostatic and decrease in tumor size as a manifestation of treatment response is unlikely. Accurate determination of response may thus require functional and molecular techniques that assess metabolism, growth kinetics, angiogenesis growth factors, tumor cell markers, and in vivo genetic and gene expression alterations.47 In this regard, PET is a clinically available method that is sensitive and specific for studying molecular interactions in vivo. FDG uptake, increased in most malignant tumors, can be measured by using PET and may allow an early and sensitive assessment of the antitumor effect of anticancer chemotherapy.48,49 Furthermore, PET may have an important role in guiding patient care after surgery or radiation therapy, as it is more accurate than conventional studies in detecting recurrent tumor.50,51

MEDIASTINAL MASSES

Mediastinal tumors comprise a diverse group of abnormalities composed of congenital, inflammatory and neoplastic lesions. To assist in diagnosis and management, these masses are usually imaged with CT or MR and described according to the site of origin and location in the mediastinum. Although CT provides the requisite information in most patients with mediastinal abnormalities, MRI, because of its multiplanar capability, is especially useful in the evaluation of the diaphragm and anatomically complex regions such as the aortopulmonary window. Contrast resolution with MRI is superior to CT and thus MRI can be useful in delineating mediastinal anatomy and demonstrating vascular structures without contrast enhancement (Figure 36c-8).

CT and MRI are particularly useful in showing local soft-tissue and vascular invasion and early dissemination to regional lymph nodes in tumors such as thymomas and thymic carcinomas (Figure 36c-9). Also, because of the varying composition of soft tissue, fat, calcium, and hemorrhage in teratomas, CT and MRI can occasionally differentiate these tumors from thymomas and lymphomas.52,53 CT, together with gallium-67 scintigraphy, is also usually used as the primary staging modality in patients with suspected mediastinal lymphoma. However, after treatment residual masses are common and distinguishing a fibrotic mass from persistent or recurrent tumor can be difficult by CT imaging.54,55 In these cases, MRI can be a useful adjunct to gallium-67 for monitoring and evaluating response to therapy, differentiating fibrosis from residual tumor, and detecting recurrent lymphoma.56 MRI is also the preferred modality for evaluating neurogenic tumors within the mediastinum as it may simultaneously assess (1) intraspinal extension, (2) spinal cord abnormalities, (3) longitudinal extent of tumor, and (4) extrudal extension.

MALIGNANT PLEURAL MESOTHELIOMA

Because accurate anatomic staging is becoming important in determining the selection of

uncommon.36,38,40,41 Consequently, 99mTc-labeled methylene diphosphonate bone scintigraphy and MRI are usually performed only if the patient has other findings of extensive disease. Recently it has been suggested that whole body FDG-PET imaging may be useful in improving and simplifying the staging of SCLC.42

ASSESSING TREATMENT RESPONSE The antitumor effect of a treatment in patients with solid tumors can be determined by clinical and/or biochemical evaluation, surgical pathologic restaging, or serial measurements of tumor size on

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Axial T1-weighted MR image shows anterior mediastinal mass with intermediate signal intensity. Chest CT reveals large lobular mediastinal mass. Chest CT shows lobular pleural mass. Invasive thymoma manifesting as a mediastinal mass. Noncontrast CT shows diffuse heterogeneous anterior mediastinal mass with intermediate signal intensity and flow within compressed left brachiocephalic vein and SVC. Patient was allergic to iodinated contrast. Coronal T1-weighted MR image shows diffuse pleural mass and reveals metastases in the right humerus. Figure 36c-8 Hodgkin’s lymphoma in a patient with clinical findings suggestive of obstruction of the superior vena cava (SVC). Patient was allergic to iodinated contrast. A, Noncontrast CT shows diffuse heterogeneous anterior mediastinal mass (M) and bilateral pleural effusions (P). Note central venous catheter in SVC (arrow) and poor visualization of SVC and aorta (A). B, Axial T1-weighted MR image shows anterior mediastinal mass with intermediate signal intensity and flow within compressed left brachiocephalic vein (asterisk) and SVC (arrow). More distal images (not shown) showed patency of markedly narrowed SVC.

In patients with potentially resectable disease, MRI can be performed to further examine the local extent of tumor (Figure 36c-10). In a recent study, MRI and CT were found to be of nearly equivalent diagnostic accuracy in the staging assessment of patients with MPM. However MRI was more accurate than CT in assessing invasion of the diaphragm and limited chest wall invasion. Accordingly, initial imaging evaluation of patients with pleural mesothelioma is usually performed using CT. In those patients considered surgical candidates who have questionable areas of local tumor extension on CT, MRI may provide additional information before extrapleural pneumonectomy is attempted. PET using the radionuclide-imaging agent FDG has been used to evaluate MPM and may aid in the preoperative evaluation of those patients being considered for extrapleural pneumonectomy. However, the role of FDG-PET in the staging of MPM has not been fully elucidated.

CONCLUSION

Conventional anatomic imaging (chest radiographs, computed tomography, magnetic resonance imaging) is an integral component in the evaluation and management of patients with thoracic neoplasms. Radiologic imaging is useful for (1) improving the accuracy of clinical staging of lung cancer and mesothelioma; (2) assessing the anatomic extent and presence of local invasion of mediastinal neoplasms; and (3) determining therapeutic response. Positron emission tomography complements conventional radiologic assessment of thoracic neoplasms and improves the accuracy of staging and determination of therapeutic response.

REFERENCES

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