Radiologic Evaluation in Chest Malignancies*
A Review of Imaging Modalities

Robert D. Pugatch, MD

Radiologic evaluation of the patient with non-small cell lung cancer (NSCLC) includes chest radiographs for detecting nodules, computed tomography (CT) for further characterizing them, CT and magnetic resonance imaging (MRI) to evaluate the mediastinum, and extrathoracic imaging of bones, the adrenal gland, the central nervous system, and liver. The current practice standards for each are reviewed. Asymptomatic solitary pulmonary nodules, which are usually detected on chest radiographs obtained for other indications, inevitably require a precise diagnosis. The radiologic characteristics that differentiate benign from malignant pulmonary lesions are given. Mediastinal CT is the preferred modality for examining the mediastinum in patients with NSCLC. Magnetic resonance imaging is used selectively, e.g., in patients with superior sulcus tumors who are candidates for surgery. When evaluation for N2/N3 disease is requested, mediastinoscopy should replace CT using the latter as a “roadmap.” The role of extrathoracic imaging in evaluating asymptomatic patients with NSCLC at initial presentation is equivocal. Computed tomographic scanning of the head is reasonable in most patients with lung cancer, given the significant incidence of occult brain metastases in this population and that solitary brain lesions may be resected in some protocol settings. Routine liver and adrenal gland scanning is similarly controversial. Bone scans do not appear to be useful in patients with NSCLC unless they have clinical signs, symptoms, or laboratory findings to indicate possible metastases. Although heavily affected by local practice, radiologic evaluation of the patient with NSCLC should attempt to provide accurate determination of local disease and a search for distant metastases.

(CHEST 1995; 107:294S-297S)

This article will address three aspects of lung cancer imaging: the radiographic characterization of pulmonary nodules, the current role of computed tomography (CT) and magnetic resonance imaging (MRI) in evaluating the mediastinum, and the use of extrathoracic imaging in patients with non-small cell lung cancer (NSCLC). It is important to note at the outset that the workup of such individuals is driven, in large measure, by prevailing local attitudes.

Solitary Pulmonary Nodules

The best survival in patients with lung cancer is achieved by individuals with asymptomatic solitary pulmonary nodules that are usually detected on chest radiographs obtained for other indications. Although detecting (or failing to detect) lung cancer is fraught with difficulty, once an abnormality has been detected, it is obligatory in the appropriate clinical setting to determine a precise diagnosis.

In framing a reasonable approach to a pulmonary nodule, nothing is too small to be lung cancer. When lung cancer is detected on a radiograph, it is anywhere from 8 to 17 years into its natural history. Small lesions must be respected. A “watch and wait” approach is not prudent, especially for high-risk patients (e.g., smokers).

When a solitary pulmonary nodule of ≤3 cm is detected, a benign diagnosis can be made only if edge characteristics include a smooth, well-demarcated contour. Once lesions become spiculated or irregular, they are far more likely to be lung cancer. Lesions with a lobular contour or an irregular shape likely represent bronchogenic carcinoma.

A lesion that has a certain pattern of calcification can ensure a benign diagnosis. Centrally calcified lesions are typically granulomas, as are homogeneously diffuse lesions. The stippled pattern and the eccentric pattern of calcification frequently seen in bronchogenic carcinoma may be the result of production of calcium by the tumor, or (as seen in mucin-producing adenocarcinomas) infarction due to vascular overgrowth, or engulfment of a preexisting granuloma.

Lesions known to be stable over 2 years can be assumed to be benign, although documenting stability with historic radiographs and scans may pose considerable logistic challenges. In general, only well-defined lesions that measure ≤3 cm in diameter should be evaluated for benign characteristics by CT. The prevalence of malignancy in larger or spiculated lesions is above 85%. Computed tomography is also capable of detecting pathologic calcification in lung cancer (10 to 15% of all lesions). To achieve the best results, thin section scanning (1 to 5 mm) of the area

*From the Department of Radiology, Harvard Medical School, Boston.
of radiographic abnormality should be used.1,2

Hamartomas can be diagnosed with confidence if fat or calcium is demonstrated on CT. In our experience, they are rarely calcified and rarely contain fat. Visual inspection of the abnormality with or without determination of density is usually adequate.

Although some groups have shown success with lung imaging using metabolically active agents such as radiolabeled F-18 fluorodeoxyglucose, the procedure is expensive, requires positron emission scanning capabilities, and has been performed only recently in sufficiently large numbers of patients to warrant further clinical study.3

Contrast-enhanced CT scans that evaluate changing patterns of enhancement to differentiate benign from malignant nodules offer another useful imaging technology.4 Regardless of the imaging modality, however, the end point—a specific diagnosis—is still the exception. Most solitary pulmonary nodules are indeterminant; they require further procedures to reach a definitive diagnosis, usually with fine-needle aspiration biopsy or resection via thoracoscopy/thoracotomy.5

**MEDIASTINAL IMAGING**

Whenever looking at the mediastinum, one must determine how the information will assist the responsible specialist in staging the condition of his patient. Mediastinal CT has many uses, including demonstrating enlarged nodes and helping to stage central malignant disease.

The presence or absence of mediastinal lymph node involvement is of important prognostic significance. Ideally, any diagnostic method short of tissue sampling would be welcome, but present techniques do not allow this. Noninvasive clinical tests for evaluating the local spread of bronchogenic carcinoma are lacking. Radiologic imaging offers a wide range of examination techniques. The chest radiograph remains very specific but highly insensitive for mediastinal metastases.

Computed tomography remains the preferred imaging modality for examining the mediastinum in patients with NSCLC. The information provided by the CT scan must then be correlated with results of various lymph node sampling procedures.

Early studies indicated fairly sensitive and specific data from CT/pathologic correlation,6 but more accurate studies clearly show that enlarged lymph nodes on CT (with a short-axis diameter >1 cm) must be sampled.7 Knowing the anatomic sites of such nodes may alter the surgical approach and help ascertain N2/N3 status as well.

The Radiologic Diagnostic Oncology Group study comparing CT and MRI showed a slight advantage for MRI, but not enough to recommend its use in patients with lung cancer who initially present for evaluation of mediastinal dissemination.8 Our group uses MRI in select cases: eg, for anatomic problem solving, and when the surgeon believes that such information will be of use. Additionally, MRI is recommended in all surgical candidates with superior sulcus tumors.

In assessing mediastinal adenopathy in patients with lung cancer, a normal CT scan does not preclude disease, because intranodal or microscopic involvement is imperceptible on CT. Magnetic resonance imaging cannot yet characterize the actual contents (benign vs malignant) of a lymph node.

Although CT is the preferred imaging modality for mediastinal evaluation, mediastinoscopy or some other technique should uniformly be used to evaluate for N2/N3 disease.

**EXTRATHORACIC IMAGING**

Some clinicians believe that extrathoracic staging has no valid role in evaluating asymptomatic patients with NSCLC at initial presentation, and studies have demonstrated that routine bone, brain, and liver/spleen scans are unnecessary and potentially misleading in evaluating lung cancer.9,10 The best method for determining the presence of metastases remains a thorough history and physical examination, with appropriate laboratory studies. Can imaging justifiably replace this approach?

Autopsy studies of patients who died of lung cancer have shown frequent extrathoracic metastases.11 The clinical significance of metastases of any cell type is catastrophic. These metastases primarily involve the central nervous system (CNS), skeleton, liver, mediastinal lymph nodes, and adrenal glands and less commonly the skin, soft tissue, bowel, pancreas, and kidneys.

By examining issues related to the known frequency of metastases (often dependent on knowledge of the cell type of the primary neoplasm) and the extent of thoracic disease, we can begin to assess the effectiveness of extrathoracic imaging in evaluating patients with lung cancer. Because small cell carcinoma is considered largely a separate entity, only NSCLC will be considered.

If the patient is a surgical candidate and the chest CT scan shows no absolute criteria for inoperability, what is the role of extrathoracic imaging? How is it supported in the literature? Should all patients with NSCLC undergo a head CT scan, MRI, bone scan, and radiographic study of the upper abdomen (ie, the liver and adrenal glands)? As before, the radiologist’s actions are ultimately guided by the surgeon’s choice and objectives.

Extent of thoracic disease is not a reliable indica-
tor of extrathoracic metastases; 25% of patients with no evidence of hilar or mediastinal lymph node enlargement—mainly patients with adenocarcinoma of the lung—have been shown to have extrathoracic metastases. Isolated metastases are rare.

The Adrenal Gland

Isolated adrenal metastases rarely occur in patients with lung cancer; 98% of patients with lung cancer who have metastasis to the adrenal glands have disease elsewhere. Approximately 50% of adrenal masses that are radiologically detected are, in fact, benign (e.g., adenomas, cysts). Nevertheless, isolated adrenal metastases have been reported in 2.4% of patients with NSCLC (most have other metastases). When the adrenal glands are a site of involvement, they are easily visualized on chest CT, because metastases usually cause the gland to enlarge.

In practice, most thoracic CTs include the adrenals in a person suspected of having lung cancer. Adrenal evaluation allows detection of the 2 to 9% of the adult population with adrenal adenomas. Yet the size, shape, homogeneity, and heterogeneity of the adrenal gland are of little help in distinguishing between benign and malignant disease. Patients never report adrenal dysfunction. Magnetic resonance imaging is of questionable help. Biopsy specimens may be diagnostic if the pathologists who review the biopsy specimens are experienced in differentiating adenoma from metastatic adenocarcinoma.

The Brain and CNS

In patients with lung cancer, brain and CNS involvement generally occurs as solitary or multiple intracranial masses, meningeal carcinomatosis, and spinal cord involvement.

Preoperative CT or MRI in asymptomatic patients with normal neurologic status remains controversial. The highest incidence of metastasis is in patients with adenocarcinoma, for whom the brain may be the only site of metastases. Among patients with NSCLC, 10% have CNS involvement at presentation. However, most brain metastases cause specific neurologic abnormalities. We know that the incidence of adenocarcinoma is rising, and that at least 20% of such patients also have occult brain metastases. We also know, however, that solitary masses may be resectable, rarely allowing some patients to achieve a cure.

The Liver

As with the adrenal gland, a portion of the liver is included in chest CT imaging. For radiologists who do not routinely use contrast media (as in our institution), hepatic lesions are not frequently detected or clarified. Isolated hepatic metastases are very uncommon in patients with NSCLC. When lesions are solitary and no other metastases are evident, such abnormalities usually represent a benign process.

Because visualization of the liver cannot be avoided during chest CT scanning, we recommend that radiologists either undertake full-fledged studies or establish a prior agreement with referring clinicians regarding attention to hepatic lesions. Again, isolated hepatic metastases in patients with NSCLC are uncommon.

Bone

In the absence of new onset of pain or elevated levels of alkaline phosphatase, bone scanning does not appear to be cost-effective in evaluating patients with NSCLC. In fact, bone scans often result in false-positive results by detecting abnormalities that have no relationship to the primary lesion.

Conclusion

Ideally, radiographic evaluation of patients with NSCLC includes accurate determination of cell type, assessment of local disease, and a search for distant metastases, as required to assist in the determination of surgical candidacy. Practical experience should prevail in making decisions regarding radiologic evaluation.

References

1. Templeton PA, Zerhouni EA. High resolution computed tomography and focal lung disease. Semin Roentgenol 1991; 26:143-58
5. Gurney JW. Determining the likelihood of malignancy in solitary pulmonary nodules with bayesian analysis. Radiology 1993; 186:405-22
14 Reing JW, Doppman JL, Dwyer AL. Adrenal masses differentiated by magnetic resonance. Radiology 1986; 158:81-4