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REVIEW

Imaging of pleural masses: Which to choose?

Aaron S. Bruns*, John G. Mastronarde

Division of Pulmonary and Critical Care, The Ohio State University Medical Center, 473 West 12th Avenue, Columbus, OH 43210, USA

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Summary
The differential diagnosis of pleural masses is limited. Asbestos-related disease and invasive bronchogenic carcinoma make up the majority of cases. The diagnostic yield of biopsies is low, and invasive procedures are often required to achieve diagnosis. A variety of imaging techniques are available to help differentiate between benign and malignant disease to help discern which patients to biopsy. While computed tomography has a relatively good sensitivity and specificity, magnetic resonance imaging (MRI) and positron emission tomography (PET) both appear to have higher accuracy. MRI has the added benefit of being an excellent aid in determining surgical resectability of tumors. MRI and PET are limited, however, by their cost and availability in certain regions.

Contents

*Corresponding author. Tel.: +1 614 247 7707; fax: +1 614 293 4799.
E-mail addresses: Aaron.Bruns@osumc.edu (A.S. Bruns), John.Mastronarde@osumc.edu (J.G. Mastronarde).

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Educational aims

- To briefly review the differential diagnosis of pleural masses.
- To familiarize the reader with the various imaging modalities available for evaluating pleural-based masses.
- To understand the strengths and weaknesses of each imaging modality.

Case presentation

A 68-year-old woman with a history of diabetes mellitus and hypertension presented to our outpatient pulmonary clinic for evaluation of an abnormal chest computed tomography (CT). She initially presented to her family practitioner with complaints of snoring, poor quality sleep, and excessive daytime sleepiness. A polysomnogram (PSG) done at that time was negative for obstructive sleep apnea (OSA). However, significant oxygen desaturation was noted during sleep, and the patient was placed on nocturnal oxygen. As part of the work-up to discern the etiology of her nocturnal desaturations, a chest X-ray revealed a possible right lower-lobe lung mass. A chest CT was then performed (Figure 1). Positron emission tomography (PET) was then performed which showed the mass to be hypermetabolic with a standardized uptake value (SUV) of 7.7.

Based on the CT findings, the patient was referred to radiology for a CT-guided biopsy of the mass. Pathology (Figure 2) revealed bland-appearing spindle cell proliferation with collagenous stroma. Immunohistochemical stains were negative for Ki-67 and calretinin. Stains for S-100 were strongly positive, suggesting a neural-based tumor.

Based on the pathology findings and the patient's symptoms, she was referred to thoracic surgery for consideration of resection of the mass. During the surgery, the mass was found to originate from the intercostal nerve between the fifth and sixth ribs in the posterior mediastinum. Frozen sections revealed a schwannoma (Figure 3).

Pleural plaques are found in 20–60% of workers exposed to asbestos, and are the most common cause of pleural masses.[1,2] Localized pleural tumors include lipomas, liposarcomas, and fibrous tumors of the pleura. These tumors are rare, often asymptomatic, and usually have a good prognosis with resection.[2] Bronchogenic carcinoma may invade the pleura; giving an appearance consistent with a pleural mass. While malignant mesothelioma and metastatic tumors from other sites usually present as extensive pleural disease or effusion, they may occasionally present as discrete pleural masses as well. As in our case, masses in the posterior mediastinum can masquerade as pleural masses depending on the imaging modality chosen. Therefore, it is important to choose the proper imaging modality to fully evaluate pleural masses.

Chest radiography

Radiography is commonly used as an initial screening test when evaluating patients with suspected lung disease or pleural abnormalities. However, conventional radiography is extremely limited in its ability to differentiate between benign and malignant pleural processes, as well as pleural processes from parenchymal ones.[3] When evaluating for asbestos-related disease, radiography has a sensitivity of only 13–53%.[4] In addition, differentiating malignant from benign disease is often difficult using less invasive diagnostic techniques, such as pleurocentesis or percutaneous pleural biopsy[5]; VATS or open thoracotomy is often required. Thus, if proper imaging can narrow the diagnosis, more invasive procedures can be avoided in some cases.

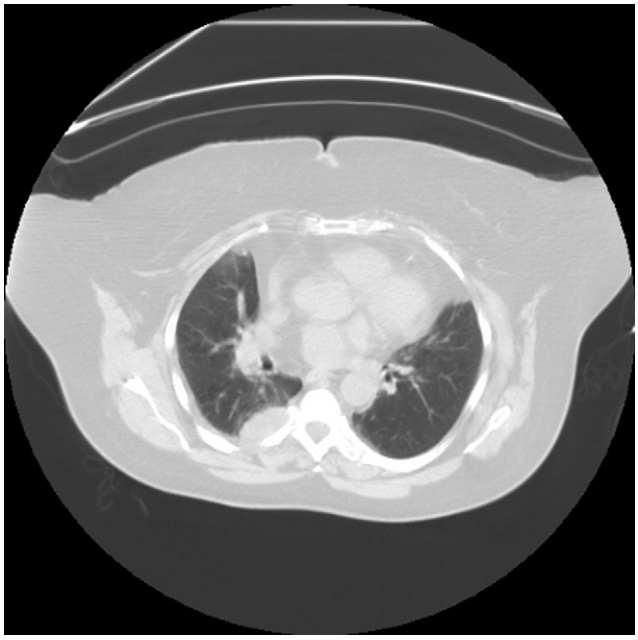

Figure 1 Chest CT.

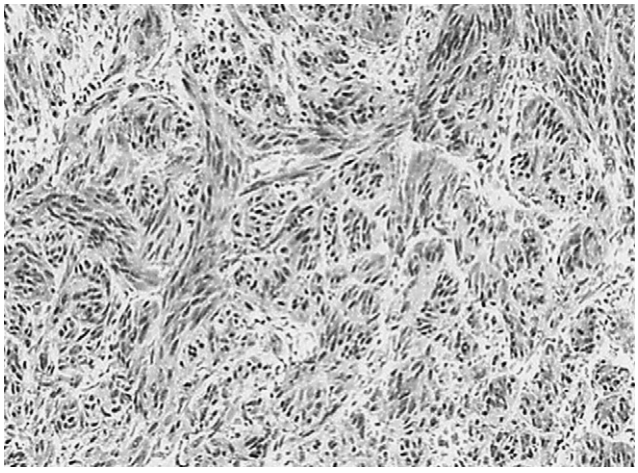

Figure 2 Spindle cell tumor, low magnification, S-100 stain.

Computed tomography

When compared to radiography, the use of CT is superior in differentiating between pleural and parenchymal disease, determining the location and extent of disease, and can occasionally allow characterization of tissue based on signal attenuation.[6] In addition, CT is more sensitive in detecting pleural plaques[7] and in detecting chest wall/pleural invasion

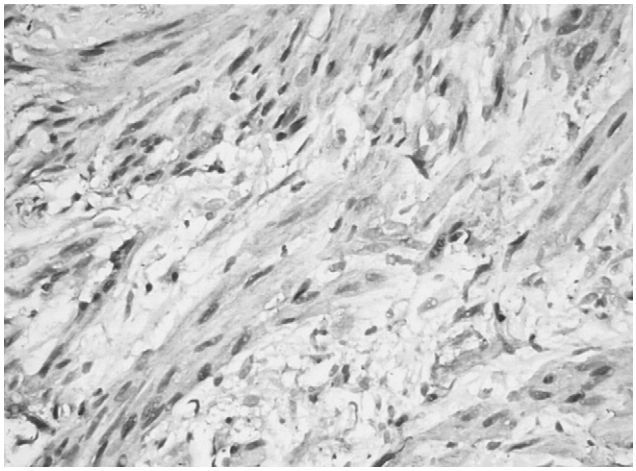

Figure 3 Frozen section of Schwannoma, low magnification, S-100 stain.

Table 1 Sensitivities and specificities for malignant disease using CT scan.

	Sensitivity (%)	Specificity (%)
Pleural rind	41	100
Nodular thickening	51	94
Parietal thickening >1 cm	36	94
Mediastinal pleural disease	56	88

by a peripheral tumor[8] (although CT is also limited in this ability, see discussion of CT versus MRI below).

One of the earliest studies investigating the use of CT in evaluating pleural disease was performed by Leung et al.[9] This was a retrospective study evaluating the CT findings in 71 patients with pleural disease who all had definitive pathologic diagnoses. Several findings were more significantly associated with malignant disease than with benign disease. The results of this study are summarized in Table 1. In addition, it was noted that pleural calcification was suggestive of a benign process, seen in 16 of 35 patients with benign disease, versus three of 39 with malignant disease.

In a more recent investigation of 42 patients with pleural disease evaluated by CT scanning, mediastinal pleural involvement and pleural nodularity were again found to be more common in malignant disease.[10] Pleural contour irregularity and infiltration of the chest wall or diaphragm were other features more often associated with malignant disease. Twenty-five of the 27 cases of malignancy had one or more of these features, versus only two of 15 cases of benign disease for a sensitivity of 93% and a specificity of 87% for detecting malignant disease.

Magnetic resonance imaging (MRI)

A major advantage of using MRI is its superior soft tissue contrast- and spatial-resolution.[11] As a result, MRI is particularly good at demonstrating infiltration of the chest wall or other adjacent tissues by malignant disease, which becomes important when determining resectability.[11,12] In a study of 34 patients with pleural lesions evaluated by MRI, high signal intensity on T2-weighted images was associated with a specificity of 87%, sensitivity of 100%, and negative predictive value of 100% in detecting malignant lesions.[13]

CT versus MRI

Most of the data in the use of MRI concerns its comparison to CT scanning in the evaluation of pleural masses. Initially, when CT and MRI were in their youth, a major advantage of MRI in evaluation of the chest was its ability to image the body in multiple planes. However, with modern computer technology and 3D reconstruction, CT is now able to provide the same information, making MRI less superior in this area.

In the previous study by Falaschi et al.,[13] all the patients enrolled also received a CT scan during the evaluation. Based on morphologic features alone, six of the 34 lesions were incorrectly identified using CT. Using these six, MRI was able to correctly identify all of them using long-TR-weighted images.

The article by Hierholzer et al.,[10] previously mentioned also compared CT and MRI in the evaluation of pleural diseases. Using morphologic criteria, the features of malignant disease were similar to that of CT: mediastinal pleural involvement, nodularity, contour irregularity, and infiltration of the chest wall or diaphragm. MRI was able to discern an additional four cases of chest wall or diaphragm infiltration over CT, which is important when staging and determining resectability. When evaluating pleural disease using signal intensity, 20 of 22 malignant cases demonstrated signal hyperintensity versus only three of 15 benign cases. The combination of morphologic criteria and signal intensity was able to correctly identify all 27 cases of malignant disease. The overall result revealed MRI as superior in determining chest wall and diaphragm invasion with CT being superior in detecting calcification (a marker of benignity) and bony destruction. CT also has the advantage of being superior in guidance for biopsy.[14]

Other studies comparing CT versus MRI have confirmed the above results and have also shown that MRI is better at discerning encasement/infiltration of vessels, which is more important for parenchymal than pleural disease, but gives further strength to its use in pre-operative evaluation.[15]

Ultrasound

The use of ultrasound in the evaluation of pleural masses is limited. While useful due to its relatively low cost, it is primarily indicated for use as a guidance tool during drainage of pleural fluid. CT is markedly superior in its ability to detect pleural thickening and focal masses compared to ultrasound.[9] Currently, ultrasound is not recommended in the workup of pleural masses.

Positron emission tomography (PET)

PET is a relatively new imaging technique that has been particularly useful in the evaluation of solitary pulmonary

Table 2 Summary of various imaging modalities.

Advantages	Disadvantages
Plain radiography	
Cost; availability	Cannot discern malignant vs. benign disease
Computed tomography	
+Cost; guidance for biopsy; calcification; detection of plaques	Limited use during surgical evaluation; lower sensitivity/specificity
Ultrasonography	
Cost; useful for drainage of effusion	Difficult to visualize plaques or thickening; cannot discern malignant vs. benign disease
Magnetic resonance imaging	
Excellent for discerning tumor respectability; high specificity/sensitivity	Cost; limited availability in some areas
Positron emission tomography	
High specificity/sensitivity	Cost; availability; limited in use for resectability

nodules for malignant potential as well as for staging of other malignancies.[16,17] A few studies have investigated its role in the evaluation of pleural masses. In one series of 25 patients, 16 with malignant disease and nine with benign, PET imaging correctly detected all cases of malignancy, and seven of the nine cases of benignity.[18] An additional study showed PET imaging as having an accuracy of 92% in differentiating benign versus malignant disease.[19] However, a large number of the patients in this study had malignant disease, which may have affected the results.

One of the larger studies evaluating PET imaging involved 92 patients, all of whom had non-small cell lung cancer.[20] PET had a sensitivity of 100%, specificity of 71%, PPV of 63%, and NPV of 100% in diagnosing pleural malignancy. When combined with CT, specificity rose to 76% and PPV to 67%.

While PET may be useful as a screening tool to decide when to send a patient for biopsy, it is limited in its ability to delineate chest wall or diaphragmatic invasion, or to help determine resectability.

Conclusion

A variety of imaging modalities are currently available for use in the evaluation of pleural masses. Radiography is usually a first step, but it is clear that further imaging beyond this is required. However, further research is required in order to determine which imaging modality (or combination of modalities) is the most useful next step prior to obtaining biopsies. Table 2 provides a summary of the advantages and disadvantages of the modalities discussed.

Conflict of interest statement

Aaron Bruns, M.D., has no conflicts or disclosures to make. John G. Mastronarde, M.D. is a Speaker for GlaxoSmithKline, AstraZeneca, and Schering-Plough.

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