Interventional Radiology in the Chest*

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Due to both the precision of imaging and the technical developments in needle placement and catheterization, interventional radiology has assumed an important role in the diagnosis and treatment of thoracic disorders. These radiologic techniques provide many benefits: they aid the pulmonologist and thoracic surgeon diagnostically, they may benefit the thoracic surgeon as a temporizing maneuver, or they may obviate surgery in selected cases. A host of procedures is available to diagnose and treat thoracic disorders: guided diagnostic and therapeutic thoracentesis; drainage of empyemas or noninfected pleural collections; drainage of empyemas or noninfected pleural collections; drainage of lung and mediastinal abscesses; transthoracic biopsy of pulmonary, mediastinal, pleural, and hilar lesions; pleural sclerosis; treatment of pneumothoraces; removal of pleural foreign bodies; and brachytherapy. This chapter will highlight the indications, techniques, and results of interventional radiologic procedures for various thoracic disorders.

Diagnosis and Treatment of Thoracic Fluid Collections

Diagnostic Thoracentesis

Most diagnostic thoracenteses are performed on the ward and do not require radiologic guidance. The value of radiologic guidance for aspiration is to increase the likelihood of obtaining pleural fluid and to decrease the risk of pneumothorax. Radiologic guidance is most useful and appropriate when there is a small amount of fluid. The capability to guide and follow the needle with ultrasound or computed tomography (CT) enhances the diagnostic yield. Similarly, since a blind needle stick is avoided, pneumothorax is less likely to develop.

Aspirated material is sent for diagnosis to the laboratory for Gram stain and culture. Cytology, pH levels, and chemistry evaluation are obtained routinely.

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Figure 1. Ultrasound-guided drainage of loculated thoracic empyema. Top: Ultrasonogram depicts large, hypoechoic fluid collection with irregular margins in a patient with a parapneumonic empyema. Bottom: After ultrasound-guided insertion of a 12F catheter and evacuation of purulent material, the collection markedly diminished in size. The fever abated, and the patient recovered in five days.
For large or free-flowing empymas, ultrasound is used as the guidance system. For loculated and less accessible collections, CT is the modality of choice. Radiologically guided catheters may be placed de novo or after a large-bore thoracostomy tube has proved ineffective. The latter occurs when these tubes migrate into the major fissure or are located remote from the empyma.

The technique for catheter drainage initially involves placement of a needle for diagnostic aspiration; this needle also serves for localization. If the needle is in the correct position and defines an appropriate route, the catheter is placed in tandem adjacent to the needle. Seldinger or trocar technique may be used; we prefer the latter, as it is more expeditious and may be performed in ultrasound or CT, without moving the patient to fluoroscopy. With multiloculated or multiple collections, more than one catheter is indicated. Empyema drainage is effective in 80 percent to 90 percent of cases. Drainage is ineffective if the abnormality is tissue, rather than fluid.

Twelve-French catheters are used routinely. These are single-bore systems with several large holes. Percutaneous radiologic catheters are available from 5F to 30F.

Complications occur in 5 percent to 10 percent of patients undergoing catheter drainage of empymas. Dislodgment of the catheter is the most frequent problem. Bleeding is rare.

Mediastinal Abscess

Mediastinal abscesses usually occur in patients who are extremely ill; therefore, general anesthesia and formal surgical procedures may be hazardous. Thus, radiologically guided percutaneous techniques are attractive for these patients. Computed tomography is the guidance modality of choice. Drainage may be performed via an anterior or posterior approach. An important guideline is that the pathway to the collection should proceed directly into the mediastinum or through the pleura without traversing normal lung whenever possible.

Mediastinal drainage often is done for esophageal leaks, which may be spontaneous or postoperative. Frequently these leaks have to be repaired surgically. Percutaneous drainage permits the patient to be cleared of infection, favoring operation in a more controlled clinical setting.

Lung Abscesses

Percutaneous drainage of lung abscesses may expedite treatment and be curative. Most patients with lung abscesses respond well to postural drainage, coughing, and antibiotics. Those patients who cannot cough or whose bronchi are obstructed (by tumor, lymph nodes, or mucus plugs) can benefit and be
cured by catheter drainage. The preferential access route is through contiguous abnormal pleura. This ensures that normal lung will not be punctured and that bronchopleural fistula is not likely to develop. Lung abscesses are cured percutaneously in 80 percent to 100 percent of cases.

Sclerotherapy

Sclerotherapy into the pleural cavity is done for recurrent malignant effusion. Tetracycline is used most frequently to induce sclerosis. A typical dose for infusion is 500 mg to 1 g, diluted in normal saline solution. Multiple sessions often are necessary for successful treatment. A 7F pigtail catheter suffices for sclerotherapy. Catheters that are placed for infusion therapy can be removed promptly if multisession therapy is not chosen.

Brachytherapy

Brachytherapy is performed for recurrent or refractory tumor that abuts, or is in, the pleural space. A fine needle for localization is inserted into the recurrent tumor. This is followed by placement of a large (16-gauge) needle into the lesion. Several needles may be necessary. Radiation pellets are loaded into the large needles for local therapy. Tumor shrinkage has occurred in some patients. Care must be taken in placing these large needles; the potential for bleeding or pneumothorax exists and theoretically is greater than with fine needles.

Percutaneous Thoracic Biopsy

Biopsy of Pulmonary and Pleural Lesions

Fluoroscopic, CT, or sonographic guidance may be used for percutaneous biopsy. Fluoroscopy is chosen whenever possible, due to its ease and relatively low cost. If a lesion is visible in two 90° planes, fluoroscopic guidance is adequate. In general, lesions greater than 1.5 to 2 cm are amenable to fluoroscopic biopsy; lesions measuring 0.5 to 1.5 cm are appropriate for CT guidance. Computed tomography is particularly advantageous for lesions that are not seen in two planes on conventional radiography. Ultrasound may be used for pleural lesions or large pulmonary lesions that abut the pleura. Sonography has the advantage that neither the patient nor the operator is exposed to radiation. Computed tomography permits accurate and unequivocal documentation of needle position in the lesion.

The main drawback to CT guidance is development of a pneumothorax; the lesion may retract from its original position, and all original localization becomes invalid. To relocalize the lesion would be impractical, due to time considerations (and occasionally the patient is too symptomatic). Since fluoroscopy is done in real-time, despite the presence of a pneumothorax (as opposed to CT), the needle still may be directed into the lesion. If a large pneumothorax develops under CT, the pneumothorax must be evacuated immediately to continue the biopsy.

Diagnosis by transthoracic biopsy is achieved in 70 percent to 90 percent of cases. An assortment of benign conditions, including histoplasmosis, coccidioidomycosis, tuberculosis, nocardiosis, aspergillosis, mucormycosis, hamartoma, and bacterial and opportunistic infections, may be diagnosed. The typical assortment of bronchogenic, metastatic, and less common pulmonary tumors (carcinoid, lymphoma) all may be diagnosed by percutaneous biopsy.

Pneumothorax occurs in 10 percent to 60 percent of patients undergoing percutaneous biopsy. A chest tube is inserted in 5 percent to 25 percent of patients. Pulmonary hemorrhage, hemothorax, and pain are less frequent complications.

Percutaneous Biopsy of Mediastinal and Hilary Lesions

When fluoroscopy was the sole guidance method, mediastinal and hilar lesions were considered hazardous for transthoracic biopsy by most authors. Presently, CT permits precise localization of major vessels, thereby allowing safe biopsy in most cases of mediastinal and hilar lesions. With current high-resolution CT, biopsy specimens of most hilar and mediastinal lesions larger than 1 cm may be obtained under CT guidance.

A frequently used system for biopsy is the coaxial technique, in which an outer needle slides over an inner localizing needle (Fig 3). After removal of the inner guiding needle, multiple biopsy passes are obtained coaxially through the outer cannula by 21- or

Figure 3. Computed tomography-guided biopsy of perihilar malignant neoplasm. Use of fine-needle, coaxial CT technique allowed better delineation of vessels and lesion. Final diagnosis was metastatic renal cell carcinoma.
22-gauge needles. Biopsy specimens may be obtained from mediastinal lesions in the pretracheal, anteroposterior window, and subcarinal regions and from pericardial and diaphragmatic nodes. Specimens from lesions in the anterior, middle, and posterior mediastinal regions may be obtained as well.

Major complications of these biopsies are uncommon and include bleeding, pneumothorax, pericarditis, and pericardial tamponade. Mediastinal and hilar biopsies permit staging of pulmonary malignancy, and may preclude unnecessary thoracotomy if a diagnosis of incurability is made on the basis of the biopsy findings.

TREATMENT OF PNEUMOTHORAX

It is well established that pneumothoraces may be treated with small, radiologic-type catheters (Fig 4). Treatment is done either during or after transthoracic biopsy. In the former instance, the CT-guided biopsy may continue by reexpansion of the lung that brings the lesion back to the original site of localization.

By convention, catheters are inserted in the second intercostal space in the midclavicular line. However, when a biopsy is being done with the patient in the prone position, the catheter may be inserted in the axillary line or even somewhat posterior to obviate turning the patient (twice) and using valuable CT time. A 7F catheter inserted by direct trocar puncture generally suffices to treat pneumothorax. Pneumothoraces may be evacuated by syringe, suction, pleurevac, or water seal or with a Heimlich valve.

Once the pneumothorax has been evacuated and reexpansion has been confirmed radiographically, the tube is clamped. After 4 h, a repeat chest x-ray film is obtained. If the pneumothorax remains evacuated, the chest catheter may be removed. Conversely, if the pneumothorax reaccumulates, drainage should continue.

Complications are few with this technique. Patients may experience pain after complete evacuation of the pneumothorax; injecting a tiny bit of air (about 10 ml) to move the catheter away from the pleura slightly is enough to relieve this discomfort.

SUMMARY

Interventional radiologic techniques offer many options and benefits in the care of patients with thoracic disorders. Imaging-guided catheter techniques provide heretofore unsurpassed precision and accuracy in performance of these procedures. Improved efficacy, with reduced morbidity is the goal and usually the result for the patient.

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SELECTED READINGS


Figure 4. Radiologic treatment of pneumothorax. Left: Immediately after CT-guided biopsy of a small nodule in the right lower lobe, the patient developed pleuritic pain and dyspnea due to tension pneumothorax. Right: After immediate insertion of a 7F pneumothorax catheter, pneumothorax was evacuated, and patient became asymptomatic.
Interventional Radiology in the Chest (vanSonnenberg et al)

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