CME CREDIT

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Imaging in Practice

Diagnostic imaging approach to pulmonary embolism

A 32-YEAR-OLD MAN with testicular cancer presents to the emergency department with dyspnea and low-grade fever, which began 1 day ago. He denies having chest pain. His temperature is 38.0°C (100.4°F), blood pressure 120/78 mm Hg, heart rate 110, respirations 24 per minute. His oxygen saturation is 89% while breathing room air. His D-dimer level is elevated.

What would be the most reasonable approach to confirm your suspicion of pulmonary embolism?

APPROACH BASED ON PROBABILITY

When you suspect that a patient has a pulmonary embolism, the approach begins by clinically assessing the probability of this diagnosis (FIGURE 1). This pretest clinical probability affects which imaging tests to order initially and how accurate they will be.[1]

Although an experienced physician's clinical suspicion is a valid method of determining pretest probability, clinical prediction models have been advocated. One such model, devised by Wells et al,[2] assigns a score based on clinical features such as symptoms of deep venous thrombosis, tachycardia, prolonged immobilization, malignancy, hemoptysis, and the likelihood of diagnoses other than pulmonary embolism.

Adding D-dimer measurement to the clinical algorithm increases its sensitivity. If the D-dimer assay is negative and the clinical probability of pulmonary embolism is low, then it is considered safe to exclude pulmonary embolism without imaging.[2]

This patient has known malignancy, signs and symptoms that suggest pulmonary embolism, and a positive D-dimer assay. Therefore, the pretest probability of pulmonary embolism is high.

*Dr. Herts has indicated that he serves as a consultant for Siemens Medical Systems.

Case continued: Normal chest radiographs

You obtain posterior-anterior and lateral chest radiographs, which are interpreted as normal.

Discussion. Standard chest radiography is always the first imaging study to order in this situation. However, it is normal in approximately one fourth of patients with pulmonary embolism. When findings are present, they are nonspecific and include cardiomegaly, pleural effusion, hemidiaphragm elevation, and atelectasis.[1] Classic signs such as regional oligemia (Westermark sign) or peripheral wedge-shaped opacities (Hampton hump) are present in less than 10%.

The role of plain radiography in suspected pulmonary embolism is to uncover alternative causes of dyspnea such as pneumonia and congestive heart failure and to guide the choice of subsequent imaging tests. Ventilation-perfusion imaging is more likely to be nondiagnostic if there are significant abnormalities on chest radiography.[1]

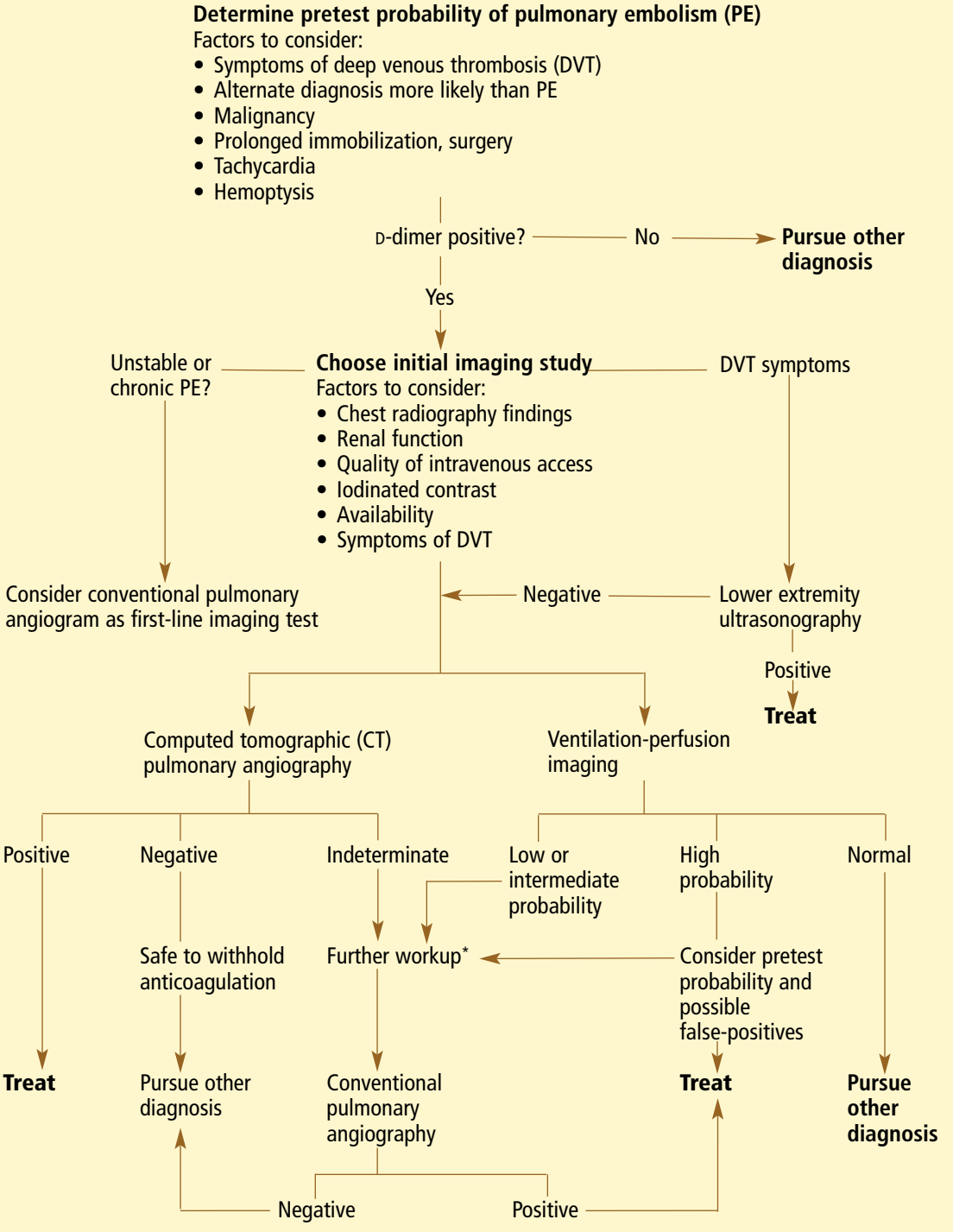
Normal lower-extremity duplex ultrasonography

Review of the patient's medical record reveals that he had a negative lower extremity ultrasound scan a few days earlier. He currently has no lower extremity symptoms. You contemplate ordering a repeat lower extremity ultrasound scan.

Discussion. The sensitivity of ultrasonography for proximal lower extremity deep venous thrombosis in patients with symptoms exceeds 95%, but it is considerably lower in patients without symptoms and in evaluating deep calf veins.[3] Furthermore, in one study in patients with proven pulmonary emboli,[4] ultrasonography revealed deep venous thrombosis in only 29%.

However, the treatment is usually the same for stable patients with either pulmonary embolism or deep venous thrombosis. Therefore, the detection of deep venous thrombosis by ultrasonography in a patient

Diagnosis of suspected pulmonary embolism



*Further workup should be dictated by pretest probability and might include lower extremity ultrasonography or CT pulmonary angiography. Repeat CT should only be considered if the condition that caused the indeterminate result has been corrected. Continued inconclusive results with moderate or high pretest probability should prompt conventional angiography.

The workup should always begin with pretest probability

FIGURE 1

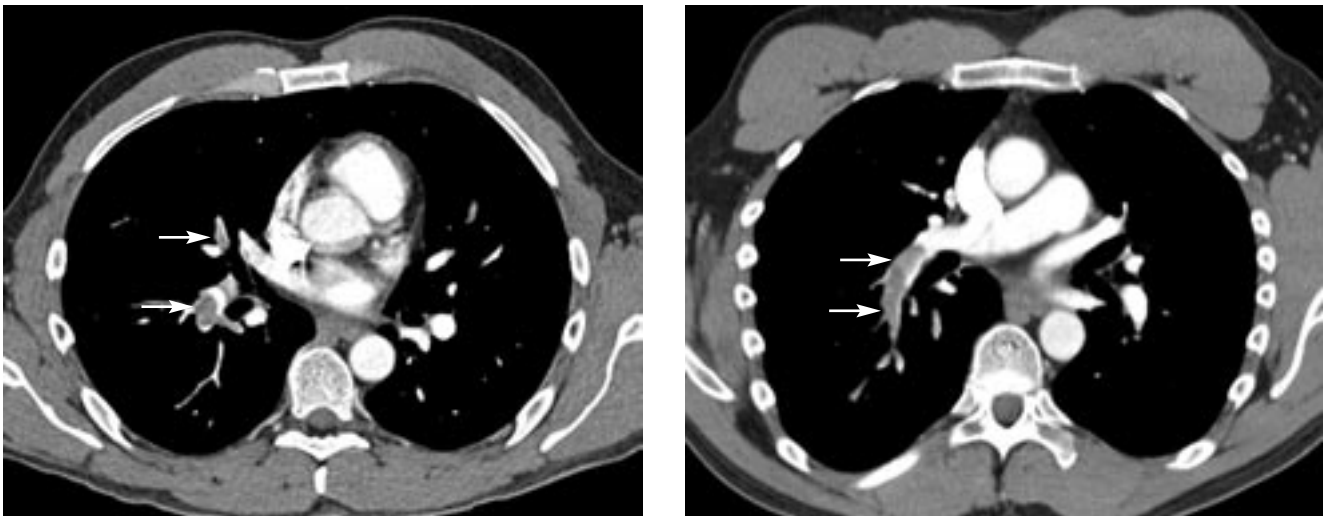


FIGURE 2. Left, axial image from a contrast-enhanced CT pulmonary angiogram shows central filling defects within the right descending pulmonary artery and right lower lobe and middle lobe lobar and segmental pulmonary arteries. **Right,** axial oblique reformation more accurately depicts the extent of thrombus in the right descending pulmonary artery.

with pulmonary symptoms that suggest pulmonary embolism may obviate the need for further diagnostic imaging.

Since this patient does not have lower extremity symptoms and had a previous scan that was normal, repeat scanning should probably be considered only if other tests are nondiagnostic. Serial ultrasound scans are sometimes performed to exclude deep venous thrombosis in patients with indeterminate pulmonary imaging studies.

Helical CT of the chest

The patient's serum creatinine concentration is 0.8 mg/dL, and he has no reported allergy to iodinated contrast. After inserting a 20-gauge needle in the antecubital vein, you obtain a contrast-enhanced helical computed tomographic (CT) scan of the chest to evaluate for pulmonary embolism (FIGURE 2).

Discussion. The appeal of helical CT pulmonary angiography to detect pulmonary embolism is easy to understand—it is fast and readily available, and it directly visualizes thrombus. CT can also show an alternative cause of the patient's symptoms such as pulmonary edema, pneumothorax, or pleural effusion. The examination is performed as a thin-collimation, helical-acquisition scan in a single breath-hold after giving iodinated contrast. The contrast must be infused quickly for adequate pulmonary arterial opacification: you need a peripheral intravenous line in the antecubital vein with a 20-gauge needle or larger.

Despite early reports of near-100% accuracy in detecting pulmonary embolism, systematic reviews have found a combined sensitivity close to 80%, with only a minority of studies reporting a sensitivity greater than 90%. The specificity has generally been greater than 90%. CT is significantly less accurate for detecting peripheral or subsegmental thrombus.[5] Despite the apparent lack of sensitivity, studies have reported a low incidence of subsequent thromboembolic disease after negative CT scans and have concluded that it is safe to withhold anticoagulation after a negative good-quality CT scan.[6]

The multidetector-row CT scanners currently in use allow for shorter breath-holds, faster examinations, and improved visualization of subsegmental emboli.[7] However, technical advances have outpaced large prospective studies, and the actual benefit of newer technology is not known.

Limitations of pulmonary CT angiography include motion artifacts in patients who are so tachypneic that they cannot hold their breath or breathe quietly during image acquisition. Pleural effusion, tumors, and consolidation also limit evaluation of the pulmonary vasculature owing to mass effect and may lead to nondiagnostic examinations. Poor cardiac function can delay the contrast bolus, leading to poor opacification of the pulmonary arteries. Inconclusive results mandate additional imaging.

If the patient cannot undergo CT: Ventilation-perfusion scanning

If the patient has a history of anaphylactoid reaction

to iodinated contrast or renal insufficiency, what other diagnostic tests are available?

Discussion. Lung scintigraphy (ventilation-perfusion [V/Q] scanning) has been the primary noninvasive diagnostic test for pulmonary embolism for decades. It is widely available, requires no iodinated contrast, and can be performed through central lines and small peripheral intravenous lines. A normal or near-normal V/Q scan effectively excludes pulmonary embolism, especially when combined with a low pretest probability. Conversely, a high-probability scan is highly correlated with pulmonary embolism on conventional angiography. However, nearly 70% of V/Q scans are of low or intermediate probability, and thus effectively nondiagnostic for pulmonary embolism.[1]

A small but significant number of patients with low-probability lung scans have pulmonary embolism demonstrated by angiography.[1] About one fourth of patients with intermediate-probability lung scans have pulmonary embolism demonstrated on subsequent CT.[8] A low- or intermediate-probability lung scan with moderate or high pretest probability should prompt further imaging. Limited specificity, poor interobserver variability, and the large percentage of examinations that are nondiagnostic have made the use of lung scintigraphy less attractive.

Conventional angiography in unstable patients

If the patient were to become unstable and intervention is contemplated, what might be the best imaging test?

Discussion. Even a good-quality negative CT will not completely exclude the diagnosis of pulmonary embolism, and most experts regard conventional pulmonary angiography as the gold-standard test. It is, however, invasive and underutilized due to potential complications, cost, and lack of availability. The complication rate associated with pulmonary angiography is 4%, and the mortality rate is 0.2%.[9] Nonetheless, conventional pulmonary angiography retains a role in unstable patients, in suspected pulmonary hypertension secondary to chronic pulmonary embolism, and when an unequivocal diagnosis is necessary for possible intervention.

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