Abstract: Pulmonary embolism (PE) remains a common and important clinical condition that cannot be accurately diagnosed on the basis of signs, symptoms, and history alone. In the absence of high pretest probability and with a negative high-sensitivity D-dimer test, PE can be effectively excluded; in other situations, diagnostic imaging is necessary. The diagnosis of PE has been facilitated by technical advancements and multidetector computed tomography pulmonary angiography, which is the major diagnostic modality currently used. Ventilation and perfusion (V/Q) scans remain largely accurate and useful in certain settings. Lower-extremity ultrasound can substitute by demonstrating deep vein thrombosis; however, if negative, further studies to exclude PE are indicated. In all cases, correlation with the clinical status, particularly with risk factors, improves not only the accuracy of diagnostic imaging but also overall utilization. Other diagnostic tests have limited roles. The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed every 2 years by a multidisciplinary expert panel. The development and review of the guidelines include an extensive analysis of current medical literature from peer-reviewed journals and the application of a well-established consensus methodology (modified Delphi) to rate the appropriateness of imaging and treatment procedures by the panel. In those instances in which evidence is lacking or not definitive, expert opinion may be used to recommend imaging or treatment.

Key Words: Appropriateness Criteria, diagnosis of pulmonary embolism and DVT, CTPAgrams, ventilation and perfusion (V/Q) scan

SUMMARY OF LITERATURE REVIEW

Introduction/Background

Pulmonary thromboembolism (PE) remains common—it is a significant cause of morbidity and mortality and is often not diagnosed until premortem. PE is usually secondary to deep vein thrombosis (DVT). As initial or recurrent PE can be fatal, and as there is significant risk associated with anticoagulant therapy, the aim of diagnosis is to accurately confirm or rule out the presence of either PE or DVT.1 This is most often done using a Bayesian approach in which the pretest likelihood of PE is modified by the results of appropriate radiologic and other tests to estimate a posttest probability of PE/DVT. The Wells criteria are the most validated support tool for this, beginning with clinical information that is then generally supplemented by high-sensitivity D-dimer testing. D-dimer levels will be elevated with any significant thrombotic process; hence, this test is of limited value in pregnant, postoperative, and trauma patients, as well as in patients at high risk for PE by validated clinical criteria. In all other settings a negative D-dimer test effectively excludes PE and DVT (Table 1).

Several diagnostic tests form the basis for definitive confirmation of PE and are reviewed in the following sections of this document.

Chest Radiography

This is an effective first test for suspected PE; it may eliminate the need for additional procedures by revealing other causes for acute symptoms (eg, pneumonia, large effusion). Normal CXR does not exclude PE, nor are there specific findings that confirm PE. A recent CXR is required to allow accurate interpretation of an abnormal radiographic ventilation/perfusion lung scan.

CT Pulmonary Angiography

Multidetector computed tomography pulmonary angiography (CTPA) is now the primary imaging modality for evaluating acute PE. Since the first major clinical study in...
TABLE 1. ACR Appropriateness Criteria®—Acute Chest Pain—Suspected Pulmonary Embolism Variant Table Ratings

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**TABLE 1. ACR Appropriateness Criteria®—Acute Chest Pain—Suspected Pulmonary Embolism Variant Table Ratings**

Rating scale: 1, 2, 3, usually not appropriate; 4, 5, 6, may be appropriate; 7, 8, 9, usually appropriate.

- Variant 1: Adult
  - 9* 87
  - Current standard of care for detecting PE.
  - To exclude other causes of chest pain.
  - Complementary to other examinations.
- Variant 2: Pregnant
  - 97 7
  - Limited experience. Has been used for major PE.
- Variant 3: Pediatric
  - 99
  - Rarely indicated. For clarification or catheter-directed intervention.

CTA indicates computed tomography angiography; MRA, magnetic resonance angiography; US, ultrasound.

Ventilation and Perfusion Imaging

Since its introduction in the mid-1960s, lung perfusion imaging has been indicated in the workup of suspected PE, although its role has diminished considerably with the increased use of CTPA. Nevertheless, a normal pattern of regional perfusion in multiple projections, accompanied by a normal ventilation scan, is widely accepted as indicating that pulmonary emboli are not present and that no further workup for PE is necessary. The choice between V/Q scans and CTPA remains somewhat controversial. Both have good diagnostic accuracy, and, in the presence of a normal radiograph in a cooperative patient, a strong argument can be made that they are equally effective in diagnosing clinically significant pulmonary emboli.

Several approaches have been validated for V/Q scan patterns to assign probabilities for the presence of PE. Most often, these are categorized as “high,” “intermediate” (not meeting the criterion of either “high” or “low”), “low,” or “very low” probability, or “normal.” All schemes incorporate the results of a recent CXR. At least one study suggests that using single photon emission CT improves the sensitivity and specificity of V/Q scans.

Use of a low-dose Tc-99m macroaggregated albumin (MAA) perfusion scan before a Xe-133 ventilation scan allows the latter to be performed in the appropriate
projection, rather than in the usual posterior projection. Further, a normal perfusion scan can eliminate the need for a ventilation scan, lowering radiation dose for the patient. Results obtained using Tc-99m-labeled microaerosol agents (DTPA, pertechnetate, etc.) are comparable to those using inert gases (xenon, krypton) and have the advantage of providing multiple views for regional V/Q comparisons.

A follow-up MAA perfusion scan may be recommended 6 to 8 weeks after the discovery of a “mismatched” V/Q pattern (presumption of PE). Failure of observed resolution, or of at least significant improvement in regional perfusion, may warn of developing pulmonary hypertension secondary to chronic pulmonary vascular obstruction. This complication occurs in <1% of patients. Caution should be exercised in interpreting perfusion imaging in the days after acute PE, because reestablishment of regional perfusion (resolution of defects) occurs at varying and unpredictable rates. In contrast, local ventilation may be compromised for minutes to hours after an acute PE.

Lung scans may be indicated in pregnant women with suspected PE. The administered dose of the radiopharmaceutical(s) should be reduced by a factor of 2 or more, with correspondingly longer acquisition times but reduced radiation dose. If the MAA perfusion scan is performed first and is normal, the ventilation scan can be avoided.

The modality of choice (CTPA vs. V/Q scan) in pregnant patients remains a matter of debate. The maternal breast dose is clearly higher with CTPA, but the fetal dose may not be. Studies suggest that if the chest radiograph is normal a perfusion scan alone may be satisfactory. In contrast, dose-lowering techniques may make the absorbed dose lower with CT.

MMA Perfusion Imaging Without Ventilation Imaging

This technique may be indicated when the condition of the patient deteriorates suddenly and acute PE is suspected as a significant contributing cause. The demonstration of regions of reduced perfusion, not explained by recent chest radiograph findings, warrants a consideration of PE and possibly the need for further workup such as pulmonary angiography. Perfusion scan alone may be considered in patients who are not candidates for multidetector CTA (those who are too large to fit into CT gantries, who are unable to remain still and hold their breath, and those with severe renal impairment).

Catheter-directed Selective Pulmonary Angiography (PAGram)

Catheter-directed, conventional PAGram, including right heart catheterization and measurement of pulmonary artery and right heart pressure levels, is an invasive but safe procedure when performed by an experienced operator with adequate monitoring of patients. Results may demonstrate PE when an acceptable level of certainty cannot be reached otherwise. Given the accuracy of CTPA, even compared with PAGrams, unacceptably low levels of certainty are increasingly rare.

In the past, indications for PAGram have included the following: (a) low probability V/Q scan, particularly when accompanied by high clinical suspicion for PE and high risk for or relative contraindication to anticoagulation; (b) circumstances in which a specific diagnosis of PE is considered necessary for the proper management of the patient; (c) clinical settings in which catheter-directed intervention may be necessary (eg, chronic pulmonary hypertension secondary to major vessel thromboembolic occlusion or symptomatic massive or submassive PE); and (d) before placement of an inferior vena cava filter. Because of the high accuracy of CTPA, PAGrams are now largely confined to situations in which catheter-directed thrombectomy or thrombolysis is thought to be clinically indicated.

Ultrasound (US)

Transthoracic echo and transesophageal echo studies are generally not indicated in the diagnosis of acute PE in the setting of acute chest pain, although they are useful in evaluating right ventricular morphology and function that in turn have prognostic implications for morbidity, mortality, and development of future venous thromboembolism. Because of the high association of DVT with PE, US evaluation of the venous drainage of the lower-extremity deep veins is probably indicated. US studies include duplex Doppler with leg compression and continuous-wave Doppler; as noted, if DVT is demonstrated, further studies are usually not indicated. A negative extremity US, however, does not exclude PE, although it decreases its likelihood significantly. For a more detailed discussion on DVT, refer to the ACR Appropriateness Criteria on “Suspected Lower Extremity Deep Vein Thrombosis.”

Magnetic Resonance Angiography (MRA), Magnetic Resonance Imaging (MRI), and Perfusion Imaging

MRA and MR perfusion imaging can provide a rapid, noninvasive evaluation of the central and segmental pulmonary arteries. MR perfusion imaging has high sensitivity for PE and is most useful in combination with MRI and MRA. Its use is mainly limited to institutions with particular interest and expertise in these methods, and in pregnant patients, although there is not yet proof that the use of gadolinium-containing contrast agents is safe in pregnancy.

MRI without MRA is probably not indicated in the routine evaluation of patients with suspected PE. It may rarely be useful in patients who have large central emboli, particularly if used in conjunction with MRI for other indications, such as cardiac morphologic evaluation.

Summary

- PE remains a common and important condition.
- A chest radiograph cannot exclude or confirm PE, but it is important (as a complementary study) as it can guide further investigations and suggest alternative diagnoses.
- In general, any test that can confirm either DVT (ie, lower-extremity venous duplex) or PE is sufficient. Only certain studies, however, have sufficient accuracy to exclude PE.
- Multidetector CT pulmonary angiography is the current standard of care for diagnosis of PE.
- V/Q scanning also seems to have high overall accuracy.
- In pregnancy, because of increased concerns about radiation, the choice between V/Q or Q scanning and CTPA depends on local equipment and expertise, as well as on patient factors (normal chest radiograph, ability to hold one’s breath).

REFERENCES


