

Pulmonary embolism - new roles for radiologists

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Pulmonary embolism (PE) is a common and potentially lethal condition, and is responsible for around 10% of all hospital deaths.¹ Furthermore, the death rate has not changed significantly in the past 30 years. These figures highlight the importance of detecting and treating PE since death from this disease is rare once treatment is started. This article reviews the methods by which pulmonary embolism is diagnosed currently and highlights the opportunities which now exist with newer imaging techniques.

Clinical evaluation

The clinical manifestations of PE are non-specific. Individual signs and symptoms, and additional tests such as the ECG and measurements of arterial blood gases are poor discriminators. In the PIOPED study² a high clinical likelihood was correct in 68% of cases and a low clinical likelihood was correct in 91%. The inference here is that clinical assessment is better at excluding PE than positively identifying it. Unfortunately, a large proportion (64% in the PIOPED study) of clinical assessments are non-

committal (indeterminate probability) and this is likely to account for the fact that the prevalence of PE in patients in whom the disease is suspected is usually below 30% in most series. Nevertheless the need for accurate clinical assessment needs to be emphasized since the clinician's *a priori* assessment of the likelihood of the presence of PE in individual cases is integral to the meaningful interpretation of ventilation perfusion scintigraphy.

Chest radiology

All patients suspected of having pulmonary embolism should have a chest radiograph performed. Some radiographic features may suggest the possibility of PE such as a raised hemidiaphragm associated with a small pleural reaction and an adjacent area of pulmonary consolidation or atelectasis. However, these appearances are non-specific and are only of indirect value. The classical radiographic features described by Hampton (a pleurally based coned shaped pulmonary opacity) and Westermarck (regional oligoemia with central vascular enlargement or cut off) once thought to be characteristic of PE are neither sensitive nor specific enough to be helpful in the diagnosis. One of the major reasons for performing chest radiography is to demonstrate abnormalities that may mimic pulmonary embolism such as pneumonia, bronchial carcinoma or a pneumothorax. Furthermore, an understanding of the chest radiographic appearances is essential for the accurate interpretation of ventilation perfusion scintigrams.

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Pulmonary angiography

For many years pulmonary angiography has been correctly regarded as the most sensitive imaging technique for the diagnosis of PE and the **gold standard** against which other imaging techniques are measured. It is seldom used as the primary imaging investigation except in patients with suspected massive PE and is usually regarded as the next investigation if scintigraphy is unhelpful. Despite the fact that the mortality and morbidity are remarkably low (and compare very favourably with those resulting from empiric anticoagulant therapy) pulmonary angiography is underused.³

This is probably related to clinicians' perception of it as an invasive costly procedure and the relative lack of immediate availability and expertise. Less than 15% of patients with unresolved suspicion of PE underwent pulmonary angiography in a major teaching centre in the USA as recently as 1996.⁴ Like any other test, the accuracy of the results depends upon the quality of the examination and in this respect selective injections with multiple views and digital subtraction are essential pre-requisites. Interobserver agreement between angiographers is good for emboli in lobar and segmental vessels (in 88% and 90% respectively) but falls off considerably for the detection of emboli in subsegmental vessels (66%). In a retrospective review of 60 pulmonary angiograms there was interobserver agreement among three radiologists in only two of 15 cases graded as subsegmental emboli.⁵ The importance of an optimal technique has been emphasized in a recent study comparing conventional angiography and digital

subtraction angiography where interobserver disagreement occurred in 20-36% of conventional studies compared with 4-11% of DSA studies.⁶

Ventilation perfusion scans

Perhaps the most important reason for the relative underuse of pulmonary angiography for the detection of PE, is the ready availability of ventilation perfusion scintigraphy, perceived by clinicians as a suitable alternative to pulmonary angiography because it is non-invasive and readily available. All that is required of the patient is the inhalation of a radioactive gas or aerosol and an intravenous injection of labelled macroaggregated albumin. Despite its popularity V/Q imaging only provides a diagnosis in a minority of patients. In the PIOPED study, a prospective multi-centre trial in the USA, 755 patients underwent V/Q imaging and selective pulmonary angiography.² In those patients with angiographically proven PE, only 41% had high probability scintigrams, 33% had intermediate probability scintigrams and 12% had low probability scintigrams. Thus less than half of the patients with PE in that study had a high probability scintigram. Although a normal study virtually excludes PE, an abnormal study is only able to provide a probability of PE being present; it cannot predict the presence of PE with absolute certainty and even with a high probability scintigram the sensitivity of the test is only 41%. Two important factors impact on the utility of V/Q scintigraphy as a test for PE. The first is the pretest clinical probability as outlined above. The second is the chest radiographic appearance. A normal chest radiograph in a patient with no underlying

respiratory disease is significantly more likely to be associated with either a high probability or normal or low probability V/Q scintigram, whereas an abnormal chest radiograph or the presence of cardiorespiratory disease is much more likely to be associated with an indeterminate scintigraphic result. Since the majority of V/Q scintigrams are of indeterminate probability, and only a minority of these patients proceed to pulmonary angiography, the diagnosis of pulmonary embolism is often based more on the clinicians' hunch than on any certainty. At best V/Q scintigraphy is only an indirect method of imaging for pulmonary embolism. As pointed out by Gurney there is a need for direct visualisation of the pulmonary vessels for accurate diagnosis of PE.³

Spiral CT

Contrast enhanced spiral CT angiography (SCTA) offers a significant advance. Like pulmonary angiography this technique directly images the pulmonary vessels and any clot within them. The initial study comparing SCTA to pulmonary angiography was by Remy-Jardin in 1992⁷ since when there have been a number of studies all of which indicate that SCTA detects emboli in the central and segmental pulmonary arteries with greater than 90% sensitivity and specificity.^{8,9,10} These figures compare favourably with pulmonary angiography and the sensitivity of SCTA is markedly better than V/Q scintigraphy. In addition to directly imaging clot SCTA also images the lungs, pleura and mediastinum thereby enabling conditions which simulate PE to be diagnosed. SCTA is a reproducible technique with minimal morbidity

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taking only minutes to perform. Whilst there is undoubtedly a modest learning curve, interobserver agreement is good between radiologists with thoracic CT experience. The increasing availability of spiral CT equipment provides the opportunity to use this technique on a much more widespread basis. Approximately 4% of examinations are technically inadequate either because of poor opacification of vessels or because of patient movement; these compare favourably with the 3% of nonconclusive pulmonary angiograms in the PIOPED study. The major limitation of SCTA is its poor sensitivity for the detection of subsegmental emboli. In two recent studies, SCTA detected only 17-25% of subsegmental emboli identified at pulmonary angiography.^{9,10} However, this may not be a major problem since emboli to subsegmental vessels alone are probably quite uncommon (only 6% in the PIOPED study). Furthermore, as already indicated, pulmonary angiography is also unreliable in the detection of subsegmental emboli.

Perhaps the most important question now is in which situation should SCTA be employed? Should it be reserved for patients with indeterminate V/Q scintigrams (as an alternative to pulmonary angiography) or should SCTA replace V/Q scanning completely as proposed by Goodman?⁴ The jury is still out and doubtless different institutions will find different solutions. What should be avoided is an over-complicated algorithm with a plethora of tests superimposed on one another with the inevitable burdens on time and expense. Assuming the availability of both scintigraphy and SCTA within an integrated imaging department a reasonable proposal which addresses the potential overload on CT

units is as follows: Patients with suspected PE have a chest radiograph. If this is normal and there is no clinical evidence of cardiorespiratory disease they proceed to scintigraphy. In these circumstances it may be appropriate to perform only a perfusion examination rather than a complete V/Q scintigram. Patients with an abnormal chest radiograph or with clinical evidence of cardiorespiratory disease proceed straight to a SCTA. Under such a scheme relatively few patients should have indeterminate V/Q results and they would proceed to SCTA. Pulmonary angiography would be reserved for patients with a high clinical probability and an indeterminate SCTA.

MRI

Magnetic Resonance Imaging (MRI) also provides cross sectional images and these may be reformatted in various planes appropriate to the pulmonary arterial tree. Furthermore there is no use of ionising radiation and no need for iodinated contrast media. The initial results were disappointing, mainly because of respiratory motion artefact and poor contrast between flowing blood and an embolus. However technical developments in MR and the use of gadolinium enhancement make high quality MR pulmonary angiography feasible and recent preliminary studies comparing it with pulmonary angiography provide encouraging results.¹¹ The possibility of imaging pulmonary emboli and venous thrombosis at the same time is an added bonus.

Undoubtedly there will be a role for MRI in the future. For the time being spiral CT will impact greatly on V/Q scintigraphy and conventional pulmonary angiography although only

outcome trials will properly establish which tests are most appropriately used for the diagnosis of this perplexing condition.

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