Management of pulmonary embolism

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Abstract

Pulmonary embolism (PE) is a common condition with significant mortality and morbidity. Its occurrence frequently triggers referral to critical care services. Patients within critical care environments are also at elevated risk of developing venous thrombo-embolism and PE. This highlights the need for critical care clinicians to be confident in their approach to the patient with PE. Furthermore, the co-morbid conditions in this patient group may present additional challenges both in diagnosis (e.g. safe access to radiology) and management (e.g. relative contraindication to anticoagulation/thrombolysis in trauma or intracranial haemorrhage). This brief review summarizes the contemporary evidence base regarding both diagnosis and treatment strategies and draws upon this to suggest a simple algorithm for investigation, risk stratification and management, particularly tailored to patients within a critical care setting.

Keywords Anticoagulation; computed tomography pulmonary angiogram (CTPA); embolectomy; IVC filter; massive pulmonary embolism; pulmonary embolism; submassive pulmonary embolism; thrombolysis; venous thrombo-embolism

Royal College of Anaesthetists CPD matrix: 2C01, 2C03, 2C04, 1B00, 2C00

Learning objectives

After reading this article you should be able to:

- describe the disease entity of venous thrombo-embolism/pulmonary embolism (VTE/PE) and outline risk factors for its development, recognizing the varied spectrum of presentation in PE
- outline an appropriate diagnostic strategy for the evaluation of possible PE, risk stratifying according to clinical presentation and investigations
- understand the various treatment options for PE and how they should be utilized in light of the risk stratification and diagnostic findings

Definitions

The term pulmonary embolism (PE) encompasses the movement of abnormal material to the pulmonary arteries and through the pulmonary vasculature such that it obstructs blood flow; examples include embolism of air/gas, fat and thrombus. The most common cause of PE is the migration of thrombus from veins (or right heart) to the pulmonary arterial tree. Other forms of PE are beyond the scope of this article.

Diagnostic considerations

PE is a commonly considered but relatively infrequently diagnosed condition in hospitalized patients. This is unsurprising when one considers that the clinical presentation of PE varies from breathlessness in isolation to sudden death, making clinical assessments insensitive and highly unspecific (Table 1, signs, symptoms and differential diagnosis of PE).

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Consideration of risk factors contributing to the development of venous thrombo-embolism (VTE) and PE (Table 2, Virchow's triad, primary and secondary hypercoagulable states) may improve diagnostic rates, but a missed diagnosis, or the inappropriate application of treatment both carry considerable risks. The use of biomarkers and choice of imaging modalities can be guided by clinical decision rule (CDR) systems of which the most widely reported are the Well's score and the Geneva score. These aim to stratify risk and focus resources on those most likely to benefit. The evolution of these tests and scoring systems has resulted in various approaches to investigating and treating possible PE; a suggested scheme geared more particularly to the critical care environment is outlined in Figure 1.

Investigation/severity assessment

Bedside investigations

An arterial blood gas analysis (ABG) demonstrating hypoxia (with widened alveolar–arterial oxygen gradient — A–a gradient) and hypocapnia with a concomitant increase in end-tidal CO_2 gradient is suggestive of PE but lacks specificity, equally a normal blood gas does not exclude PE. A normal ECG is found in one-third of cases, other findings include sinus tachycardia, T-wave inversion, right bundle branch block, p-pulmonale and other features suggestive of right ventricular strain. The classically described deep S wave in lead I, with a Q-wave and inverted T-wave in lead III (so called S1Q3T3) is rare and suggests more significant disease. The ECG is also important in screening for differential diagnoses. The chest X-ray may help to exclude common differentials such as pneumothorax, pneumonia or pleural effusion. Identifying more specific abnormalities such as oligaemia and abnormal pulmonary artery contours is generally the preserve of radiologists.

Biomarkers

D-dimers are cross-linked fibrin degradation products. Serum levels are elevated in VTE and therefore PE. They have poor specificity and poor positive predictive value for PE. The most useful D-dimer result is a negative, which makes the diagnosis of

Clinical assessments aiding in the diagnosis of PE

History
Previous DVT/PE
Family history of DVT/PE/sudden death
History/family history of thrombophilia
Secondary hypercoagulability (Table 2)

Signs
Increasing risk of massive pulmonary embolism
None
Tachycardia
Moderate fever
RV dysfunction (raised JVP, parasternal heave, loud P2)
Hypotension
Skin mottling
Peripheral cyanosis
Central cyanosis
Cardiovascular collapse/arrest
NB also important to examine for signs of DVT in limbs

Differential diagnoses
Acute myocardial infarction
Acute pulmonary oedema
Asthma/exacerbations of COPD
Pericardial tamponade
Pleural effusion
Fat embolism
Pneumothorax
Aortic dissection
Rib fracture
Anxiety

Symptoms
Dyspnoea (most common)
Pleuritic chest pain
Haemoptysis (late sign, lung infarction)
Syncope

COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis; JVP, jugular venous pressure; PE, pulmonary embolism; RV, right ventricular.

Table 1

PE unlikely, although a high D-dimer concentration is an independent predictive factor associated with mortality.[1]

Measurements of troponin, brain natriuretic peptide (BNP) or NT-terminal pro-BNP (NT-pro-BNP) although not useful in diagnosing PE may stratify risk and determine prognosis in confirmed PE.[2] Raised troponin predicts haemodynamic instability in non-massive PE and increased risk of death regardless of PE size. In proven PE, low levels of BNP and NT-pro-BNP correlate with good outcomes,[2] the latter is likely a superior predictor of outcome than troponin.[3]

Imaging

There is no ideal imaging modality in PE, studies show that confidence in any result can be improved by first assessing the pre-test probability of there being a PE. Unfortunately these studies are not representative of the critical care population, where a majority of patients have high pre-test probability of PE, in each scoring system.

Computed tomography

Computed tomography pulmonary angiography (CTPA) scanning, especially the multi-detector scanner (MD-CTPA), has now largely replaced lung ventilation–perfusion (V/Q) scanning as the cost-effective and reliable imaging procedure of choice in patients with suspected PE.[4] The CTPA scan has the advantage of greater diagnostic accuracy, being readily available at most hospitals, more rapid image-acquisition time, and the possibility of making an alternative diagnosis (Figure 2). High-resolution images to the level of segmental and in some cases subsegmental pulmonary arteries can be obtained in a short time-period (often a single breath-hold). When compared to conventional angiography it appears reliable, with excellent sensitivity, specificity and accuracy.[5] The CTPA scan can also be used to assess the severity of PE. An increased right ventricular/left ventricular (RV/LV) ratio[6] and clot in the proximal branches of the pulmonary artery correlate with the clinical severity of PE. It is therefore recommended that the CTPA scan should be the principal imaging test for patients with high and moderate probability of PE.

Although inconclusive CTPA scans occur in around 10%, a negative CTPA result means that withholding anticoagulant therapy is safe. An emerging problem of CTPA scanning, however, is the increased detection (around 10%) of small peripheral emboli in subsegmental pulmonary arteries due to better visualization of these arteries. The clinical significance of these findings in critically ill patients is unknown, however these are usually unlikely to lead to a bad outcome if left untreated.

Ventilation/perfusion scans

Lung ventilation/perfusion scanning demonstrates regional abnormalities in the distribution of inhaled radioactive gas, and injected radioactive contrast agent respectively. Matched or mismatched defects are interpreted, and reported as low, intermediate or high probability for PE. This technique is still widely and effectively employed where CTPA is unavailable or contraindicated (such as intravenous contrast allergy) but is limited by the large proportion of patients with intermediate or low probability results — leaving clinical uncertainty as to who to treat (as many as 40% of these patients will have had a PE).

Echocardiography

Echocardiograms have poor negative predictive value (up to 50% of clots missed) but can show pathognomonic patterns for PE, and may identify clot in the right ventricle or proximal pulmonary arteries (generally only on trans-oesophageal studies). It is of greatest utility in the most severe cases, where haemodynamic instability may prevent safe transport to CT. In these patients trans-thoracic echocardiography (TTE) can be employed at the bedside to investigate the cause of haemodynamic instability, to exclude other diagnoses (tamponade, myocardial infarction, aortic dissection) and assess severity of known PE (the presence of RV dysfunction in any patient implies a more grave prognosis). In a selected group of patients, where there is a high index of clinical suspicion for PE, findings on TTE may be sufficiently compelling to allow the rapid institution of potentially life-saving treatments such as thrombolysis.