The management of pulmonary embolism

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Abstract

Pulmonary embolism (PE) is a significant cause of hospitalization, morbidity and mortality and frequently triggers referral to critical care services. Critically ill patients are also at increased risk of developing venous thrombo-embolism (VTE) and acute PE. Critical care clinicians should be confident in their approach to the patient with suspected and diagnosed 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. absolute and relative contraindications to anticoagulation/thrombolysis in critically ill patients). 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 (VTE)

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 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
- describe the various treatment options for PE and how they should be utilized in light of the risk stratification and diagnostic findings
- acknowledge and address challenges in the management of massive and submassive PE
- appreciate the fundamental importance of VTE prophylaxis in the prevention of PE

Definition

Pulmonary embolism (PE) describes an obstruction of the pulmonary arterial tree with abnormal material (thrombus, tumour, air or fat). Patients can present acutely (immediately after the event), sub-acutely (within days/weeks after the embolism) or chronically (years after the embolism). The most common cause of acute PE is the migration of thrombus from veins (or right heart) to the pulmonary arteries. Figure 1 summarizes severity stratification, assessment and treatment of patients with pulmonary embolism. Other forms of PE are beyond the scope of this article.

Diagnostic considerations

Acute pulmonary embolism (PE) is a commonly considered but relatively infrequently diagnosed condition in hospitalized patients. This is unsurprising considering the clinical presentation of PE varies from dyspnoea to haemoptysis to sudden death, thus clinical assessments are insensitive and highly unspecific (Table 1, signs, symptoms and differential diagnosis of PE). The risk of VTE doubles for each decade above 40 years of age, which impacts significantly on first-world nations where life expectancy continues to rise. Consideration of risk factors contributing to the development of 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. Further investigations should be guided by the assessment of pre-test probability. The most widely reported and clinically validated are the Wells rule and the Revised Geneva scoring system (Table 3). These aim to risk stratify and focus resources on those most likely to benefit; however, the majority of patients who reach a critical care environment meet criteria for high-risk pre-test probability. Particularly complex are pregnant patients where the risk of VTE is significantly elevated and imaging modalities are not without risk to the fetus.

Investigations

Bed side 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, and equally a normal blood gas does not exclude PE. The most common ECG finding is sinus tachycardia (up to 40%) and a normal ECG is found in one third of cases. The classically described deep S wave in lead I, with a Q-wave and inverted T-wave in lead III (S1Q3T3) is rare and is usually found in severe cases of acute PE. Other evidence of RV strain, including T-wave inversion, right bundle branch block and p-pulmonale may be see, as well as atrial arrhythmias (most commonly atrial fibrillation). The ECG is more important for screening alternate diagnoses. The chest X-ray may exclude common differentials such as pneumothorax, pneumonia or pleural effusion. Identifying more specific and

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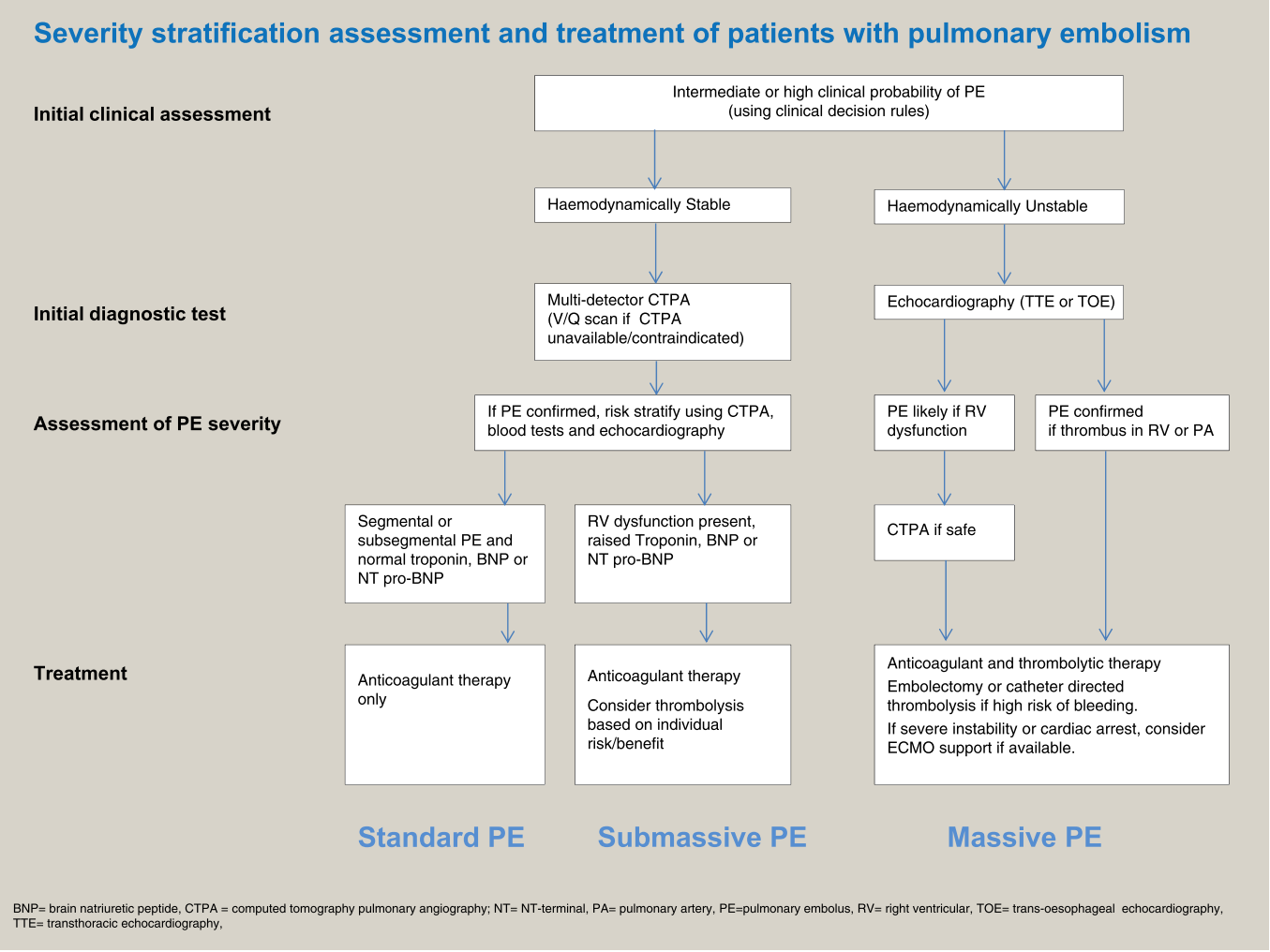

Figure 1

subtle abnormalities such as oligaemia and abnormal pulmonary artery contours is generally the perview of radiologists.

Biomarkers

Plasma D-dimer is a fragment generated from fibrin degradation and has an important role in excluding VTE and PE in the stable outpatient/ED population when it is negative. A level above a certain threshold (usually 500 ng/ml) has a high sensitivity but low specificity and low positive predictive value for PE. Age-adjusted cutoffs for D-dimer have been validated and provide more useful data in patients over 50 years of age. However, when a patient's pre-test probability is high (which describes the majority of critically ill patients), D-dimer is not recommended due to its low negative predictive value and definitive imaging is necessary. In patients with known acute PE, elevated levels of D-dimer at diagnosis are associated with an increased risk of death and show a dose-related effect. D-Dimer levels <1500 ng/ml has a negative predictive value of 99% for excluding three-month mortality.

Measurements of troponin, brain natriuretic peptide (BNP) or NT-terminal Pro-BNP (NT-Pro-BNP) are useful to risk stratify and determine prognosis in confirmed PE. 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 as well as undetectable cardiac troponin I (highly sensitive assay) correlate with good outcomes.[1,2] Heart-type fatty acid-binding protein (H-FABP) is an early marker of myocardial injury and is been associated with increased short-term mortality.

Imaging

There is no ideal imaging modality in PE. Studies show that confidence in diagnosing an acute PE can be improved by determining the pre-test probability. 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. In addition, transferring critically ill patients poses its own set of logistical obstacles and risks and these need to be weighed against the risk of empiric anticoagulation.

Computed tomography (CT)

With the improved precision and availability of CT scanners, CT pulmonary angiography (CTPA) with multi-detector scanning technique has essentially replaced all other imaging modalities,

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