Pulmonary embolism diagnosis

Pulmonary Embolism Diagnosis: Clinical assessment at the front door

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Abstract

This first of two practice reviews addresses PE diagnosis considering important aspects of PE clinical presentation and comparing evidence-based PE testing strategies. A companion paper addresses the management of PE [1]. Symptoms and signs of pulmonary embolism (PE) are varied, and emergency physicians frequently use testing to 'rule out' the diagnosis in people with respiratory or cardiovascular symptoms. The emergency clinician must balance the benefit of reassuring negative PE testing with the risks of iatrogenic harms from over investigation and overdiagnosis.

Manuscript text

INTRODUCTION

Pulmonary embolism (PE) occurs when a thrombus, usually originating in the deep veins of the lower limbs or pelvis, lodges in the pulmonary arteries. Without early treatment, PE can progress to become fatal [2,3]. The clinical diagnosis of PE remains challenging; 'classical' symptoms such as dyspnoea and chest pain are not always present in the context of acute disease, and features such as haemoptysis, unilateral extremity swelling and syncope are even less frequent [4]. There are no reliable discriminating features that individually confirm or exclude disease [5]. However, the consequences of missed disease can be serious; in a case series of in-hospital autopsy cases with pathological findings of PE, in only one third of cases was the diagnosis of PE considered antemortem [6]. As a result, clinicians considering the diagnosis of PE increasingly rely on objective laboratory and radiological investigation.

Computed tomography pulmonary angiography (CTPA) is the current imaging modality of choice in the context of suspected PE. This strategy is costly, time consuming, incurs potentially unnecessary irradiation and often detects incidental findings requiring further investigation [7]. In addition, indiscriminate use can lead to misdiagnosis of PE and potential overuse of therapeutic anticoagulation [8].

It is vital that clinicians have a pragmatic and evidence-based understanding of these challenges to enable provision of optimal care for patients. This practice review explores how a diagnosis of PE might be made and contextualises evidence-based diagnostic strategies.

CLINICAL PRESENTATION

Which clinical factors are risks for PE?

A meta-analysis of diagnostic studies in 2007 reported that in the context of clinical suspicion, past history of venous thromboembolism (VTE), active cancer, immobilization, exogenous oestrogen and recent surgery are independent predictors of PE diagnosis [5]. Cancer is a key VTE risk factor for multiple reasons: it often leads to a pro-coagulant state; cancer patients have frequent hospitalizations and surgeries; indwelling venous catheters are common; and some cancer treatments directly promote thrombus formation [9]. People with a first degree family history of venous thrombosis have a two to four fold higher odds of developing venous thrombosis themselves, independent of known thrombophilia [10]. These individual risks are cumulative [11]. For example, a person with a prior history of VTE has an increased risk of a recurrent thrombotic event, however if they are subsequently diagnosed with cancer and then undergo surgery, their personal risk of VTE will continue to increase with each additional risk factor.

Symptoms and signs

The presence of dyspnoea, haemoptysis, syncope and leg swelling all individually increase the likelihood of PE diagnosis [5]. Symptoms of deep vein thrombosis have been reported in 23% of confirmed PE cases [12]. The most commonly reported symptoms of PE are shortness of breath (likelihood ratio (LR) of 1.4 (95% confidence interval (CI) 1.1-1.8)) and chest pain (LR 1.1 (95% CI 0.8-1.3)) [4,5]. 'Classic' pleuritic chest pain has been found to occur as frequently as in 39.4% of patients with confirmed PE. A large embolic burden can also present with pre-syncope or syncope (LR 2.4 (95% CI 1.5-3.7)) on exertion [5].

Clinical findings on examination also vary in prevalence. Theoretically, the larger the embolic burden, the more likely there are to be signs of cardiovascular compromise, such as clinical shock (LR 4.1 (95% CI 1.8-8.9)) [5,13]. Absence of tachypnoea reduces the likelihood of PE (LR 0.6, (95% CI 0.4-0.8)) [5].

Electrocardiography (ECG)

ECG findings are never diagnostic for PE, and patients with acute disease will frequently have sinus rhythm with a normal heart rate [14]. However, the ECG is vital to assess the likelihood of important differentials, such as acute myocardial infarction, particularly in the context of

ongoing chest pain. Inverted T-waves in leads III and V_1 can be seen in acute PE and are rare in acute coronary syndrome [15]. The most common ECG findings in PE are sinus tachycardia, non-specific ST segment changes and T-wave changes [16]. The classic finding of an S wave in lead I, a Q wave and inverted T-wave in III, (S1Q3T3) has been previously reported as 97% specific for right ventricular enlargement in the context of confirmed PE, although sensitivity is poor at 7.1% [17]. Signs of right ventricular strain on ECG can be potentially predictive for clinical deterioration in the context of confirmed PE, but add little to the diagnostic process [18].

Chest radiography

The chest x-ray (CXR) is a routine investigation for any patient presenting to the emergency department (ED) with chest pain and/or breathlessness. In the context of suspected PE, CXR can help exclude alternative diagnoses (e.g. pneumothorax, pneumonia) and may aid diagnosis of rare pathology (e.g. aortic dissection, pericardial effusion). In addition, there are subtle signs on CXR which can potentially increase the clinical concern for PE, including the Westermark sign (oligaemia), Fleischner sign (prominent central pulmonary artery) and Hampton hump (pleural-based area of increased opacity). When studied in isolation, all are poor predictors of PE diagnosis [19]. A normal CXR is not sensitive for ruling out PE, with a prospective observational study finding 40.1% of patients ultimately diagnosed with PE having no abnormal CXR findings [4]. A CXR suggestive of alternative diagnosis is also not sensitive for ruling out PE, with atelectasis (16.9%), effusion (16.2%) and infiltrates (13.5%) being concurrent in patients ultimately diagnosed with PE [4]. Similar data has also been reported in the PE in pregnancy literature, with the DiPEP study reporting CXR abnormalities (both PE-related and PE-unrelated) in patients with and without embolic disease [20]. Clinicians should therefore be cautious in attributing non-specific CXR findings to alternative, non-PE diagnoses.

HOW TO TEST FOR PE

When should you test for PE?

The decision to evaluate for PE is dependent on compatible clinical presentation, assessment of risk factors and clinician gestalt. The presence of established VTE risk factors should influence pretest probability and increase suspicion in the context of less specific symptoms.

Clinicians should also consider testing for PE in patients with unexplained breathlessness, especially when exertional breathlessness is poorly explained by other diagnoses.

When PE is raised as a differential diagnosis in the ED, it is common for clinicians to approach the consultation wanting to 'rule out' PE as a diagnosis. However, this is trickier than it seems. Even pulmonary angiography, widely regarded as the reference standard investigation, has a reported 90-day VTE diagnosis rate following negative testing of 1.1% (95% CI 0.5-2.2%) [21]. A pragmatic approach is to avoid imaging when the pretest probability of PE is so low that further diagnostic imaging would be as likely or more likely to cause harm than to provide benefit [22]. Consequently, patients with negative testing for acute PE should always be advised to seek further medical review if their symptoms worsen. In addition, patients with negative tests for acute PE may be experiencing symptoms from another aetiology, which requires further investigation and treatment.

Deciding whether to test for PE

The pulmonary embolism rule-out criteria (PERC) **[Table 1]** contains 8 specific demographic/clinical features and is designed for use in patients where the diagnosis of PE is being considered but is felt to be unlikely. Prior studies have classified an unlikely gestalt further, at a pretest probability of PE estimated to be less than 15% [23]. If all PERC criteria are negative, the probability of harm from CT scanning is likely to be greater than the benefit, supporting cessation of further work up for PE. PERC is now highlighted within guidance produced by the National Institute for Health and Care Excellence, European Society of Cardiology and American College of Emergency Physicians. It has also been advocated within the North American 'Choosing Wisely' campaign to reduce unnecessary diagnostic testing in emergency medicine [24–27]. PERC allows a safe, rapid, and convenient assessment for patients without the need for invasive tests. However, concerns remain about how to define patients suitable for evaluation using PERC. A large cluster randomised trial included patients who the treating clinician estimated the pretest probability to be less than 15% [28]. In this study, the true pretest probability was only 2%, suggesting that clinicians over-estimated the pretest probability of PE. The implications of applying PERC to a population where PE is not really suspected or where clinicians over-estimate the pre-test probability of PE, is that it is likely to lead to an increase in unnecessary testing in those who are PERC positive (e.g. over 50) without any real clinician suspicion of PE. In attempt to reduce subjectivity, some authors

have studied application of the PERC rule to low probability patients identified through prior structured pretest probability assessment using the Wells or revised Geneva scores [29,30]. This approach has potential advantages and a developing evidence base, but no supporting randomised trial data. There is no evidence base yet to support the application of the PERC rule after YEARS assessment in YEARS negative patients, and if using a YEARS based strategy, PERC should be applied before YEARS assessment/D-dimer testing.

Table 1: Overview of the PE Rule Out Criteria (PERC) clinical decision rule

When to use	Following history and examination where PE is thought to be unlikely (i.e. pretest probability is < 15%)	
Criteria	• 50 years of age or older • Heart rate 100 or more • SpO2 on room air less than 95% • Unilateral leg swelling • Haemoptysis • Surgery requiring general anaesthesia or trauma within the past 4 weeks • Prior PE or DVT • Any hormone use	
Interpretation	If the test is negative (i.e. no items are present): investigation of PE is unlikely to benefit the patient and can be stopped. Estimated incidence in this group is 0.9% [23]	If the score is positive (i.e. any items are present): PE cannot be excluded clinically and further work up would be required in order to reject the diagnosis.

Adapted from [23].

Clinical probability estimation

Tacit knowledge and clinical gestalt are often useful in complex clinical medicine. However, this approach can be unsatisfactory for reliable and reproducible PE testing because of the unavoidable risk of bias and the overestimation of pretest probability [31]. A more structured estimate for the probability of PE is provided by clinical models, several of which have been derived and validated in large populations of emergency patients. It is worth noting that Wells and YEARS do still incorporate clinical gestalt to some degree (e.g. pulmonary embolism the most likely diagnosis in YEARS and alternative diagnosis less likely than PE in Wells) and clinical gestalt may be used to determine when to apply and how to interpret structured models. In addition, when structured models have been compared against clinical gestalt alone in observational cohort studies, there appears to be little difference in diagnostic accuracy [32]. The optimal approach is therefore likely to be a structured estimate alongside clinical gestalt, rather than a structured estimate alone. **Table 2** summarises the most common validated structured pretest probability assessments in clinical use at present, their components and associated stratification.

Table 2: Comparison of validated structured pretest probability assessments for PE diagnosis

Tool	When to employ	Variables (score)	Outcome (PE prevalence)
Wells PE [33]	Applicable for all patients following history and examination where PE is suspected	Clinical signs of DVT (3) Alternative diagnosis less likely than PE (3) Previous PE or DVT (1.5) Heart rate >100 (1.5) Surgery or immobilisation within the past 4 weeks (1.5) Haemoptysis (1) Active cancer (1)	Two level score: 0-4 PE unlikely (8.4%) 4.5 or more PE likely (34.4%)[34] Three level score: Low (5.7%) Intermediate (23.3%) High (49.3%) [34]
Simplified Revised Geneva [35]	Following history and examination where PE is suspected	Previous PE or DVT (1) Heart rate 75-94bpm (1) Heart rate 95bpm or greater (1) Surgery or fracture within past month (1) Haemoptysis (1) Active cancer (1) Unilateral lower limb pain (1) Pain on lower limb deep venous palpation and oedema (1) Age greater than 65 (1)	0-1 Low risk (7.7%) 2-4 Intermediate risk (29.3%) 5 or more High risk (64.3%)[34]
YEARS [36]	Following history and examination where PE is suspected, a YEARS score is done and a D-dimer taken.	*YEARS items:* Clinical signs of deep vein thrombosis Haemoptysis Pulmonary embolism the most likely diagnosis	No YEARS items and D-dimer <1000 ng/ml (0.3%) No YEARS items and D-dimer ≥1000 ng/ml (14.4%) Any YEARS item and D-dimer <500 ng/ml (0.9%) Any YEARS item and D-dimer ≥500 ng/ml (29.2%)

DVT: deep venous thrombosis; PE: pulmonary embolism. Note that prevalence of PE in YEARS row is not directly comparable to the two other scores because the presence or absence of variables necessarily affects investigation strategy.

The Wells PE or Geneva scores (see **Table 2**) are used to identify patients who have a lower probability of having PE. Patients with a lower probability of PE (Wells unlikely or Geneva low/moderate) can progress to further evaluation with D-dimer testing, in attempt to reduce the potential harm associated with imaging studies [37,38]. These clinical models have advantages and disadvantages. For example, the Wells PE has the fewest items to remember and the commonly used two level outcome score simplifies interpretation. However, Wells contains points for clinician gestalt (i.e. PE is the most likely diagnosis), raising concerns about reproducibility of the score, with reported poor interobserver reliability [39]. Both the Wells and Geneva scores have been extensively validated, and prospective efforts to compare the two approaches have not demonstrated superiority of either method [40,41].

D-dimer thresholds

In acute PE, activation of the coagulation and fibrinolysis pathway leads to elevation in blood D-dimer levels. Although the D-dimer result is a continuous variable, it is often reported with a prespecified manufacturer recommended dichotomous cut off (usually <500 ng/mL FEU). In this context, a negative test is routinely used to exclude PE in patients with a low to moderate probability, given the high negative predictive value of D-dimer [42]. There is evidence that adjusting the D-Dimer cut off by age can also safely exclude PE in patients with a Wells unlikely, or Geneva low / moderate score [37]. This approach carries the advantage of improved specificity (further reducing the need for imaging and the associated harms) without any decrease in sensitivity. There is also increasing evidence that adjusting the D-dimer cut off based on initial clinical probability estimation is more efficient than other methods. The YEARS algorithm [36] varies the D-dimer cut off based on the presence of YEARS items (clinical signs of DVT; haemoptysis; PE being the most likely diagnosis). The PEGeD study used clinical probability-adjusted D-dimer cut offs based on estimation using the Wells score; this approach has only been validated in one prospective study to date [43]. The range of approaches is compared in **Table 3**.

Table 3: Comparison of D-dimer cutoff approaches

	Standard approach	**Age adjusted D-dimer**	**Clinical probability adjusted D-dimer**	**YEARS**
Method	PE ruled out if D-dimer <500 ng/mL* when combined with low-moderate clinical probability	PE ruled out if D-dimer < (10 x age of patient) (if age >50) when combined with low-moderate clinical probability	When Wells PE score <4.0, PE ruled out with D-dimer <1000 ng/mL When Wells PE score 4.5 – 6.0, PE ruled out with D-dimer <500 ng/mL	When no points scored for YEARS, PE ruled out with D-dimer <1000 ng/mL Otherwise, PE ruled out with D-dimer <500 ng/mL
Potential benefits	Simple, already embedded into most local protocols, compatible with straightforward auto-alerts on electronic laboratory report systems	Addresses increasing D-dimer with age, reduces imaging in older population	Incorporates pre-test probability into D-dimer interpretation, reduces imaging in low-risk presentations	Simpler than clinical probability adjusted D-dimer, reduces imaging in low-risk presentations
Validation	Very extensively validated in multiple independent prospective cohort studies.	Validated in many post hoc analyses of prospective diagnostic PE studies outside of index cohort study [44]	Validated in one prospective cohort [43]	Formally validated in two prospective studies by post hoc analysis, outside of index cohort [45,46]
What proportion of patients would undergo CTPA?	59.8% of patients required chest imaging [43]	43.9% of patients required chest imaging [43]	35.1% of patients required chest imaging in original PEGeD study [43]	36.3% of patients required chest imaging [43]
Reported VTE event rate at 3 months when anticoagulation withheld using	0.1% (95% CI 0.0 to 0.7) [47]	0.3% (95% CI 0.1 to 1.7) [47]	0.0% (95% CI 0.0 to 0.3) [43]	0.61% (95% CI 0.4 to 1.0) [36]

this diagnostic strategy				

*CTPA: computer tomography pulmonary angiogram; PE: pulmonary embolism. * When using a D-dimer assay with a manufacturer recommended cutoff of 500 ng/ml*

IMAGING

CTPA is the most frequently used and most widely available imaging modality for PE diagnosis. However, other options remain available in most healthcare systems. There are several important considerations; pretest probability, timing, contraindications and whether alternative imaging strategies may be more appropriate. The relative merits of imaging modalities are summarised in **Table 4**.

Table 4: Relative strengths and weaknesses of imaging modalities for PE.

Modality	Strengths	Disadvantages
CTPA	Widely available including out of hours Relatively fast procedure May provide alternative diagnosis Low rate of inconclusive results (3-5%)	Risk of anaphylaxis to contrast/iodine Risk of contrast nephropathy Radiation dose: 3-10mSv, a particular risk for young and pregnant women because of breast tissue irradiation
Planar V/Q	Almost no contraindications Well validated[48] Lower radiation dose	Relatively poor availability, only available in day hours. Must combine result with previously documented clinical probability to rule in or rule out PE Inconclusive in up to 50% of cases Higher radiation dose for foetus compared to CT in pregnant patients Radiation dose ~2mSv
V/Q SPECT	Almost no contraindications Binary answer	Not extensively validated Variability in method and nonstandard diagnostic criteria Radiation dose ~2mSv

CTPA: Computed Tomography Pulmonary Angiography; SPECT: single photon emission computed tomography; V/Q: ventilation/perfusion.

CTPA is usually first choice imaging, with relative ease of access in many EDs. Advances in technology (e.g. dual source CT) are leading to higher imaging quality and a relative reduction in ionising radiation/contrast dose requirements, improving safety for patients [49]. However, there is increasing concern about false positive PE diagnoses, with easier detection of smaller (subsegmental) clots and ensuing questions on clinical relevance / need for treatment [50].

Planar V/Q (ventilation/perfusion) imaging provides an established alternative to CTPA. However, definitive results are less likely when there is an abnormal chest x-ray and unlike CTPA, this strategy rarely provides an alternative diagnosis. To diagnose or exclude PE, the planar V/Q result must match patient clinical probability. [25] Unlike planar V/Q, V/Q SPECT

provides a binary result ('PE' versus 'no PE'). However, whilst a recent meta-analysis suggested V/Q SPECT may have high sensitivity and high specificity for the diagnosis of PE, [51] there remain issues in the variability of technique and diagnostic criteria as well as the lack of validation through prospective management outcome studies. The technique is also not widely available and consigned to daylight hours.

Compression ultrasound (CUS) has a sensitivity >90% and a specificity of ~95% for proximal symptomatic deep vein thrombosis (DVT), and confirmation of DVT can sometimes negate the need for further pulmonary imaging to confirm VTE in haemodynamically stable patients [52]. Although out of hours availability is often limited, it remains a useful diagnostic option to rule in DVT (and presume a diagnosis of PE) in a patient with suspected PE and relative contraindications to CTPA.

Point of care ultrasound (POCUS) is an additional assessment tool for trained emergency clinicians and can impact pre-test probability. The sensitivity of POCUS for DVT appears to be reasonable when compared to formal sonographer CUS evaluation [53,54], although it remains operator dependent. POCUS may be useful to rule in DVT (and increase pre-test probability of PE) in a patient with suspected PE who is unstable or has relative contraindications to CTPA. POCUS can also be used to assess for indirect signs of PE, including right ventricular dilation, abnormal tricuspid annular plan systolic excursion (TAPSE), McConnells sign and increased pulmonary artery pressure [55]. All demonstrate good correlation with severity in the context of confirmed PE, although TAPSE has the highest sensitivity and specificity for early mortality [56]. POCUS may have a particular role in evaluating patients during cardiopulmonary resuscitation, given ease of access, the potential to influence treatment modalities and widespread availability [57].

Magnetic Resonance Pulmonary Angiography (MRPA) with gadolinium contrast is an alternative imaging modality, with sensitivities ranging from 31-92% and specificities quoted between 85-100% [58]. However, there are concerns about acceptability to patients, access is often limited from the ED, and the method is contraindicated in pregnancy and renal failure because of the contrast agent. Without contrast, sensitivity has been estimated as low as 82% compared to CTPA [59].

THE PREGNANT PATIENT

In the western world, PE is a leading (albeit rare) cause of mortality in pregnant patients [60]. Diagnosis can be challenging as many PE symptoms also result from normal physiological changes associated with pregnancy. Imaging is a source of unease as methods often require radiation exposure for mother and foetus. Pregnant patients have been excluded from most diagnostic PE research, so there is a relative lack of evidence to guide testing [61].

A recent prospective cohort study reported a pregnancy-adapted YEARS protocol utilising D-dimer to safely rule out PE across all trimesters of pregnancy. If the patient has signs and symptoms of DVT, CUS of the symptomatic leg is undertaken and, if positive, treatment is started. Patients with a negative CUS, and those without symptoms of DVT, have YEARS scoring (see **Table 1**) and a D-dimer test. The D-dimer cutoff for ruling out PE is 1000 ng/ml for those with no YEARS components and 500 ng/ml for those with any YEARS components [61]. This approach has been validated for D-dimer assays with a manufacturer recommended cutoff of 500 ng/ml. The pregnancy-adjusted YEARS protocol reduced radiological imaging by 65% in the first trimester and 32% in the third trimester in a research context [61]. No validation studies have been published, but several are planned [62]. A second prospective study demonstrated the safety of excluding PE in pregnant patients using a standard D-dimer cutoff in combination with the Geneva clinical probability score. [63]. However, a UK observational case-control study recently reported no value to biomarker testing (including D-dimer) [20] and in a secondary analysis of this same cohort, concluded that strategies using clinical probability and D-dimer (YEARS/D-dimer and Geneva/D-dimer) have limited diagnostic accuracy and do not accurately rule out all PE in pregnancy [64]. A health economic analysis by the same group showed that a strategy of scanning all women with a suspected PE appeared optimal. This strategy accrued more Quality Adjusted Life Years (QALYs) and incurred fewer costs than any selective strategy based on a clinical decision rule and was therefore the dominant strategy computed by the model in the pregnant patient [65].

At present, most guidelines do not support the use of D-dimer testing to exclude PE in pregnancy. Further validation studies of the pregnancy adapted YEARS algorithm may inform future practice. At present, the Royal College of Obstetricians and Gynaecologists in the UK suggest the following approach: routine clinical assessment including bloods, CXR and ECG, then bilateral CUS in the stable patient with leg symptoms, although is this is unlikely to be

available 24 hours a day in the ED. If all tests are normal and suspicion remains, CTPA or planar V/Q should be considered to enable definitive diagnosis [66]. Shared decision making should take place to consider diagnostic imaging. CT scanning will expose hypertrophied breast tissue to radiation, a risk for later breast cancer. However, V/Q scanning exposes the foetus to a higher dose of radiation. The absolute risk in both scenarios is low [67].

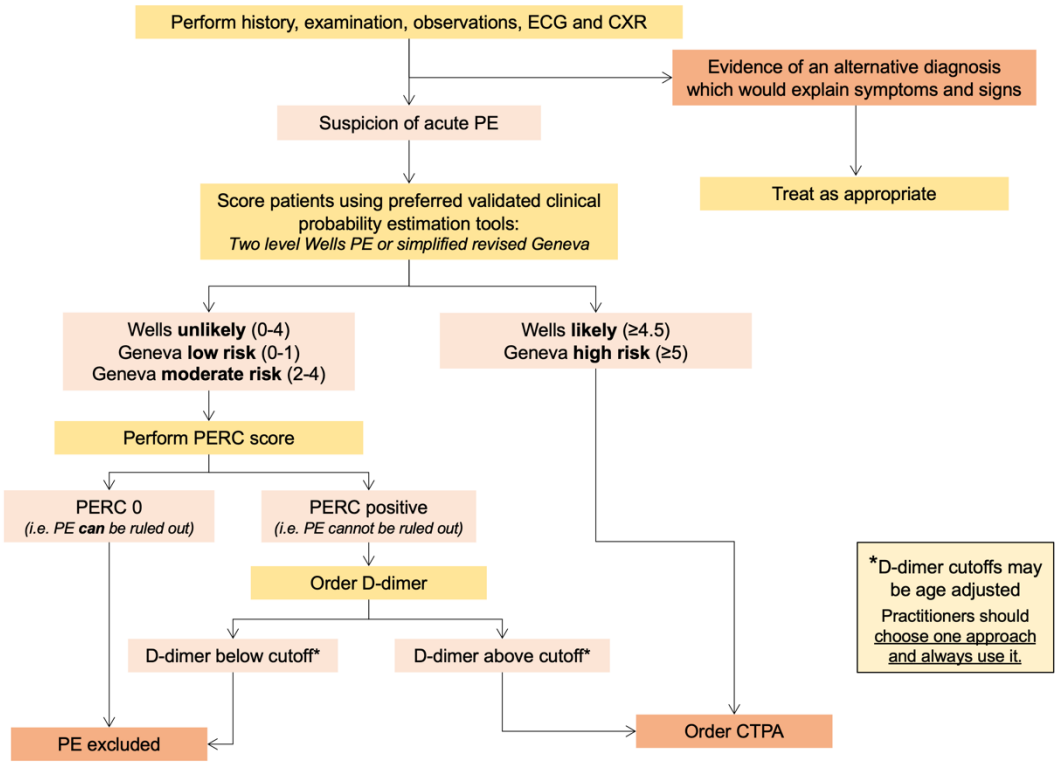
PE TESTING ALGORITHM OPTIONS

Given the diversity of PE testing options, clinicians should employ their preferred approach to testing based chiefly upon their own departmental and national guidance. Choice of diagnostic protocols may depend on available adjuncts, such as availability of a phone app or embedded support within the departmental electronic medical record. Consistency allows for familiarity, proficiency, reliability, and safety within the diagnostic approach. Broadly, there are two approaches to take following initial assessment in a haemodynamically stable patient where PE is suspected:

Option 1: Wells or Geneva models [Figure 1]

Patients should be scored using the Wells or Geneva models. Ensure you document the score in the patient's notes. For Wells unlikely or Geneva low / moderate scoring patients, PERC can be utilised; if PERC is positive then D-dimer testing should be ordered. An age-adjusted D-dimer cut off can be used. If the D-dimer result is above the age-adjusted cut off, diagnostic imaging should be ordered. If D-dimer is below the age-adjusted cut off, PE can be excluded. For patients with a likely Wells score or high probability Geneva score, diagnostic imaging for PE should be arranged without additional testing.

Figure 1

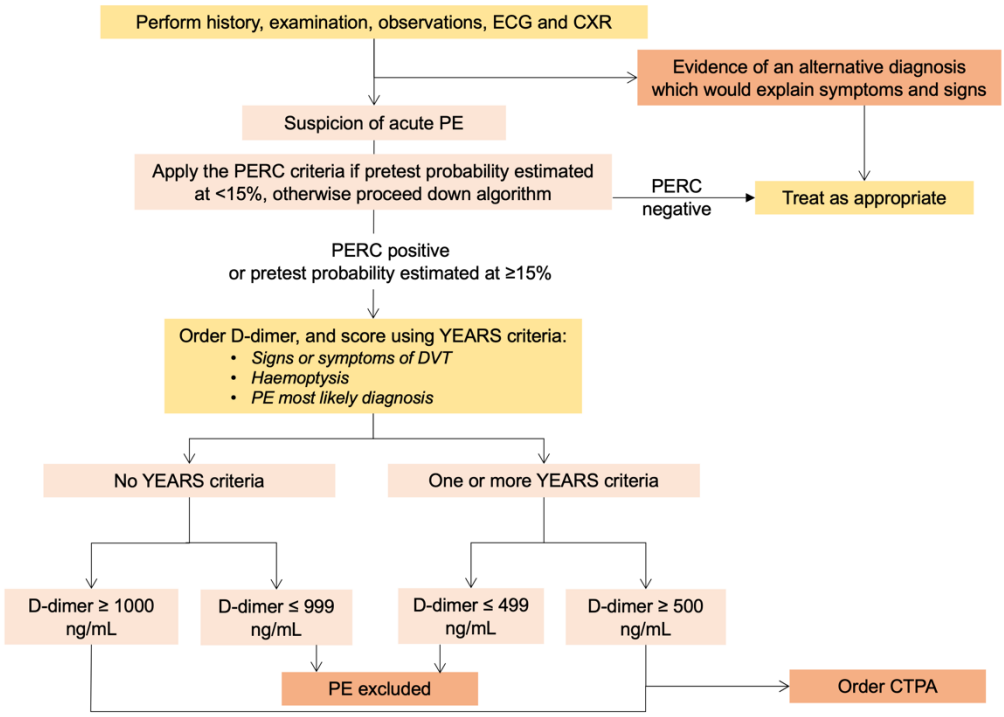


CTPA: computer tomography pulmonary angiography; CXR: chest X-ray; ECG: electrocardiogram; PE: pulmonary embolism.

Option 2: YEARS model [Figure 2]

D-dimer testing is conducted for all patients with suspected PE who are PERC positive or who have a pretest probability estimated at ≥15%. Document the presence or absence of the YEARS items (signs or symptoms of DVT; haemoptysis; PE most likely diagnosis) before ordering D-dimer. If no items are present, use a 1000 ng/mL D-dimer cutoff to exclude PE. If one or more items are present, use a 500 ng/mL D-dimer cutoff to exclude PE. Patients with D-dimer results above the YEARS cut off should progress to diagnostic imaging [36]. This approach is supported by the ESC 2019 guidance [25].

Figure 2



CTPA: computer tomography pulmonary angiography; CXR: chest X-ray; DVT: deep venous thrombosis; ECG: electrocardiogram; PE: pulmonary embolism; PERC: PE rule out criteria.

SUMMARY

Clinical assessment of suspected PE is difficult. The disease presents with a broad spectrum of symptoms, signs and severity and continues to be misdiagnosed, despite being a commonly considered diagnosis in the ED. Whilst clinicians should follow a consistent approach advocated in their local and/or national guidance where possible, they must also weigh up the individualised harms of missed PE against the benefits and harms of investigation / treatment. The importance of timely and confident diagnosis of PE is paramount. However, broad use of diagnostic imaging for PE carries important risks of harm from unnecessary testing. The risks may also vary markedly between patient groups (i.e. PE due to metastatic malignancy versus pregnancy-related PE). Considered and individualised assessment alongside patient engagement and shared decision making are therefore vital aspects of the diagnostic process.

Competing interests

JC, PS, KdW and MR have no conflicts of interest to declare.

DH was a previous topic expert for NICE NG158 and QS201, regarding the diagnosis and management of venous thromboembolic disease and venous thromboembolism in adults, respectively. DH was also a subject matter expert for the recent HSIB report on diagnosis of pulmonary embolism in emergency departments and a co-author on the BTS guidelines for the outpatient management of pulmonary embolism and the accompanying national quality standards.

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