Chapter 20
Pulmonary Embolism

Dhakshinamoorthy Vijayasankar

Key Points

- Deep venous thrombosis (DVT) probably accounts for the majority of detached thrombus that becomes lodged in the pulmonary arteries giving rise to pulmonary embolism (PE).
- Negative highly sensitive D-dimer test with a low or indeterminate pretest probability essentially excludes VTE.
- High-risk or massive PE is defined by the American Heart Association as 'sustained hypotension (systolic blood pressure of <90 mmHg for more than 15 min) or the requirement for inotropes or signs of shock'.
- Thrombolysis is only recommended for patients who have a diagnosis of massive PE.

Introduction

Venous thromboembolism includes deep vein thrombosis (DVT) and pulmonary embolism (PE), and it is the third most frequent cardiovascular disease with an annual incidence of 74.5 per 100,000 person-years in hospitalised patients [1, 2]. The quality of life in patients with history of acute PE tends to have moderate to severe impairment of social activities and physical performance. In addition, recurrent thromboembolic events were associated with increased body pain and decreased health change and health functioning [3]. Pulmonary embolism is a major cause of mortality and morbidity in Europe with reported 317,000 deaths in six countries of the European Union in 2004 [4]. The mortality rate is relatively

D. Vijayasankar, MBBS, MRCS, FCEM, Dip IMC, FIMC
Department of Emergency Medicine, Peterborough City Hospital,
PO Box 014, PE3 9GZ Bretton, UK
e-mail: dhakshinamoorthy.vijayasankar@pbh-tr.nhs.uk

S.S. David (ed.), *Clinical Pathways in Emergency Medicine: Volume I*,
DOI 10.1007/978-81-322-2710-6_20

lower in patients with haemodynamic stability and higher in patients presenting after a cardiorespiratory arrest. If PE is left untreated, the prognosis remains poor, even for treated patients who might develop thromboembolic pulmonary hypertension.

The rate of PE in pregnancy is 1–2/7,000 births [5] and usually occurs postpartum, particularly associated with preeclampsia, caesarean section and multiple births. Current smoking used to be regarded as a minor risk factor for VTE but this has not been conclusively demonstrated.

Definition

Mechanical obstruction of pulmonary artery which is usually due to blood clot from venous thromboembolism.

Classification

American Heart Association classification of pulmonary embolism [6]

- Massive pulmonary embolism
  - Sustained hypotension

    Systolic blood pressure <90 mmHg for >15 min or requiring inotropic support
  - Persistent profound bradycardia
  - Pulselessness
- Submassive PE – acute PE without systemic hypotension but with either right ventricular dysfunction or myocardial necrosis
- Low-risk PE
  - Acute PE without clinical markers of adverse prognosis

European Society of Cardiology (ESC) classification of pulmonary embolism [7]

- High-risk pulmonary embolism – haemodynamic instability with shock or hypotension
- Intermediate risk (without shock or hypotension)
  - Pulmonary embolism index (PESI) class 3–5 or sPESI >1
- Intermediate low-risk pulmonary embolism
  - PESI class 1–2 or sPESI = 0
- Low risk – absence of all the above factors

Pathogenesis

VTE develops when there is stasis, endothelial damage and hypercoagulability (Virchow's triad). This can occur in any part of the venous system, although most thrombus formation occurs in lower extremity deep veins [8]. Deep venous thrombosis (DVT) probably accounts for the majority of detached thrombus that becomes lodged in the pulmonary arteries giving rise to pulmonary embolism.

Risk Factors (Table 20.1)

Table 20.1 Risk factors for venous thromboembolism (VTE)

Major risk factors (relative risk 5–20)	
Surgery[a]	Major abdominal/pelvic surgery
	Hip/knee replacement
	Postoperative intensive care
Obstetrics	Late pregnancy
	Caesarian section
	Postpartum
Lower limb problems	Fracture
	Varicose veins
Malignancy	Abdominal/pelvic disease
	Advanced or metastatic cancer
Reduced mobility	Hospitalisation
	Institutional care
Miscellaneous	Previous proven VTE
Minor risk factor (relative risk 2–4)	
Cardiovascular	Congenital heart disease
	Congestive cardiac failure
	Hypertension
	Superficial venous thrombosis
	Indwelling central venous catheter
Oestrogens	OCP, HRT
Miscellaneous	COPD
	Neurological disability
	Occult malignancy
	Thrombotic disorders
	Long-distance sedentary travel
	Obesity
	Other[b]

VTE venous thromboembolism, *OCP* oral contraceptive pill, *HRT* hormone replacement therapy, *COPD* chronic obstructive pulmonary disease

[a]Where appropriate prophylaxis is used, relative risk is much lower

[b]Inflammatory bowel disease, nephrotic syndrome, chronic dialysis, myeloproliferative disorders, paroxysmal nocturnal haemoglobinuria, Behçet's disease

History [4, 6, 7]

Consider history of

- Thrombophilia
  - Factor V Leiden mutation
  - Antithrombin deficiency
  - Protein C and S deficiency
  - Antiphospholipid antibody syndrome
  - Dysfibrinogenaemia
- Risk factors – Table 20.1
- Symptoms
  - Dyspnoea
  - Tachypnoea
  - Pleuritic chest pain
  - Cough
  - Fever
  - Symptoms of shock in patients with massive pulmonary embolism

  Less common symptoms
- Haemoptysis
- Leg pain or swelling
- Syncope
- Symptoms of encephalopathy
- Seizure

Examination

- Sinus tachycardia may be present.
- Persistent bradycardia or pulselessness may be present in massive pulmonary embolism.
- Sustained hypotension may be present in massive hypotension.
- Respiratory signs may not be more common in patients with PE than in other patients [9].
- Chest pain on palpation does not rule out PE in patients with suspected PE [10].
- Signs of deep vein thrombosis may be present.

Making the Diagnosis

- *Pretest probability of PE*

D-dimer is a circulating fibrin degradation product that is elevated in the presence of clot formation. It is not specific to VTE and can be elevated in sepsis, pregnancy, chronic kidney disease, trauma and post-surgery. However, a negative highly sensitive D-dimer test with a low or indeterminate pretest probability essentially excludes VTE. The D-dimer test should not be undertaken if the pretest probability is high as a diagnostic investigation is required. There are many validated scores that can be used to assess the likelihood of PE including Wells and Geneva (Table 20.2).

Table 20.2 Scoring scales for grading the clinical likelihood of acute symptomatic PE

Wells score	Score
Alternative diagnosis less likely than PE	3.0
Signs or symptoms of DVT	3.0
History of PE or DVT	1.5
Immobilisation for at least 3 days or surgery in the previous month	1.5
Heart rate >100 beats/min	1.5
Haemoptysis	1.0
Active cancer (treatment ongoing, within previous 6 months or palliative)	1.0
Risk stratification	
For high sensitivity D-dimer:	
Low probability: <2 points	
Intermediate probability: 2–6 points	
High probability: ≥6 points	
For lower sensitivity D-dimer:	
PE unlikely: ≤4 points	
PE likely: >4 points	
Geneva score	
Age >65 years	1.0
Previous DVT or PE	3.0
Surgery under general anaesthesia or fracture ≤1 month	2.0
Active cancer, solid or haematologic, or considered cured ≤1 year	2.0
Unilateral lower limb pain	3.0
Haemoptysis	2.0
Heart rate 75–94 beats/min	3.0
Heart rate ≥95 beats/min	5.0
Painful lower extremity on palpation and unilateral oedema	4.0
Risk stratification	
Low probability: 0–3 points	
Intermediate probability: 4–10 points	
High probability: ≥11 points	

Investigations

- Hypoxia is common in PE but up to a fifth of patients with PE will have normal oxygenation.
- Chest radiograph is often normal but may reveal a small pleural effusion, plate atelectasis or a slight elevation of hemi-diaphragm. Local oligaemia (Westermark's sign) or Hampton's hump (a wedge-shaped, pleural-based consolidation associated with pulmonary infarction) is rarely seen.
- Electrocardiograph (ECG) often reveals sinus tachycardia but there may be evidence of right heart strain as evidenced by atrial fibrillation, right bundle branch block or inverted T waves V1-3. The classic SI QIII TIII strain pattern is rare and non-specific.
- Urgent CT pulmonary angiography is the investigation of choice to demonstrate filling defects within the pulmonary arterial circulation (Fig. 20.1).

Treatment [7, 8, 11]

Low-Risk PE

- Patients with PE should be started on low molecular weight heparin for a minimum of 5 days.
- Concomitant warfarin therapy should also be administered until the INR is within therapeutic range. Anticoagulation with warfarin or other novel therapies such as rivaroxaban (oral factor Xa inhibitor) should be continued for a duration dependent upon the likely cause.
- VTE with temporary risk factors may only require 3 months anticoagulation.

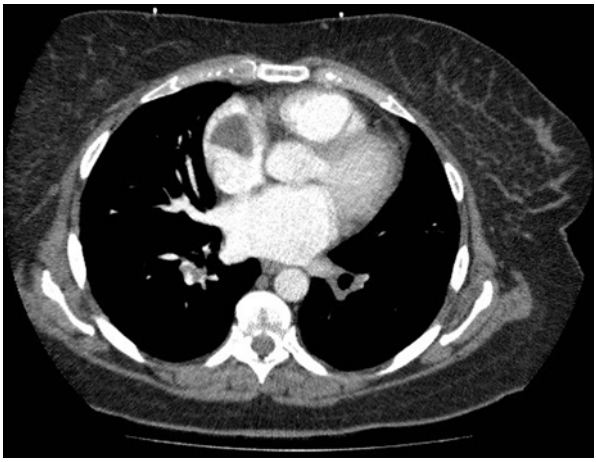

Fig. 20.1 Pulmonary emboli in the right lower lobe pulmonary arteries with right atrial thrombus demonstrated on computed tomography pulmonary angiogram (CTPA)

- A first episode of unprovoked PE is treated for a duration of 6 months, and recurrent VTE should be treated for as long as the benefit of anticoagulation outweighs the risk of severe bleeding.

High-Risk PE

This group of patients have improved mortality with thrombolysis; the earlier given the better. In most treatment algorithms, imminent cardiac arrest in massive PE should be treated with half-dose thrombolysis. The most widely used thrombolytic agent is alteplase using the same treatment as for acute myocardial infarction.

Other Treatments for PE

Occasionally, conventional angiography or CTPA examination may be contraindicated and another modality of investigation is required.

- Isotope lung scanning should only be considered if the chest radiograph is normal. If isotope lung scanning is normal, PE can be reliably excluded. Lower limb examination with USS Doppler or venography in this situation may confirm DVT and thus the increased likelihood of PE.
- Occasionally, the CTPA is negative despite a high probability of PE. Isotope lung scanning may identify areas of ventilation-perfusion mismatch presumably secondary to multiple small sub-segmental peripheral PE. The disadvantage of isotope lung scanning is the high number of indeterminate examinations and that other diagnosis such as infarction, pneumonia and cancer cannot be confirmed or excluded.
- In high-risk PE, surgical interventions should be considered if the risk of anticoagulation is too great. Thromboendarterectomy, right atrial appendage resection of thrombus and the insertion of vena caval filters can successfully treat PE and VTE in acute and chronic disease.

Complications

- Sudden cardiac death
- Obstructive shock
- Pulseless electrical activity
- Atrial or ventricular arrhythmias
- Secondary pulmonary hypertension
- Cor pulmonale

- Severe hypoxaemia
- Right to left intracardiac shunt
- Lung infarction
- Pleural effusion
- Paradoxical embolism
- Heparin-induced thrombocytopaenia
- Thrombophlebitis

Prognosis

- Prognosis depends upon clinical severity at diagnosis and response to treatment.
- Poor prognostic factors include

Table 20.3 Prognostic scores in patients with acute symptomatic PE

Variable	Score
PESI score (Pulmonary Embolism Severity Index)	
Age	1/year
Male gender	10
Cancer	30
Heart failure	10
Chronic lung disease	10
Heart rate ≥110 beats/min	20
Systolic blood pressure <100 mmHg	30
Respiratory rate ≥30 breaths/min	20
Temperature <36 °C	20
Altered mental status	60
O_2 saturation <90 %	20
Risk stratification	
Class I (very low risk): <65 points	
Class II (low risk): 66–85 points	
Class III (intermediate risk): 86–105 points	
Class IV (high risk): 106–125 points	
Class V (very high risk): >125 points	
Simplified PESI score	
Age >80 years	1
Cancer	1
Chronic cardiopulmonary disease	1
Heart rate ≥110 beats/min	1
Systolic blood pressure <100 mmHg	1
O_2 saturation <90 %	1
Risk stratification	
Low risk: 0 points	
High risk: ≥1 point(s)	

- Major embolism (hypotension and evidence right heart strain)
- Co-morbidities (congestive cardiac failure, COPD, malignancy)
- Previous or current DVT

Non-fatal recurrence is least likely in those patients with a temporary risk factor. To further complicate prognosis, there is an increased chance of cancer being diagnosed within 6–12 months of the first episode of VTE (Table 20.3).

References

1. Huerta C, Johansson S, Wallander MA, Rodriquez G. Risk factors and short term mortality of VTE diagnosed in primary care setting in the UK. Arch Intern Med. 2007;167(9):935.
2. Heit JA. The epidemiology of venous thromboembolism in the community. Arterioscler Thromb Vasc Biol. 2008;28(3):370–2.
3. Klok FA, van Kralingen KW, van Dijk AP, Heyning FH, Vliegen HW, Kaptein AA, Huisman MV. Quality of life in long-term survivors of acute pulmonary embolism. Chest. 2010; 138(6):1432–40.
4. Cohen AT, Agnelli G, Anderson FA. Venous thromboembolism (VTE) in Europe. The number of VTE events and associated morbidity and mortality. Thromb Haemost. 2007;98(4): 756–64.
5. Jackson E, Curtis KM, Gaffield ME. Risk of VTE during postpartum period: a systematic review. Obstet Gynecol. 2011;117(3):691–703.
6. Jaff MR, McMurtry MS, Archer SL, et al. American heart association council on cardiopulmonary. Circulation. 2011;123(16):1788–830.
7. Konstantinides S, Torbicki A, Agnelli G, et al. Task force for the diagnosis and management of acute pulmonary embolism. Eur Heart J. 2014;35(43):3033–73.
8. Busse L, et al. Submassive PE. Crit Care Clin. 2014;30(3):447–73.
9. Buse LW, Vourleksi JS. Submassive PE. Critical Care Clinic 2014;30:447–73 (critical care.theclinics.com).
10. Gal GL, et al. Reproduction of chest pain by palpating: diagnostic accuracy in suspected PE. BMJ. 2005;330:452.
11. Condliffe R, et al. Management dilemmas in acute pulmonary embolism. Thorax. 2014;69:174–80.