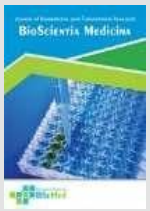
eISSN (Online): 2598-0580



Bioscientia Medicina: Journal of Biomedicine & Translational Research

Journal Homepage: www.bioscmed.com

Pulmonary Embolism: A Narrative Literature Review

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ARTICLE INFO

Keywords:
Pulmonary embolism
Thrombus
Deep vein thrombosis

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All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/bsm.v6i16.705

A B S T R A C T

Pulmonary embolism (PE) is a pulmonary emergency that is quite common with various clinical manifestations, from asymptomatic to life-threatening. The incidence of pulmonary embolism is reported to be 1 per 1000 population, with 50,000 deaths per year. Making the diagnosis is difficult because the symptoms vary widely in each patient. Management of acute pulmonary embolism is carried out with a systematic approach involving early intervention, patient risk stratification, selection of therapy, and determination of the length of treatment.

1. Introduction

A pulmonary embolism (PE) is a pulmonary emergency that requires immediate treatment to reduce mortality. The incidence of pulmonary thromboembolism is very high, but the diagnosis is difficult because the symptoms are very variable in each patient. Venous thromboembolism (VTE), which clinically presents as deep vein thrombosis (DVT) or EP, is the third most common acute cardiovascular syndrome after myocardial infarction and stroke globally. In epidemiological studies, the annual incidence rate for PE ranges from 39-115 per 100,000 population; for TVD, the incidence rate ranges from 53-162 per 100,000 population. Cross-sectional data show that the incidence of VTE is almost eight times higher in individuals aged ≥ 80 years than in the fifth decade of life. In parallel longitudinal studies have revealed an increasing trend in the annual PE incidence rate over time.[1]

Pulmonary embolism can cause ≤300,000 deaths per year in the US, ranking the highest among cardiovascular causes of death. In six European countries with a total population of 454.4 million, more than 370 000 deaths were related to VTE in 2004, of which 34% died suddenly or within hours of the acute event before therapy could be started or applied. Among patients who died from acute PE who was diagnosed after death, 59% and only 7% of patients who died early were diagnosed correctly before death.[1] In 2015, around 340 deaths were reported in Australia due to pulmonary embolism, where 50-60% of DVT patients developed PE. The incidence of PE in Asia alone is found to be only about 15 – 20% of the western states.[2,3] PE data for Indonesia is not yet available. Analysis of time trends in European, Asian, and North American populations suggests that case fatality rates for acute PE may

decrease due to increased use of more effective therapies and interventions and possibly better adherence.[1] There are three main factors that contribute to the formation of venous thrombosis, which is known as Virchow's triad, consisting of venous stasis, hypercoagulability, and damage to the blood vessel walls, and when migrating, can cause blockage of the pulmonary arteries.[4,5]

Management of acute pulmonary embolism is carried out with a systematic approach by ensuring adequate oxygenation, providing hemodynamic support, and preventing the spread of thrombus and embolic recurrence. When a patient has suspected venous thromboembolism, empiric therapy should be considered until the diagnosis is ruled out or confirmed objectively so that the mortality rate from pulmonary embolism is not high.[4,6] This literature review aims to describe the description of pulmonary embolism from the risk factors to its management.

Pulmonary embolism definition

According to the European Society of Cardiology (ESC), pulmonary embolism is a cardiovascular emergency resulting from pulmonary artery occlusion, which is life-threatening but potentially reversible in right ventricular failure.[7] Pulmonary embolism is a condition due to blockage of the pulmonary arteries, which can cause death at all ages.[8] Pulmonary embolism is a condition in which a blood clot (thrombus or multiple thrombi) migrates from the systemic circulation to the pulmonary vessels, starting from an area with turbulent blood flow, such as a venous branch or behind a venous valve.[4] When a thrombus propagates beyond the normal rate, and there is increased adherence of the thrombus to the endothelium, part or all of the thrombus ruptures and migrates through the venous system to the lungs.[4,5] Rudolf Virchow first identified several predisposing factors that increase the likelihood of pulmonary embolism, which are shown in Table 1.[4,9]

Table 1. Triassic Virchow.[4]

Static	Immobilization
	Bed rest
	Anesthesia
	CHF or cor pulmonale
	History of venous thrombosis
Hypercoagulability	Violence
	Anticardiolipin antibodies
	Nephrotic syndrome
	Essential thrombocytosis
	Estrogen therapy
	Heparin-induced thrombocytopenia
	Inflammatory bowel disease
	Paroxysmal nocturnal hemoglobinuria
	Disseminated intravascular coagulation
	Deficiency of proteins C and S
	Antithrombin III deficiency
Endothelial damage	Trauma
	Surgery

Pathophysiology of pulmonary embolism

Emboli that escape from their place of origin will be carried through the systemic venous system, the right ventricle of the heart, and then reach the pulmonary artery system. The physiological effects and clinical features of pulmonary thromboembolism vary greatly, from asymptomatic to hemodynamic collapse and death. The main factors that determine the clinical picture include; (1) embolism size and location; (2) another cardiopulmonary disease; (3) secondary humoral mediator release and hypoxic vascular response; and (4) the speed of embolism resolution.[4,10]

Rudolf Virchow, in 1856 made a postulate which stated that there are three factors that can cause intravascular coagulation conditions, namely:[4] (1) local trauma to the blood vessel wall, resulting in damage to the vascular endothelium. Usually caused by previous thrombophlebitis, trauma, or surgery; (2) Blood hypercoagulability caused by various medications, such as oral contraceptives, hormone therapy, steroid therapy, malignancy, nephrotic syndrome, thrombocytopenia due to heparin use, deficiency of protein C, protein S, antithrombin III, and DIC states; (3) Venous stasis, usually caused by immobilization or prolonged bed rest, incompetent venous valves due to previous thromboembolic processes, side effects of anesthesia, congestive heart failure, and corpulmonale disease.

Obstruction of the pulmonary vascular bed by an acute embolism can increase right ventricular afterload. In the normal pulmonary artery system, a large increase in blood flow can be accommodated by a small increase in pulmonary artery pressure. The thin-walled right ventricle is not designed to generate the pressure necessary to overcome the significantly increased pulmonary vascular resistance. Compensatory mechanisms exist that allow up to 70% obstruction of the pulmonary vascular bed before right ventricular failure occurs.[4]

In patients without a history of cardiopulmonary disease, obstruction of less than 20% of the pulmonary vascular bed can result in minimal hemodynamic compensation as a result of pulmonary vessel retention and distension. When the degree of pulmonary vascular obstruction exceeds 30% to 40%, there is a slight increase in right ventricular pressure, but the cardiac output is maintained through increased heart rate and myocardial contractility. Compensatory mechanisms begin to fail when the degree of pulmonary artery obstruction exceeds 50% to 60%. The cardiac output begins to fall, and the right atrial pressure rises abruptly. Mixed venous oxygen saturation is decreased and lactic acidosis may develop. If the acute obstruction persists, the right heart will dilate, right ventricular wall tension will increase, right ventricular ischemia will develop, cardiac output will decrease, and hypotension will occur. In patients without a history of cardiopulmonary disease, the maximum pulmonary artery pressure that the right ventricle can produce is 40 mm Hg.[4,11]

Patients with a history of cardiopulmonary disease often have a reduced pulmonary vascular reserve. In addition, relatively small emboli can cause significant hemodynamic instability in patients with a history of cardiopulmonary disease, as shown in Figure 1, showing that previously normal pulmonary vessels (open circles) have increased pulmonary vascular resistance (PVR) until the blood clot load exceeds 50%. In patients with a history of cardiopulmonary disease, the PVR will increase with only a small clot load. If the right ventricle hypertrophies in response to a gradual increase in demand, such as left ventricular compromise, idiopathic pulmonary arterial hypertension, or chronic thromboembolism, this can increase pulmonary artery pressure significantly.[4]

Several studies suggest that other mechanisms involved in hemodynamic compensation from acute pulmonary embolism include elective lobectomy, pneumonectomy, or even single lung transplantation. In an experimental study, cyproheptadine (non-selective serotonin antagonists) and ketanserin (a selective serotonin antagonist) have been shown to reduce some of the hemodynamic and airway responses that occur after pulmonary embolization. In some patients, changes in pulmonary hemodynamics are large and fluctuate disproportionately in response to relatively small emboli, suggesting that other mechanisms, such as reflex vasoconstriction and release of vasoactive compounds, may also be involved.[4]

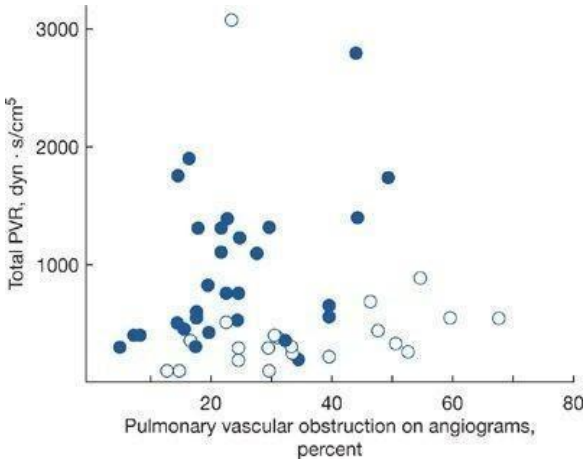

Figure 1. Pulmonary vascular hemodynamic compensation.

Large or multiple emboli tend to cause more severe symptoms and changes in oxygenation and hemodynamics. Given the greater surface area of the peripheral pulmonary vascular bed compared to the central pulmonary vascular bed, symptom improvement may occur when large central emboli are ruptured by the forces generated by cardiac contraction or even by chest compressions during cardiopulmonary resuscitation. Ultimately, the embolism may be treated by fibrinolysis, or it may turn into scar-like tissue that adheres to the vascular endothelium. Recent studies have shown that complete resolution is rare and that as many as 50% of patients have residual obstruction 6 months after the occurrence of an embolism.[4]

Hypoxemia is the most common physiological compensatory mechanism in pulmonary embolism. The pulmonary vascular obstruction prevents blood from the systemic veins from reaching the pulmonary capillaries and redirects blood flow to other parts of the pulmonary vascular bed, resulting in increased ventilation-perfusion (V/Q) imbalance, intrapulmonary shunting, and decreased O_2 level mixed venous, then enhance the effect of normal mixed venous blood. Sustained shunting and increased alveolar space may also occur as a result of alveolar hemorrhage or atelectasis related to surfactant loss. Patients with pulmonary embolism, despite an increase in alveolar space, are often hypocapnic due to hypoxia-induced intrapulmonary reflex vagal stimulation, resulting in hyperventilation. A large enough embolism can increase right atrial pressure and cause a right-to-left intracardiac shunt through a patent foramen ovale. [4,5,10]

One of the rare complications of pulmonary embolism is pulmonary infarction. Infarction is rare because the lung parenchyma has three potential sources of oxygen: the pulmonary arteries, bronchial arteries, and the airways. Infarction develops when two of these three sources are disturbed. Despite widespread obstruction, infarction does not occur due to the lung's dual blood supply. Infarction occurs in approximately 20% of patients with significant cardiac or pulmonary disease compromising bronchial artery flow or airway patency. In patients with left ventricular failure, increased pulmonary venous pressure can reduce bronchial outflow and cause infarction.[4,5]

Pulmonary embolism diagnosis

The diagnostic approach to pulmonary embolism has changed over the last decades. The prospective investigation of pulmonary embolism diagnosis (PIOPED) demonstrating the diagnosis based on clinical judgment, computer tomography (CT), the highly sensitive D-dimer test, stratification according to clinical judgment, and the application of Bayesian analysis have become the cornerstone of the current diagnostic approach.[4]

Clinical symptoms

Acute pulmonary embolism can be suspected if one of three clinical syndromes occurs: (1) isolated dyspnea; (2) pleuritic pain or hemoptysis; and (3) circulation disorders. In patients without a history of cardiopulmonary disease in the PIOPED study, pleuritic pain syndrome or hemoptysis were the most common clinical features, occurring in approximately 60% of patients. Isolated dyspnea occurs in approximately 25% of patients with pulmonary embolism, whereas circulatory collapse occurs in 10% of patients with pulmonary embolism. Dyspnea in patients with pulmonary embolism usually lasts minutes to hours but may last several days in 15% of patients. The most common physical examination is unexplained tachypnea (breathing rate greater than 20 breaths/minute) which is present in approximately 70% of patients with embolism. Less frequently, physical examinations include crackles, tachycardia, and an additional component of the second heart sound. Fever may develop several hours after the event with an average temperature of 38.3°C. The incidence of signs and symptoms of pulmonary embolism can be seen in Table 2.[4,12]

With the increasing use of CT, emboli may occasionally be seen in asymptomatic patients. Usually, these emboli are found in the peripheral segments of the pulmonary arteries and are asymptomatic. Patients who are known to be at high risk for recurrent thromboembolism, such as those with congenital thrombophilia and taking hormonal therapy or those with poor cardiopulmonary reserve, should consider anticoagulation or at least use more aggressive prophylactic therapy in high-risk settings, such as prolonged hospitalization or air travel.[4,12]

Table 2. Incidence of signs and symptoms of pulmonary embolism.[4]

	Massive PE (%)	Submissive PE (%)	Without pre-existing cardiopulmonary
Dyspnea	85	82	73
Pleuritis chest pain	64	85	66
Cough	53	52	37
Hemoptysis	23	40	13
Tachypnea	95(>16 breaths/min)	87(>16 breaths/min)	70(>20 breaths/min)
Tachycardia (>100 beats/min)	48	38	30
Increased pulmonic component of second heart sound	58	45	23
Rales	57	60	51
Phlebitis	36	26	11

A major advance in the diagnostic approach to pulmonary embolism is one that uses Bayesian analysis. These pretest probabilities assist in the selection and interpretation of further diagnostic tests in determining probabilities post-test disease as a basis for clinical decision-making. In pulmonary embolism, these scores have been developed and validated by Wells et al., as shown in Table 3. In addition, there is also the revised Geneva prediction score in Table 4.[4,13]

Laboratory examination

Routine laboratory tests do not play a major role in confirming or eliminating the diagnosis of pulmonary embolism but can assist in other possible diagnoses. Mild leukocytosis may accompany embolism but rarely exceeds 20,000/mm^3.[4]

Table 3. Wells clinical prediction score.[4]

Variable	Points
DVT symptoms/signs	3,0
PE likely or more likely than alternative diagnosis	3,0
Heart rate >100	1,5
Immobilization/surgery previous 4 weeks	1,5
Previous DVT or PE	1,5
Hemoptysis	1,0
Malignancy	1,0
Total Score	Pretest probability
<2,0	Low
2,0-6,0	Moderate
>6,0	Severe
Dichotomized Score	
≤4	PE unlikely
>4	PE likely

Table 4. Geneva revised the clinical prediction score.[4]

Variable	Point
Age >65	1
Previous DVT or PE	2
Surgery (under general anesthesia) or lower limb fracture within 1 month	2
Active malignancy (currently active or considered cured <1y)	2
Symptoms	
Unilateral lower limb pain	3
Hemoptysis	2
Clinical sign	
Heart rate; 75-94 beats/min	3
≥95 beats/min	5
Pain on lower limb deep venous Palpation or unilateral edema	4
Total score	
0-3	Low
4-10	Moderate
≥11	Severe

Hypoxaemia is common with acute pulmonary embolism, although the diagnosis cannot be ruled out by PO_2 level, which is normal. The more massive the obstruction, the more severe the hypoxaemia that may occur. However, many other conditions can cause hypoxaemia, and conversely, acute pulmonary embolism does not always cause hypoxaemia or a widening of the A-a O2 gradient. Although most patients with emboli have a gradient of PaO_2 low, $PaCO_2$ low, or PO_2 high, the presence/absence of these abnormal values has not been able to rule out the diagnosis of pulmonary embolism.[4,5]

The D-dimer test has been shown to be highly sensitive but non-specific. Elevated D-dimer levels occur in nearly all patients with venous thromboembolism but occur in a variety of other settings, including the elderly, pregnancy, trauma, infection, postoperative, inflammatory states, and malignancy. Therefore, the role of the D-dimer test is limited to one of the venous thromboembolic exclusion methods. This test is of limited use in hospitalized patients, given the high frequency of positive results in this population.[4,10]

Electrocardiogram

The electrocardiogram in acute pulmonary embolism is generally non-specific, including T-wave changes, ST segment abnormalities, and left or right axis deviation, as shown in Figure 2. Atrial arrhythmias can occur but appear to be more common in patients with cardiopulmonary disease. The S1Q3T3 pattern, considered specific for pulmonary embolism, appears in only a minority of patients. Electrocardiographic findings may explain the extent and compensatory hemodynamic features of the embolism. The electrocardiogram is rarely normal in pulmonary embolism associated with right ventricular dysfunction. The presence of an S1Q3T3 pattern, bundle branch block, or T-wave inversion in leads V1 to V3 in a patient with a pulmonary embolism suggests right ventricular dysfunction.[4,14]

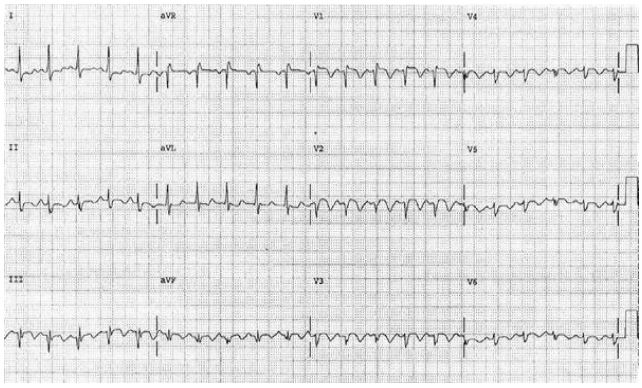

Figure 2. Electrocardiogram.

Thorax's photo

Most patients with pulmonary embolisms have abnormal but non-specific chest X-ray findings. Common radiographic findings include atelectasis, pleural effusion, pulmonary infiltrates, and a slightly elevated hemidiaphragm. You can find classic features of lung infarction, such as Hampton's hump or decreased pulmonary vascularity (Westermark sign), shown in Figure 3. Chest X-ray in suspected pulmonary embolism is used to rule out differential diagnostic possibilities such as pneumothorax, which can precipitate a pulmonary embolism. A normal chest X-ray in a patient with unexplained acute tachypnea, dyspnea, or hypoxaemia should be suspected of a pulmonary embolism.[4]

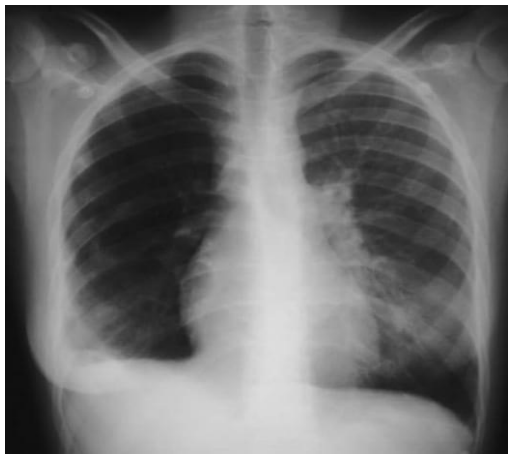

Figure 3. Thorax's photo.

V/Q scanning

V/Q (ventilation/perfusion) scanning has been an important diagnostic test in suspected chronic pulmonary embolism but has now been replaced by CT imaging. Despite its limitations, V/Q scanning can provide important information when properly used and interpreted.[4]

Computed tomography (CT)

Computed tomography pulmonary angiogram (CT-PA) has become a test First-line imaging for pulmonary embolism in Figure 4 shows a nearly occlusive thrombus in both lower lobe pulmonary arteries (arrows).[4]

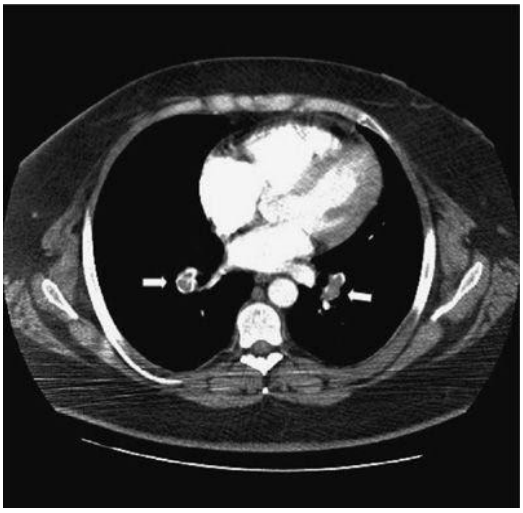

Figure 4. CT angiogram.

Conventional pulmonary angiography

Prior to CT-PA, pulmonary angiography was considered the gold standard for diagnosing pulmonary embolism. A pulmonary angiogram in Figure 5 using conventional contrast shows a large embolism within the left main pulmonary artery and extending into the lobe branches.[4]

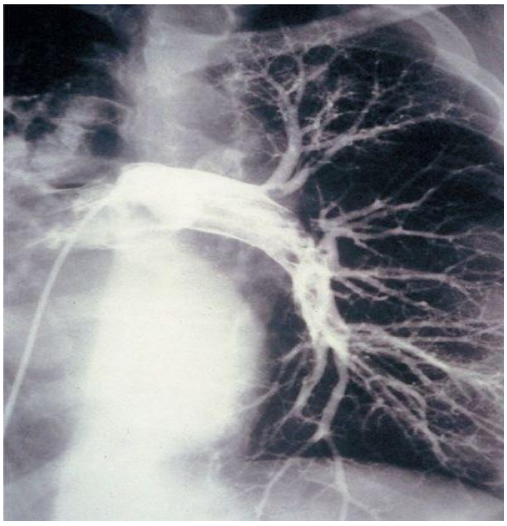

Figure 5. Lung angiogram with contrast.

Differential diagnosis of pulmonary embolism

Pulmonary embolism has a clinical picture that varies from dyspnea to sudden cardiac arrest. The differential diagnosis of pulmonary embolism is broad and includes:[15-18] Acute coronary syndrome, stable angina, acute pericarditis, congestive heart failure, malignancy, cardiac arrhythmia, pneumonia, pneumonitis, pneumothorax, and vasovagal syncope.

Management

Management of acute pulmonary embolism is carried out with a systematic approach involving early intervention, patient risk stratification, selection of therapy, and determination of the length of treatment. The goals of therapy in pulmonary embolism include ensuring adequate oxygenation, providing hemodynamic support, preventing the spread of thrombus, and preventing embolic recurrence. When a patient has suspected venous thromboembolism, empiric therapy should be considered until the diagnosis is ruled out or objectively confirmed. Where rapid D-dimer testing and CT are available, diagnostic confirmation or exclusion of pulmonary embolism is short-lived. Initial treatment of a pulmonary embolism should be started if diagnostic tests are not available.[4]

Availability of low–molecular-weight heparin (LMWH) may be selected on an outpatient basis. However, most physicians still recommend short-term hospitalization in patients with newly diagnosed acute pulmonary embolism. Hospitalization is mandatory for elderly patients. Other indications for hospitalization include hypoxemia, hypotension, hemodynamic instability, or renal disease, which contraindicates the use of LMWH or factor Xa inhibitors.[4,19]

Heparin

Heparin is the standard initial anticoagulant therapy in cases of pulmonary thromboembolism. The main benefit of heparin is to reduce the spread of thrombus and prevent an embolic recurrence. Options include intravenous unfractionated heparin (UFH) or subcutaneous LMWH preparations.[4] Intravenous unfractionated heparin (UFH) administration needs to be monitored until an adequate activated partial thromboplastin time (aPTT) is achieved. A standard protocol for administering and monitoring UFH has been recommended. The dosing regimen often used is an initial intravenous bolus of 80 U/kg followed by a continuous infusion starting at 18 U/kg/hour, where this regimen reaches the therapeutic threshold more rapidly than the fixed-dose regimen. The heparin drip is adjusted based on aPTT monitoring, checked 6 hours after the initial bolus dose, then checked 6 hours after each dose adjustment, with a target aPTT ratio of 1.5 to 2.5.[4]

A recent study used fixed-dose subcutaneous unfractionated heparin without aPTT monitoring, administered at an initial dose of 333 U/kg followed by 250 U/kg every 12 hours, and has been shown to be safe and have the same level of effectiveness as LMWH in patients with TVD and pulmonary embolism.[4]

In special circumstances, LMWH preparations can replace unfractionated heparin as the anticoagulant of choice in uncomplicated venous thromboembolism, including pulmonary embolism. These special conditions include renal insufficiency, extreme body weight, and circumstances in which dose adjustment or anticoagulant reserve is required, such as women in the last trimester of pregnancy which may require a cesarean section, patients with a history of surgery or recent history of bleeding, and patients who hemodynamically unstable with venous thromboembolism which may require surgical procedures such as emergency embolectomy.[4] Studies have shown that LMWH is at least as effective as UFH in treating acute pulmonary embolism. The advantages of LMWH, compared to UFH, include[4,17] a longer half-life and ease of use, serving as early anticoagulant therapy, eliminating the need to monitor the effect of anticoagulants, and reducing the incidence of major bleeding complications.

In general, therapeutic monitoring is not necessary in LMWH, except in certain cases such as;[4,20] patients with antiphospholipid antibodies or other circulating anticoagulants who have an increased aPTT, extreme

body weight (less than 40 kg and greater than 150 kg), kidney disease with a creatinine clearance of less than 30 mL/min, pregnancy, and irreversible bleeding unexplained or recurrent thrombosis during therapy. The therapeutic target range for peak anti-Xa levels is from 0.6 to 1.0 IU/mL after 4 hours of administration. The target ranges for peak anti-Xa levels with once-daily enoxaparin are likely to be greater than 1.0 IU/mL and greater than 0.85 IU/mL with tinzaparin and 1.3 IU/mL and 1.05 IU/mL with nadroparin and dalteparin.[4,20]

Factor Xa inhibitors

Fondaparinux and synthetic pentasaccharides are the main options in a new class of antithrombotic agents. Unlike unfractionated heparin and LMWH, the antithrombotic properties of fondaparinux are selective for factor Xa. By binding rapidly and strongly to antithrombin, fondaparinux specifically catalyzes the inhibition of factor Xa, resulting in the inhibition of thrombin formation. Fondaparinux does not bind to other components of plasma or platelets, has a half-life of approximately 17 hours, and is excreted by the kidneys. In a study, it was stated that fondaparinux was proven to be as effective and safe as UFH. Fondaparinux is approved for prophylaxis in patients undergoing hip, knee, and abdominal surgery and for the treatment of warfarin-associated TVD and pulmonary embolism. [4,21,22] rivaroxaban is the first choice in a new generation of oral factor Xa inhibitors. In a randomized study, rivaroxaban was shown to be as effective as conventional therapy (LMWH followed by a vitamin K antagonist) in patients with symptomatic TVD.[4]

Intravenous direct thrombin inhibitors (lepirudin, argatroban) are another class of anticoagulant agents that have been approved for the management of patients with venous thromboembolism in the presence of heparin-induced thrombocytopenia (HIT). The mechanism of action differs between heparin and synthetic pentasaccharides in that it directly inhibits the active site of thrombin and does not require interaction with antithrombin to produce an anticoagulant effect. Argatroban is a synthetic agent derived from arginine. Argatroban has a half-life of about 45 minutes and is cleared by the liver. Lepirudin is a recombinant polypeptide similar to hirudin. Lepirudin has a half-life of 40 to 60 minutes and is cleared by the kidneys. Both agents were given by continuous intravenous infusion, and dose adjustment was made based on aPTT monitoring. Both agents affect the international normalized ratio (INR), making it difficult to change to oral warfarin therapy. So far, the use of intravenous direct thrombin inhibitors in the management of HIT is still better than fondaparinux. Based on its size, fondaparinux is less immunogenic than unfractionated heparin or LMWH. The FDA has not approved the use of fondaparinux for HIT indications.[4,19,23]

Thrombolytic therapy

Thrombolytic agents cause direct lysis of the thrombus by increasing plasmin production through the activation of plasminogen. The potential benefits of thrombolytic agents are often accompanied by a relatively higher incidence of hemorrhagic complications. Several thrombolytic agents that are often used for the management of pulmonary embolism include streptokinase, alteplase (rt-PA), and urokinase. The PEITHO (pulmonary embolism thrombolysis) trial is currently evaluating the efficacy and safety of tenecteplase in normotensive patients with right ventricular (RV) dysfunction.[4]

The role of thrombolytic agents in acute pulmonary embolism is controversial. While thrombolytic therapy may accelerate the rate of thrombolysis, there is no evidence to suggest that it reduces mortality, increases the final rate of embolic resolution at day 7, reduces the rate of thromboembolic recurrence, improves symptoms, or reduces the incidence of thromboembolic-induced pulmonary hypertension. One issue that is still controversial is the use of thrombolytic agents along with an increased risk of bleeding, including intracranial bleeding. Intracranial hemorrhage has occurred in 0.5% to 3.0% of patients treated with thrombolytic agents in a study aimed at

evaluating the use of thrombolytic agents in pulmonary embolism and myocardial infarction. [4,24,25]

Interventional radiology techniques

Interventional thrombus fragmentation is a potential therapeutic option for systemic thrombolysis. If the risk of bleeding is not too high, catheter fragmentation can be combined with local or systemic thrombolysis. A variety of devices designed to break down and/or remove newly embolic material have been tested in patients with pulmonary embolism. In general, these devices use pressurized saline or a rotating impeller to rupture the central thrombus. Fragments are aspirated through separate ports on the catheter or allowed to migrate distally. Most devices have been shown to be effective, safe, and potentially life-saving when a central acute clot is found. However, so far, neither device has been investigated in large-scale trials. These limitations include the risk of concurrent embolism from clot fragments. Therefore, intervention is contraindicated in patients who have intracardiac clefts, such as a patent foramen ovale.[4]

Embolectomy

Embolectomy has been used for the emergency removal of a pulmonary embolism. Studies have shown that thrombolytic agents are not significantly different from embolectomy, although there is a trend toward better survival and lower bleeding rates in the surgical group. Based on the current study, surgical embolectomy should be considered in patients with persistent hypotension, shock, or cardiac arrest who have failed thrombolysis or have contraindications to thrombolytic management.[4,26,27]

Pulmonary embolism prevention strategy

The use of prophylactic strategies in hospitalized patients is beneficial in preventing the morbidity and mortality associated with venous thromboembolism. Current research indicates that thrombosis prophylaxis is still underutilized in at-risk patients, especially medical patients whose risk approaches moderate-risk surgery. Patients need to be stratified according to DVT risk and specific prophylactic measures. The intensity of the prophylactic regimen needs to take into account the relative risk of thrombosis.

The patient's thrombotic risk may change over time based on periodic assessments of the prophylactic strategy undertaken. Most hospitalized patients are at risk for venous thromboembolism and should receive some form of prophylaxis unless contraindicated. Prophylaxis may not be necessary in some cases, such as in the case of young outpatients (less than 40 years of age) who are hospitalized for a short time (less than 48-72 hours), as well as in patients with no prior history of venous thromboembolism or thromboembolism vein recently. Four categories of drugs have been used successfully for thromboembolic prophylaxis, including:[4] unfractionated heparin, LMWH (enoxaparin, dalteparin), factor Xa inhibitors (fondaparinux, rivaroxaban), and the vitamin K antagonist warfarin.

Prophylactic doses are subtherapeutic (except warfarin) but sufficient to reduce the likelihood of thrombus formation. When administered properly, anticoagulant prophylaxis is safe and effective with an absolute reduction in venous thromboembolic events by the range of 40% to 60%.[4]

Prevention of venous thromboembolism can also be achieved using mechanical therapy. This therapy falls into two categories, graded compression stockings, and intermittent pneumatic compression stockings. The use of pneumatic compression stockings has been shown to be as effective as subcutaneous unfractionated heparin in preventing thrombosis. Mechanical prophylactic methods are beneficial in patients at risk of bleeding and can be an adjunct to pharmacological methods in patients at high risk of thrombosis.[4]

The risk of thromboembolism does not always end with discharge from the hospital. In inpatients or outpatients, prophylaxis should be continued until the thrombotic risk has been resolved. The potential for bleeding complications associated with prophylaxis is

a common dilemma in surgical or trauma patients, where bleeding may occur from the surgical site, especially in the immediate postoperative period. On the other hand, effective prophylaxis depends on the timely administration of therapy before a thrombus develops. In some cases, anticoagulation may be delayed, and graded compression stockings or pneumatic compression stockings may be applied before surgery is initiated or immediately after surgery is completed.[4]

Pulmonary embolism prognosis

Shock and right ventricular dysfunction have a poor prognosis in patients who die from pulmonary embolism. Patients with coexisting pulmonary embolism and dePEvein thrombosis are also at high risk of death. The simplified pulmonary embolism severity index (PESI) and simplified PESI (sPESI) prognostic models are the most frequently used, as shown in Table 5. The main advantage of the PESI and sPESI scores lies in the identification of patients with a low risk of death within 30 days (PESI class I and II).[27-34]

Table 5. Pulmonary embolism severity index (PESI).

PESI	sPESI
Age > 80 years (+1 point)	Age > 80 years (+1 point)
Man (±10 points)	-
Cancer (±30 points)	Cancer (+1 point)
Chronic heart failure (+ 10 points)	Chronic heart failure (+1 point)
Chronic lung disease (+10 points)	Chronic lung disease (+1 point)
Pulse rate ≥110 beats/minute (+20 points)	Pulse rate ≥110 beats/minute (+1 point)
Systolic BP <100 mmHg (+30 points)	Systolic BP <100 mmHg (+1 point)
Respiratory rate > 30 breaths per minute (+20 points)	-
Temperature <36°C (+20 points)	-
Changes in mental status (+60 points)	-
Arterial oxyhemoglobin saturation <90% (+20 points)	Arterial oxyhemoglobin saturation <90% (+1 point)

Risk stratification in PESI consists of A) Class I: Points ≤ 65; the 30-day risk of death is low from 1 - 6 percent, B) Class II: Points 66–85; low risk of death from 1.7 to 3.5%, C) Class III: 86–105 points; moderate risk of death from 3.2 to 7.1 percent. D) Class IV: Points 106–125; high mortality risk from 4.0 to 11.4%, E) Class V: Points over 125; very high mortality risk from 10.0 to 24.5%. Risk stratification in sPESI consists of[28,30] A) If 0 points, then the risk of death within 30 days is 1.0%, and B) If one or more than one point, then within 30 days, the risk of death is 10.9%

Complete resolution of a pulmonary embolism is rare. If there is residual pulmonary vascular obstruction, some patients may develop chronic thromboembolic pulmonary hypertension (CTEPH). It is estimated that approximately 0.5% - 1% of patients will develop this condition after the initial episode of a pulmonary embolism with symptoms. The diagnosis should be considered even if there is no history of acute embolism. Approximately 30% of patients presenting with CTEPH have no previous history of acute embolism and are diagnosed during the evaluative process for unexplained dyspnea or pulmonary hypertension.[4,10]

2. Conclusion

Pulmonary embolism is a vascular disease due to blockage of the pulmonary artery or bronchial artery due to a thrombus. Clinical manifestations are atypical, making them difficult to diagnose. Treatment with anticoagulants or surgical procedures such as embolectomy. Prognosis depends on the speed of

diagnosis, the severity of the disease, management, and comorbidities.

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