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Review

Approaches to Acute Pulmonary Embolism in High-Risk Pregnancies in the Emergency Department

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Abstract

Pulmonary embolism (PE) is a life-threatening complication in pregnancy, particularly for high-risk individuals, and can have severe maternal and fetal consequences if not promptly diagnosed and managed. This narrative review provides an in-depth overview of the current diagnostic and treatment approaches for high-risk PE in pregnant women. It examines the challenges in diagnosing PE due to pregnancy-related physiological changes and the overlap of symptoms with other common conditions, emphasizing the importance of early and accurate identification using clinical risk assessment tools, D-dimer testing, and imaging techniques such as computed tomography pulmonary angiography (CTPA) and ventilation-perfusion (V/Q) scans. The review also discusses the multidisciplinary management approach, focusing on anticoagulation therapy with low-molecular-weight heparin (LMWH) as the first-line treatment, along with the use of thrombolysis, catheter-directed interventions, and surgical embolectomy for severe cases. Preventive strategies, including thromboprophylaxis and early mobilization, are highlighted as crucial for reducing the incidence of PE in high-risk pregnant women. The paper concludes by identifying gaps in the current evidence base, including the need for prospective studies and more research on newer anticoagulants, to improve the management of PE in pregnancy.

Keywords: *Pulmonary embolism, pregnancy, emergency department*

Introduction

Pulmonary embolism (PE) is a serious and potentially life-threatening complication that can occur during pregnancy, particularly in high-risk individuals. PE is defined as the obstruction of the pulmonary arterial system by a thrombus that originates elsewhere in the body, most commonly in the deep veins of the lower extremities (deep vein thrombosis or DVT). Pregnant women are at an increased risk of developing PE due to physiological changes associated with pregnancy, such as hypercoagulability, venous stasis, and vascular injury (1).

The incidence of PE during pregnancy is estimated to be 1 in 1,000 to 2,000 deliveries, with a higher risk in the postpartum period (2). Certain factors can further increase the risk of PE in pregnant women, including advanced maternal age, obesity, history of thromboembolism, thrombophilia, assisted reproductive technology, and immobilization. Additionally, women with pre-existing medical conditions, such as heart disease, chronic lung disease, or cancer, are also at a higher risk of developing PE during pregnancy (3).

Early recognition and prompt management of PE in high-risk pregnant women are crucial to prevent adverse outcomes. The diagnosis of PE during pregnancy can be challenging due to the physiological changes associated with pregnancy and the overlap of symptoms with other conditions. Diagnostic tools, such as D-dimer testing, compression ultrasonography, and computed tomography pulmonary angiography (CTPA), are commonly used to evaluate suspected PE in pregnant women (4).

The management of PE in high-risk pregnancy typically involves a multidisciplinary approach, including anticoagulation therapy, thrombolytic therapy, and, in some cases, surgical intervention. Anticoagulation with low-molecular-weight heparin (LMWH) is the mainstay of treatment, as it has been shown to be safe and effective in pregnant women. Thrombolytic therapy may be considered in cases of massive or life-threatening PE, but its use during pregnancy is limited due to the increased risk of bleeding. In rare cases, surgical interventions, such as embolectomy or inferior vena cava filter placement, may be necessary to manage PE in high-risk pregnant women (5, 6).

Preventive strategies are crucial in reducing the incidence of PE in high-risk pregnant women. These strategies include thromboprophylaxis with LMWH, early mobilization, and the use of compression stockings (7). Identifying and managing risk factors, such as obesity, prior history of thromboembolism, and thrombophilia, can also help mitigate the risk of PE during pregnancy (8).

This narrative review aims to provide a comprehensive overview of the current approaches to the diagnosis, risk assessment, and management of pulmonary embolism in high-risk pregnant women. The discussion will focus on the unique challenges and considerations associated with this patient population, as well as the latest evidence-based recommendations for clinical practice.

Methodology

This study is based on a comprehensive literature search conducted on 23 November 2024 across the Medline and Cochrane databases. Using medical subject headings (MeSH) and relevant keywords, the search aimed to identify studies on pulmonary embolism in high-risk pregnancy. The focus was on identifying research related to epidemiology, clinical management, outcomes, and treatment approaches for high-risk PE during pregnancy, as well as diagnostic strategies and prevention measures. To ensure a thorough search, a manual review of references was also conducted through Google Scholar, examining the citation lists of identified papers for additional relevant studies. No restrictions were placed on publication date, language, participant age, or type of publication to allow for a comprehensive exploration of the available literature.

Discussion

Pregnancy-associated pulmonary embolism (PA-PE) is a rare but potentially fatal complication that requires prompt recognition and management. It is one of the leading causes of maternal mortality,

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particularly in high-risk pregnancies, where factors such as pre-existing medical conditions, advanced maternal age, and obesity can exacerbate the likelihood of developing venous thromboembolism (VTE). The pathophysiology of PA-PE is influenced by pregnancy-related physiological changes, including increased blood volume, hypercoagulability, and venous stasis, all of which heighten the risk of thrombus formation (3). Moreover, the postpartum period is marked by a further increase in PE risk, making it a critical time for vigilant monitoring and prevention (9).

Diagnostic Approaches

Diagnosing high-risk PE in pregnancy presents unique challenges. The overlap between pregnancy-related physiological changes and symptoms of VTE, such as dyspnea, tachycardia, and leg swelling, complicates clinical assessment. Accurate diagnosis is essential to reduce maternal and fetal morbidity and mortality. At the same time, unnecessary diagnostic procedures must be avoided to minimize fetal exposure to ionizing radiation and maternal stress (4).

Clinical Risk Assessment

Clinical decision rules, such as the Wells score and the Geneva score, are commonly used in non-pregnant populations to assess the probability of PE (10). The Wells score evaluates factors like clinical signs of DVT, prior history of PE, and the presence of other risk factors such as recent surgery or malignancy, assigning weighted points to each factor to categorize patients into low, moderate, or high-risk groups for PE. The Geneva score operates similarly, with a points system based on clinical findings, including age, history of VTE, and symptoms such as hemoptysis or immobilization. Both scores aim to assist in determining the need for further diagnostic testing, such as imaging or D-dimer testing, in order to guide clinical decision-making (11).

However, the application of these scores during pregnancy is limited due to the unique physiological changes that occur during gestation. For example, tachycardia, decreased systemic vascular resistance, and fluid retention are all common in pregnancy, which can lead to false-positive results when these rules are applied. Additionally, pregnancy-specific risk factors, such as cesarean delivery, thrombophilia, advanced maternal age, and obesity, are not included in the traditional models, potentially reducing their accuracy in assessing the true risk of PE in pregnant women (12, 13). Consequently, modified or additional risk stratification methods tailored to this unique patient group are highly needed.

The pregnancy-adapted YEARS algorithm is a significant advancement, offering a tailored approach to risk assessment. It incorporates three clinical criteria: signs of DVT, hemoptysis, and whether PE is the most likely diagnosis, in conjunction with adjusted D-dimer thresholds based on pregnancy status (14). In a large multicenter study of 498 pregnant women, this algorithm safely reduced the need for imaging in 39% of cases without compromising diagnostic accuracy. The algorithm demonstrated the greatest efficiency in the first trimester of pregnancy and the least efficiency in the third trimester. CT pulmonary angiography was not performed in 65% of patients who started the study in the first trimester, compared to 32% of those who began in the third trimester (15). This approach not only minimizes fetal exposure to radiation but also reduces the burden of diagnostic interventions on healthcare systems. Nevertheless, further validation across diverse populations and settings is necessary to establish its widespread applicability.

Imaging Modalities

Imaging is the gold standard for diagnosing PE when clinical suspicion remains high after initial assessment. Compression ultrasound is the first-line imaging modality for patients with suspected DVT. A positive result eliminates the need for further imaging, as treatment protocols for VTE cover both DVT and PE. Ultrasound is a non-invasive technique that does not pose a radiation risk, unlike ventilation-perfusion (V/Q) scans or computed tomography pulmonary angiography (CTPA), which involve radiation exposure to both the mother and fetus (10). Clinical guidelines recommend the use of lower limb ultrasound for pregnant women

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with suspected PE (16-18). However, there is ongoing debate regarding the optimal selection of patients to ensure the most effective diagnostic outcomes.

For direct visualization of PE, CTPA and V/Q scans are the primary options. CTPA is highly sensitive and specific, providing critical information about the extent of clot burden and evidence of right ventricular strain. It can also identify alternative diagnoses, such as pneumonia or aortic dissection. Concerns about radiation exposure to the fetus, particularly to maternal breast tissue, have historically limited its use in pregnancy. However, advances in low-dose CTPA protocols have significantly reduced radiation exposure while maintaining diagnostic accuracy, making it a safer and more practical option in many cases (19).

V/Q scans, especially low-dose perfusion protocols, involve lower radiation doses to the fetus compared to CTPA but may be less reliable in patients with abnormal chest X-rays or pre-existing lung conditions (20). Studies comparing the efficacy of CTPA and V/Q scanning in pregnancy have found similar diagnostic accuracy, suggesting that the choice of modality should be guided by local expertise, patient-specific factors, and availability (21). Shared decision-making, with clear communication about risks and benefits, is essential when selecting an imaging modality.

Biochemical Testing

D-dimer, a fibrin degradation product, is a widely used marker for excluding VTE in non-pregnant populations. However, its utility in pregnancy is limited due to physiological increases in D-dimer levels throughout gestation. By the third trimester, most pregnant women exceed the standard threshold (500 ng/mL), reducing the specificity of the test (22). Adjusted thresholds based on gestational age or integration into clinical algorithms, such as the pregnancy-adapted YEARS algorithm, have shown promise in improving diagnostic accuracy (23).

A multicentric prospective study has suggested that D-dimer levels < 500 ng/mL combined with clinical decision rules can safely exclude PE in a significant proportion of low-risk cases, reducing the need for CTPA (24). However, the lack of standardized pregnancy-specific thresholds remains a limitation. Further research is needed to refine D-dimer use in pregnancy, particularly in conjunction with emerging risk stratification models.

Limitations and Research Gaps

Despite recent advancements, significant gaps remain in the diagnostic landscape for PE in pregnancy. Most current guidelines rely on extrapolated data from non-pregnant populations or small retrospective studies, limiting their applicability to pregnant patients (4). There is a need for large-scale prospective studies to validate existing diagnostic algorithms and develop new tools tailored to the unique physiological and clinical challenges of pregnancy. Additionally, strategies for optimizing diagnostic pathways in low-resource settings where access to advanced imaging is limited require further exploration.

Treatment Approaches

Management of high-risk PE in pregnancy necessitates a multidisciplinary approach involving obstetricians, hematologists, critical care specialists, and, in severe cases, cardiothoracic surgeons. The primary goals of treatment are to restore maternal hemodynamic stability, prevent further thromboembolic events, and minimize risks to the fetus (25).

Anticoagulation

Anticoagulation is the cornerstone of PE treatment during pregnancy. Low molecular weight heparin (LMWH) is the preferred agent due to its favorable safety profile, including minimal placental transfer, predictable pharmacokinetics, and reduced bleeding risk compared to unfractionated heparin (UFH). LMWH is administered subcutaneously in weight-adjusted doses, typically based on actual body weight at the time of diagnosis. In patients with obesity or renal impairment, anti-Xa level monitoring may be used to optimize dosing (5).

For postpartum anticoagulation, LMWH remains the standard for at least six weeks due to the heightened risk of VTE recurrence. Alternatives

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such as vitamin K antagonists (VKAs) or direct oral anticoagulants (DOACs) may be considered in women who are not breastfeeding, offering greater convenience with oral administration (25).

Systemic Thrombolysis

In high-risk PE cases characterized by hemodynamic instability, systemic thrombolysis is the treatment of choice. Recombinant tissue plasminogen activator (rtPA) rapidly dissolves clots, reducing pulmonary artery pressure and improving right ventricular function. However, the risk of bleeding, particularly postpartum, is significant, with rates of severe hemorrhage as high as 58% reported in some studies. Another concern is the potential impact of fibrinolytic therapy on the placenta, which may lead to pregnancy loss or premature labor. It is challenging to distinguish the effects of high-risk PE, including hemodynamic compromise, from those caused by the fibrinolytic medication itself (26).

A systematic review of thrombolysis in pregnant women with PE demonstrated maternal survival rates exceeding 90%, underscoring its efficacy despite associated risks (27). Strategies to mitigate bleeding complications include dose reduction or early cessation of thrombolysis once hemodynamic stability is achieved. While promising, these approaches require further evidence to establish their safety and effectiveness in pregnancy.

Catheter-Directed Interventions

Percutaneous treatments for pulmonary embolism, including catheter-directed thrombolysis and purely mechanical interventions like thrombectomy, offer alternatives to systemic fibrinolysis. These methods deliver lower doses of fibrinolytics or avoid them altogether, reducing bleeding risks (28). The 2019 ESC guidelines recommend these approaches for high-risk non-pregnant patients with contraindications to systemic thrombolysis, though evidence from randomized trials is lacking (29). In pregnancy, catheter-directed thrombolysis is rarely used, while mechanical thrombectomy has shown promise as a fibrinolytic-free option in cases with high bleeding risk (27). Decisions should weigh bleeding and radiation risks and be performed only in specialized centers with appropriate expertise.

Surgical Embolectomy

Surgical embolectomy is reserved for patients who fail thrombolysis or have contraindications to fibrinolytic therapy. The procedure involves removing emboli from the pulmonary arteries, typically under cardiopulmonary bypass. Although associated with significant perioperative risks, embolectomy offers life-saving potential in extreme cases (26). Previous case reports in pregnant women undergoing surgical embolectomy reported maternal survival rates of 84% and live birth rates of 80%, emphasizing its utility in carefully selected cases (27). Successful outcomes require coordination between cardiothoracic surgeons, obstetricians, and anesthesiologists, underscoring the importance of a multidisciplinary approach.

Extracorporeal Membrane Oxygenation (ECMO)

Extracorporeal membrane oxygenation (ECMO) is a modified cardiopulmonary bypass system used to stabilize hemodynamic and respiratory function in critical cases, but it is not a reperfusion therapy. In high-risk PE, venoarterial (VA) ECMO is often utilized due to its dual support of respiratory and cardiac functions, with venous cannulation near the right atrium and arterial cannulation in the femoral artery. While ECMO is gaining interest in high-risk PE, evidence for its efficacy is limited to case series and retrospective studies, which are prone to bias (26). Studies report mixed outcomes, with some declaring greater mortality (30) and others revealing better prognosis after using VA-ECMO in high-risk PE (31, 32).

In pregnancy, the use of ECMO is rare and primarily reported in cases of refractory hypoxemia or cardiac arrest, often in the postpartum period (33). Outcomes are mixed, with maternal survival rates of 72% (34) and live births in over 70% of cases (35). However, the risk of major complications, including bleeding, is significant, especially when ECMO is combined with thrombolytic or surgical therapies. Other complications include thrombocytopenia, coagulopathy, thrombosis, and infection (36).

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Despite the lack of robust evidence, ECMO may be considered in cases of refractory cardiac arrest, as a bridge to reperfusion therapy, or when such therapies are contraindicated. Decisions should be guided by local expertise and availability. Obstetric monitoring, including continuous fetal monitoring in hemodynamically stable pregnancies, may be warranted. However, the high complication rate underscores the need for careful patient selection and individualized management (37).

Postpartum Management

Anticoagulation should be resumed after delivery as soon as hemostasis permits, typically 12 to 24 hours postpartum, though delays may be necessary if bleeding persists. If therapeutic anticoagulation is delayed beyond 24 hours, a prophylactic dose can be started. For most women stopping anticoagulation at 6 weeks postpartum, continuing therapeutic-dose LMWH until that time is practical (38).

For women requiring long-term anticoagulation, LMWH is initially restarted alongside the introduction of vitamin K antagonists (VKAs), such as warfarin, with LMWH discontinued after at least 3 days when the international normalized ratio (INR) exceeds 2.0. Both LMWH and VKAs are safe during breastfeeding, particularly non-lipophilic types like acenocoumarol and warfarin (39). For non-breastfeeding women, direct oral anticoagulants are an alternative.

Women with pregnancy-related VTE are typically treated with therapeutic-dose LMWH for 6 weeks postpartum and a minimum of 3 months total. For first-episode VTE, anticoagulation may be discontinued after this period. However, the 2019 ESC guidelines highlight pregnancy as a minor transient risk factor, recommending consideration of extended anticoagulation in some cases due to an intermediate risk of recurrence (3%–8% annually) (40).

Despite recent advancements, significant gaps remain in the evidence base for treating high-risk PE in pregnancy. Randomized controlled trials comparing systemic thrombolysis, CDT, surgical embolectomy, and ECMO are urgently needed to guide clinical decision-making. The safety and efficacy of DOACs during pregnancy, particularly in early gestation, also warrant further exploration.

Conclusion

Pulmonary embolism in pregnancy, especially in high-risk cases, remains a significant cause of maternal morbidity and mortality, and its diagnosis and management require a nuanced, multidisciplinary approach. Accurate and early diagnosis is essential to prevent adverse outcomes, yet the unique challenges of pregnancy, including physiological changes and symptom overlap, complicate this process. The pregnancy-adapted YEARS algorithm and imaging techniques, such as CTPA and V/Q scans, have improved diagnostic accuracy while minimizing risks to the fetus. Treatment strategies are centered around anticoagulation therapy, with LMWH being the most commonly used due to its safety profile. In cases of massive PE or hemodynamic instability, thrombolysis, catheter-directed therapies, or surgical interventions may be necessary. Despite these advancements, knowledge gaps remain, particularly regarding the comparative efficacy of various therapeutic approaches, the safety of novel anticoagulants, and the long-term management of pregnant women with PE. Further research, including large-scale, prospective studies and randomized trials, is essential to optimize the diagnosis and treatment of PE in pregnancy, ensuring improved maternal and fetal outcomes.

Disclosure

Conflict of interest

There is no conflict of interest

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Data availability

Data that support the findings of this study are embedded within the manuscript.

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Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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