

ТРОМБОЭМБОЛИЯ ЛЕГОЧНОЙ АРТЕРИИ: КЛИНИЧЕСКИЙ АНАЛИЗ КЛИНИЧЕСКИХ И ПАТОФИЗИОЛОГИЧЕСКИХ ОСОБЕННОСТЕЙ

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ТРОМБОЭМБОЛИЯ ЛЕГОЧНОЙ АРТЕРИИ: КЛИНИЧЕСКИЙ АНАЛИЗ КЛИНИЧЕСКИХ И ПАТОФИЗИОЛОГИЧЕСКИХ ОСОБЕННОСТЕЙ. ЖКМП.-2025.-Т.3.-№3.-С

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Аннотация: Тромбоэмболия легочной артерии (ТЭЛА) - это опасное для жизни состояние, характеризующееся обструкцией легочной артериальной системы из-за тромботического материала, что приводит к нарушению газообмена, дисфункции правого желудочка и потенциальной смертности. Несмотря на достижения в области диагностической визуализации, биомаркеров и терапевтических стратегий, ТЭЛА продолжает создавать значительные диагностические и управленческие проблемы. В этой статье представлен интегративный анализ клинических случаев и современной литературы для оценки диагностических инструментов, терапевтических стратегий, прогностических показателей и профилактических мер. Полученные данные свидетельствуют о том, что междисциплинарные подходы, точная медицина и возникающие минимально инвазивные вмешательства обещают улучшить результаты лечения пациентов.

Ключевые слова: тромбоэмболия легочной артерии, антикоагуляция, тромболитиз, стратификация риска, клинические случаи, профилактика.

О'PKA ARTERIYASI TROMBOEMBOLIYASI BILAN BOG'LIQ KLINIK MISOLLAR TAHLILI

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Annotatsiya: O'pka arteriyasining tromboemboliyasi (O'ATE) - bu trombotik material tufayli o'pka arterial tizimining to'silishi bilan tavsiflanadigan hayot uchun xavfli holat bo'lib, bu gaz almashinuvining buzilishiga, o'ng qorinchaning disfunktsiyasi va potentsial o'limga olib keladi. Diagnostik vizualizatsiya, biomarkerlar va terapevtik strategiyalar sohasida erishilgan yutuqlarga qaramay, O'ATE sezilarli diagnostika va boshqaruv muammolarini keltirib chiqarishda davom etmoqda. Ushbu maqolada diagnostika vositalari, terapevtik strategiyalar, prognostik ko'rsatkichlar va profilaktika choralarini baholash uchun klinik holatlar va zamonaviy adabiyotlarning integratsiyalashgan tahlili ko'rsatildi. Olingan ma'lumotlar shuni ko'rsatadiki, fanlararo yondashuvlar, aniq tibbiyot va yuzaga kelayotgan minimal invaziv aralashuvlar bemorlarni davolash natijalarini yaxshilashga qaratilgan.

Kalit so'zlar: o'pka arteriyasi tromboemboliyasi, antikoagulyatsiya, tromboliz, xavf-xatar tabaqalanishi, klinik holatlar, profilaktika.

PULMONARY ARTERY THROMBOEMBOLISM: CLINICAL CASE-BASED ANALYSIS OF CLINICAL AND PATHOPHYSIOLOGICAL FEATURES

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Abstract: Pulmonary artery thromboembolism (PATE) is a life-threatening condition characterized by obstruction of the pulmonary arterial system due to thrombotic material, leading to impaired gas exchange, right ventricular dysfunction, and potential mortality. Despite advances in diagnostic imaging, biomarkers, and therapeutic strategies, PATE continues to pose significant diagnostic and management challenges. This article presents an integrative analysis of clinical cases and contemporary literature to evaluate diagnostic tools, therapeutic strategies, prognostic indicators, and preventive measures. The findings suggest that multidisciplinary approaches, precision medicine, and emerging minimally invasive interventions hold promise in improving patient outcomes.

Keywords: *pulmonary artery thromboembolism, anticoagulation, thrombolysis, risk stratification, clinical cases, prevention.*

Introduction: Pulmonary artery thromboembolism (PATE) is a major cardiovascular emergency with high morbidity and mortality rates. Its incidence is estimated at 39–115 per 100,000 population annually, with mortality ranging between 15% and 30% in untreated patients [1, 2]. The heterogeneous clinical presentation—ranging from mild dyspnea to sudden cardiac arrest - makes timely diagnosis a critical determinant of survival. Standardized clinical scoring systems, advanced imaging modalities, and laboratory biomarkers have been developed, yet diagnostic uncertainty remains a significant barrier in real-world practice [3–5].

This article aims to provide an evidence-based analysis of clinical cases of PATE, focusing on diagnostic challenges, therapeutic strategies, prognostic factors, and preventive approaches, structured within the IMRAD framework.

Methods: Literature Search Strategy: A comprehensive literature search was conducted to identify peer-reviewed studies, systematic reviews, meta-analyses, and case reports addressing pulmonary artery thromboembolism (PATE). The databases PubMed, Scopus, Web of Science, and Embase were systematically searched for publications from January 2005 to June 2024. Search terms included combinations of: “pulmonary artery thromboembolism,” “pulmonary embolism,” “deep vein thrombosis,” “case report,” “anticoagulant therapy,” “thrombolysis,” and “clinical outcome.” Boolean operators (AND, OR) were applied to broaden or narrow the scope as appropriate [6]. Reference lists of relevant articles were further hand-searched to identify additional studies.

Inclusion and Exclusion Criteria:

Eligible articles included (1) clinical trials, (2) prospective and retrospective observational studies, (3) case series, and (4) single-case reports directly related to pulmonary embolism. Only studies published in English and indexed in peer-reviewed journals were considered. Exclusion criteria were: (1) non-English publications, (2) animal studies, (3) conference abstracts without full text, and (4) articles lacking adequate clinical details [7].

Data Extraction and Case Selection:

Two reviewers independently extracted data using a structured form. Extracted information included:

- Demographics (age, sex, comorbidities)
- Risk factors (surgery, immobilization, pregnancy, cancer, trauma, thrombophilia)
- Clinical presentation (symptoms, signs, hemodynamic stability)
- Diagnostic modalities (CT pulmonary angiography, ventilation–perfusion scan, echocardiography, biomarkers)
- Therapeutic interventions (anticoagulation, thrombolysis, catheter-directed procedures, surgical embolectomy)
- Outcomes (survival, recurrence, complications, mortality)

Clinical case examples were selected to illustrate diverse presentations and management approaches. Specifically, four representative case categories were chosen:

1. Postoperative pulmonary embolism in elderly patients.
2. Pregnancy-associated embolism in young women.
3. Cancer-related thromboembolism.
4. Recurrent embolism despite adequate anticoagulation.

This approach ensured that both high-risk populations and atypical presentations were represented.

Quality Assessment:

The methodological quality of included studies was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies and the Cochrane Risk of Bias Tool for randomized controlled trials [8]. Case reports and case series were evaluated for clarity, diagnostic confirmation, and completeness of treatment and outcome reporting. Only studies scoring above the minimum quality threshold were retained for synthesis.

Data Synthesis:

Extracted data were synthesized in a narrative review format, focusing on identifying common clinical features, diagnostic pathways, treatment strategies, and outcomes. Case reports were presented alongside epidemiological and clinical trial data to highlight similarities and discrepancies between controlled studies and

real-world scenarios. Quantitative pooling (meta-analysis) was not performed due to heterogeneity in study designs and outcomes [9, 10]. Instead, the findings were integrated into a descriptive analysis structured around the IMRAD framework.

Ethical Considerations As this research involved the secondary analysis of published data, no direct patient involvement occurred, and ethical approval was not required. Nevertheless, all clinical cases included in the review were derived from peer-reviewed sources where patient confidentiality and informed consent procedures had already been respected [11].

Results: Clinical Presentation Analysis of 42 relevant studies and case reports revealed that the majority of patients with pulmonary artery thromboembolism (PATE) presented with dyspnea (72%), pleuritic chest pain (54%), tachycardia (46%), and syncope (18%). Less frequent but clinically significant findings included hemoptysis (7%), fever (5%), and cyanosis (3%) [12]. Hemodynamic instability at presentation, defined by systolic blood pressure <90 mmHg, was reported in 11–15% of patients and strongly correlated with increased short-term mortality [13]. Risk factor analysis indicated that recent surgery (particularly orthopedic and abdominal procedures), active malignancy, prolonged immobilization, and pregnancy were the most common predisposing conditions [14]. Approximately 30% of patients did not have an identifiable risk factor, highlighting the importance of vigilance in low-risk populations [15].

Diagnostic Approaches Computed tomography pulmonary angiography (CTPA) was the diagnostic modality of choice in over 85% of reported cases [16]. CTPA demonstrated sensitivity >90% and specificity >95%, making it the gold standard for diagnosis. Echocardiography was frequently used in unstable patients, where findings such as right ventricular (RV) dilation and tricuspid regurgitation were indicative of massive embolism [17]. D-dimer testing maintained high sensitivity (94%) but low specificity (38%), limiting its role to exclusion in low-to-intermediate risk patients [18].

Several case reports highlighted the limitations of diagnostic imaging in pregnant women and patients with renal insufficiency, where ventilation-perfusion (V/Q) scanning remained the preferred alternative [17]. Lower extremity Doppler ultrasound confirmed the presence of deep vein thrombosis (DVT) in approximately 40% of cases, providing indirect evidence of embolic origin [18].

Therapeutic Strategies Anticoagulation was universally implemented as first-line therapy. Unfractionated heparin (UFH) and low molecular weight heparin (LMWH) were commonly used in hospitalized patients, while direct oral anticoagulants (DOACs) were increasingly favored in outpatient management [14].

- Systemic thrombolysis (e.g., alteplase, streptokinase) was employed in 12–15% of high-risk cases with hemodynamic compromise, achieving rapid hemodynamic improvement but at the expense of major bleeding in ~6% of patients [14,16].
- Catheter-directed thrombolysis and thrombectomy emerged as effective alternatives, especially in patients with contraindications to systemic thrombolysis.
- Surgical embolectomy was rarely performed (1–3%) but remained a life-saving intervention for massive, refractory embolism [13].

Case-Based Analysis Case 1: Postoperative Pulmonary Embolism in an Elderly Patient A 72-year-old male underwent hip replacement surgery and developed sudden-onset dyspnea and hypotension on postoperative day 5. CTPA revealed a massive saddle embolism. Intravenous heparin was initiated, followed by systemic thrombolysis with alteplase. The patient achieved hemodynamic stabilization but required prolonged intensive care monitoring. This case underscores the importance of thromboprophylaxis in orthopedic surgery [12,14].

Case 2: Pregnancy-Associated Embolism in a Young Woman A 29-year-old woman at 28 weeks of gestation presented with chest pain and tachycardia. V/Q scanning demonstrated a high probability of pulmonary embolism. Anticoagulation with LMWH was initiated, and thrombolytic therapy was avoided due to pregnancy-related risks. The patient completed therapy without recurrence, highlighting the complex risk-benefit balance of anticoagulation during pregnancy [15,17].

Case 3: Cancer-Related Thromboembolism A 61-year-old female with metastatic ovarian carcinoma developed acute dyspnea during chemotherapy. CTPA confirmed bilateral emboli. Despite anticoagulation with LMWH, recurrence occurred within two months, requiring indefinite anticoagulation. This reflects the high recurrence risk in malignancy-associated thromboembolism [17,20].

Case 4: Recurrent Embolism Despite Anticoagulation A 45-year-old male with a history of recurrent venous thromboembolism presented with syncope.

He had been on therapeutic warfarin with INR monitoring. Workup revealed recurrent bilateral pulmonary embolism. A switch to DOAC therapy, combined with placement of an inferior vena cava (IVC) filter, was undertaken. This case highlights the need for individualized therapy in refractory or recurrent embolism [18,21].

Outcomes and Prognosis: Overall survival was highest in patients diagnosed early and managed promptly with anticoagulation. In-hospital mortality for massive PE ranged between 20–25%, whereas submassive and low-risk cases had significantly better outcomes [13,16]. Predictors of poor prognosis included right ventricular dysfunction, elevated troponin/BNP levels, active malignancy, and delayed diagnosis [17].

Discussion: The present analysis of pulmonary artery thromboembolism (PATE) demonstrates that despite advances in diagnostic and therapeutic modalities, the condition remains associated with considerable morbidity and mortality. The case-based review highlights not only the classical clinical presentations but also the heterogeneity of risk profiles and outcomes. When compared with existing literature, several key themes emerge.

Diagnostic Considerations Our findings reinforce the role of computed tomography pulmonary angiography (CTPA) as the gold standard for diagnosis in most patient populations, consistent with the results of the PIOPED II trial [18]. However, as illustrated by the pregnancy-associated case, CTPA is not universally applicable due to concerns about radiation exposure. In such instances, ventilation-perfusion (V/Q) scanning continues to provide a safe and reliable alternative, particularly when combined with clinical probability assessment [19].

The variability in clinical presentation remains a major diagnostic challenge. Nonspecific symptoms such as dyspnea, chest pain, or syncope frequently overlap with other cardiopulmonary conditions, contributing to misdiagnosis or delayed treatment [20]. Clinical scoring systems, such as the Wells and revised Geneva scores, have improved pre-test probability estimation, yet their predictive power may be limited in atypical cases or in populations with multiple comorbidities [21]. Biomarkers such as D-dimer, troponin, and BNP offer additional diagnostic support, but their low specificity requires cautious interpretation [22].

Therapeutic Challenges and Outcomes Anticoagulation remains the cornerstone of therapy, with direct oral anticoagulants (DOACs) showing superior safety and convenience compared to traditional

vitamin K antagonists. Nevertheless, as illustrated by the recurrent embolism case, therapeutic failures can occur even with adequate anticoagulation. Such cases highlight the importance of individualized treatment, including the potential role of inferior vena cava (IVC) filters or switching anticoagulant classes.

Systemic thrombolysis is life-saving in massive PE but carries a significant bleeding risk, particularly intracranial hemorrhage, which has been reported in 1–3% of treated patients. Catheter-directed interventions are increasingly recognized as effective alternatives, offering localized therapy with reduced systemic exposure. However, randomized controlled trial evidence remains limited, and further research is needed to define their precise role.

The postoperative and malignancy-associated cases underscore the persistent challenge of secondary prevention. Despite prophylactic regimens, orthopedic and oncological patients remain disproportionately affected. Malignancy-associated PATE, in particular, is associated with higher recurrence and poorer outcomes compared to non-cancer cases.

This supports the recommendations for extended-duration anticoagulation in cancer patients, although balancing the risk of bleeding remains complex.

Prognostic Indicators: The prognostic significance of right ventricular dysfunction has been consistently demonstrated in both observational studies and meta-analyses [22]. In our analysis, cases with hemodynamic instability at presentation had markedly worse outcomes. Elevated biomarkers such as troponin and BNP correlated with increased mortality risk, supporting their inclusion in prognostic models. Early recognition of these markers may guide clinicians toward more aggressive management strategies.

Preventive Strategies: Prevention remains the most effective strategy against PATE. Pharmacological prophylaxis with LMWH or DOACs, combined with mechanical measures (compression stockings, intermittent pneumatic compression), has proven efficacy in reducing postoperative venous thromboembolism. However, adherence to prophylactic protocols remains suboptimal, particularly in resource-limited settings. The elderly postoperative case underscores the importance of strict adherence to prophylactic guidelines.

Future Perspectives: Looking ahead, several avenues hold promise for improving PATE management: Personalized anticoagulation therapy

guided by genetic and biomarker profiling may optimize efficacy while minimizing adverse effects.

Artificial intelligence (AI)-assisted imaging may enhance diagnostic sensitivity in cases with subtle or atypical presentations. Development of novel anticoagulants with improved safety profiles may broaden treatment options, especially for high-risk populations such as cancer patients or pregnant women.

Large-scale, multicenter randomized trials are required to clarify the role of catheter-directed therapies and surgical embolectomy in modern practice.

Limitations of the Study
The present review is limited by reliance on published literature, which may be subject to publication bias. Additionally, heterogeneity across case reports and clinical trials precluded quantitative synthesis. Nevertheless, the integration of diverse clinical scenarios with established evidence provides valuable insight into the multifaceted nature of pulmonary artery thromboembolism.

Conclusion: Pulmonary artery thromboembolism (PATE) represents a persistent and multifaceted clinical challenge due to its variable presentation, diagnostic complexity, and life-threatening complications. The analysis of clinical cases and supporting literature highlights that early recognition, risk stratification, and timely initiation of therapy remain the key determinants of patient outcomes. While anticoagulation continues to be the cornerstone of treatment, novel therapeutic approaches such as catheter-directed interventions and targeted pharmacological strategies are expanding the therapeutic landscape, particularly for patients with contraindications to systemic thrombolysis.

Importantly, right ventricular dysfunction, elevated cardiac biomarkers, and recurrent thromboembolic events remain strong prognostic indicators of morbidity and mortality. Prevention through thromboprophylaxis in high-risk groups, especially postoperative and oncology patients, is crucial to reducing disease burden. Despite advances, significant gaps remain in the areas of personalized therapy, bleeding risk minimization, and long-term management of complications such as chronic thromboembolic pulmonary hypertension.

Future research must focus on precision medicine approaches, integration of advanced imaging and artificial intelligence for earlier detection, and the development of safer anticoagulant agents. A multidisciplinary, patient-centered approach will be es-

sential to optimize both acute management and long-term outcomes in individuals affected by PATE.

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