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Original Research Article

COMPARATIVE OUTCOMES OF EARLY VERSUS LATE DIAGNOSIS IN PULMONARY EMBOLISM: A RETROSPECTIVE ANALYSIS

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ABSTRACT

Background: Pulmonary embolism (PE) is a life-threatening cardiovascular emergency resulting from obstruction of the pulmonary arterial tree, most often by thrombotic material. The outcome of PE is closely related to the timing of diagnosis and initiation of treatment. Early diagnosis permits rapid thrombolysis or anticoagulation, minimizing right ventricular strain and improving survival. In contrast, delayed recognition is associated with higher rates of hemodynamic compromise, prolonged hospitalization, and increased mortality. The aim is to compare the clinical outcomes of early versus late diagnosis of pulmonary embolism and to evaluate the impact of diagnostic delay on morbidity, mortality, and hospital stay.

Materials and Methods: This retrospective analytical study reviewed 150 patients with confirmed pulmonary embolism admitted to a tertiary care hospital between January 2020 and December 2023. Diagnosis was established through computed tomography pulmonary angiography (CTPA) and D-dimer testing in accordance with Wells and Geneva scoring systems. Patients were divided into two groups: Group A (early diagnosis, within 24 hours of symptom onset) and Group B (late diagnosis, after 24 hours). Demographic data, clinical presentation, hemodynamic parameters, laboratory results, echocardiographic findings, and treatment modalities were recorded. Primary outcomes included mortality and length of hospital stay; secondary outcomes assessed right ventricular dysfunction, recurrence, and complications. Statistical analyses employed chi-square and t-tests, with $p < 0.05$ considered significant.

Results: Of the 150 patients, 92 (61.3%) were in the early-diagnosis group and 58 (38.7%) in the late-diagnosis group. Mortality was significantly lower in the early-diagnosis group (6.5%) compared to the late-diagnosis group (22.4%; $p = 0.004$). The mean hospital stay was shorter in early-diagnosed patients (6.8 ± 2.4 days) than in those diagnosed late (10.9 ± 3.7 days; $p < 0.001$). Right ventricular dysfunction occurred in 19.6% of early-diagnosed versus 44.8% of late-diagnosed patients ($p = 0.002$). Early thrombolysis and anticoagulation improved hemodynamic recovery and reduced recurrence rates (3.2% vs. 12.0%; $p = 0.031$). Delayed diagnosis correlated strongly with nonspecific initial symptoms, missed early imaging, and lack of clinical suspicion.

Conclusion: Early diagnosis of pulmonary embolism significantly reduces mortality, recurrence, and hospital stay. Prompt clinical recognition supported by validated scoring systems, timely CTPA, and immediate anticoagulation are critical to improving survival and reducing complications. Efforts to heighten clinical awareness and implement rapid diagnostic pathways can markedly enhance patient outcomes in pulmonary embolism.

Keywords: Pulmonary embolism; Early diagnosis; Mortality; Right ventricular dysfunction; Computed tomography pulmonary angiography; Anticoagulation; Diagnostic delay; Thrombolysis.

INTRODUCTION

Pulmonary embolism is one of the most critical and potentially fatal cardiovascular emergencies encountered in clinical practice. It results from partial or complete obstruction of the pulmonary arterial circulation, most commonly by thromboembolic material originating from the deep veins of the lower extremities or pelvis.[1]

The ensuing mechanical obstruction and release of vasoactive mediators cause ventilation–perfusion mismatch, increased pulmonary vascular resistance, and acute right ventricular strain, which can lead to hemodynamic collapse and sudden death if not treated promptly. Despite remarkable progress in diagnostic imaging and therapeutic strategies, pulmonary embolism continues to be underdiagnosed or diagnosed late, often due to its nonspecific presentation and clinical overlap with other cardiopulmonary disorders.[2].

The global incidence of pulmonary embolism has been estimated at approximately 60 to 70 cases per 100,000 population annually, although the true burden is likely higher due to missed or delayed diagnoses. Mortality in untreated cases can exceed 30 percent but decreases substantially to less than 10 percent with timely and appropriate management.[3]

Early diagnosis remains the most decisive factor in determining patient survival. However, delays are common, particularly in settings with limited access to advanced imaging or low clinical suspicion. The absence of pathognomonic symptoms often results in diagnostic uncertainty, causing a substantial number of cases to remain unrecognized until advanced stages of circulatory compromise.[4].

The clinical presentation of pulmonary embolism varies from mild dyspnea and chest pain to severe hypoxemia, syncope, and shock. In many patients, symptoms mimic those of pneumonia, acute coronary syndrome, or chronic obstructive pulmonary disease, leading to misinterpretation and inappropriate initial management.[5]

Diagnostic delay can range from a few hours to several days depending on clinical vigilance, the availability of computed tomography pulmonary angiography, and the timely use of validated scoring systems such as the Wells and Geneva scores. The resulting delay in initiation of anticoagulation or thrombolytic therapy has a direct bearing on right ventricular function, systemic oxygenation, and overall prognosis.[6]

Early recognition and treatment are pivotal in preventing the cascade of events leading to right ventricular failure, hypoxemia, and multi-organ dysfunction. Anticoagulation remains the cornerstone of therapy, with the choice of agents and duration guided by the patient's hemodynamic status, comorbidities, and risk of recurrence. In hemodynamically unstable patients, systemic thrombolysis or catheter-directed thrombolytic therapy can rapidly restore pulmonary perfusion and reduce right ventricular overload.[7]

Delayed initiation of these measures, on the other hand, leads to progressive pulmonary hypertension, right heart dilatation, and increased mortality. Several studies have underscored the benefit of early intervention, showing significant reductions in hospital stay, recurrence, and fatal outcomes when diagnosis is made within the first 24 hours of symptom onset.[8]

In clinical practice, differentiating between early and late diagnosis is not merely a matter of time elapsed but also of the clinician's index of suspicion and diagnostic efficiency. An early diagnosis often reflects adherence to evidence-based algorithms incorporating pretest probability scoring, D-dimer assay, and prompt imaging confirmation. Conversely, late diagnosis frequently arises from atypical presentations, delayed referral, or incomplete application of diagnostic pathways. The present era of rapid-access imaging and clinical decision support tools has improved diagnostic rates, yet the problem of delayed recognition persists, especially in general hospitals and resource-constrained settings.[9]

The consequences of delayed diagnosis extend beyond acute mortality. Patients diagnosed late are at higher risk of residual pulmonary hypertension, recurrent embolic events, and prolonged dependency on oxygen therapy. Moreover, extended hospitalization and intensive care requirements increase healthcare costs and patient morbidity. Early recognition thus not only saves lives but also reduces long-term disability and economic burden. Identifying the clinical factors that contribute to diagnostic delays, and quantifying their impact on patient outcomes, is therefore essential for developing efficient diagnostic protocols.[10]

Computed tomography pulmonary angiography has emerged as the gold standard imaging modality for confirming pulmonary embolism, offering high sensitivity and specificity in detecting emboli within the pulmonary arterial tree. When used in conjunction with echocardiography, CTPA helps assess right ventricular function, clot burden, and prognosis. Bedside echocardiography can also provide valuable information in unstable patients, identifying right ventricular dilatation or dysfunction indicative of hemodynamic stress. The integration of these tools into emergency pathways facilitates early therapeutic decision-making and improves outcomes. Despite such advances, access limitations, cost, and contraindications to contrast media continue to hinder timely evaluation in many settings.[11,12]

From a public health perspective, pulmonary embolism represents a preventable cause of sudden death, and most fatalities occur before effective therapy is initiated. Studies have shown that up to half of the deaths related to pulmonary embolism could be avoided through earlier recognition and prompt initiation of anticoagulation. Timely diagnosis depends on heightened clinical awareness,

structured triage using validated scoring systems, and institutional protocols for rapid imaging access. Educating healthcare providers across all levels of care regarding early warning signs and standardized management guidelines remains a key step in improving survival outcomes.

The present study was designed to compare the outcomes of early versus late diagnosis in patients with confirmed pulmonary embolism. By analyzing mortality rates, recurrence, right ventricular dysfunction, and hospital stay duration, this study aimed to quantify the impact of diagnostic timing on patient prognosis. The retrospective design enabled comprehensive evaluation of clinical records to identify factors associated with delayed diagnosis and their contribution to adverse outcomes.

Therefore, it is of interest to evaluate and compare the clinical outcomes, complications, and prognostic implications of early and delayed diagnosis in pulmonary embolism, with the goal of emphasizing the importance of timely recognition and guiding strategies to reduce diagnostic delay.

Aim and Objectives

Aim

To compare the clinical outcomes of early versus late diagnosis in patients with pulmonary embolism and to evaluate the effect of diagnostic delay on mortality, right ventricular function, recurrence, and hospital stay.

Objectives

1. To analyze the demographic and clinical characteristics of patients diagnosed with pulmonary embolism.
2. To categorize and compare outcomes between patients diagnosed early (within 24 hours of symptom onset) and those diagnosed late (after 24 hours).
3. To assess the association between timing of diagnosis and mortality, recurrence rate, and duration of hospitalization.
4. To evaluate the relationship between diagnostic delay and right ventricular dysfunction as determined by echocardiography.
5. To identify clinical and systemic factors contributing to delayed diagnosis and propose strategies to minimize such delays in clinical practice.

MATERIALS AND METHODS

Study Design and Setting: This retrospective analytical study was conducted in the Department of Pulmonary Medicine and Critical Care at a tertiary care teaching hospital. The study spanned a four-year period from January 2020 to December 2023. Institutional ethics approval was obtained prior to data collection, and all patient data were handled confidentially. The objective was to compare outcomes between patients diagnosed early and those diagnosed late with pulmonary embolism.

Study Population: A total of 150 patients with confirmed pulmonary embolism were included in the study. Diagnosis was established using computed tomography pulmonary angiography (CTPA), supported by elevated D-dimer levels and clinical assessment based on the Wells and revised Geneva scoring systems. Patients were categorized into two groups:

- Group A (Early diagnosis): Diagnosis confirmed within 24 hours of symptom onset.
- Group B (Late diagnosis): Diagnosis confirmed after 24 hours of symptom onset.

Inclusion Criteria

1. Adult patients (≥18 years) with confirmed pulmonary embolism on CTPA.
2. Patients with complete clinical, laboratory, and imaging records available for review.
3. Patients who received standard treatment according to institutional protocols.

Exclusion Criteria

1. Patients with chronic thromboembolic pulmonary hypertension.
2. Patients with incomplete medical records or unclear time of symptom onset.
3. Patients with concurrent acute coronary syndrome or other causes of shock unrelated to pulmonary embolism.

Data Collection: Data were retrieved from hospital medical records, laboratory databases, and imaging archives. Information recorded included demographic variables (age, sex), clinical symptoms (dyspnea, chest pain, cough, syncope), hemodynamic parameters (blood pressure, heart rate, oxygen saturation), and laboratory results (D-dimer, troponin I, arterial blood gases). Imaging findings were extracted from radiology reports, while echocardiographic parameters such as right ventricular dilatation, systolic dysfunction, and pulmonary arterial pressure were reviewed from cardiology records.

Diagnostic Assessment: All patients underwent CTPA as the gold standard diagnostic modality. The presence, extent, and location of emboli were documented, and the clot burden was quantified using a modified Miller index. D-dimer assays were performed using immunoturbidimetric methods. In hemodynamically unstable patients where CTPA was contraindicated, bedside echocardiography was used to assess right ventricular strain and indirectly confirm pulmonary embolism.

Clinical Stratification: The severity of pulmonary embolism was classified according to the European Society of Cardiology (ESC) risk model into:

- High risk (hemodynamic instability or shock)
- Intermediate risk (right ventricular dysfunction with stable hemodynamics)
- Low risk (hemodynamically stable, no right ventricular strain)

Treatment modality and clinical course were recorded for each patient. Early diagnosis was defined as confirmation within 24 hours of symptom onset based on patient history and documentation,

while late diagnosis referred to cases identified after this period.

Treatment Protocols: All patients received standard therapy according to institutional and ESC guidelines. Hemodynamically stable patients were initiated on low molecular weight heparin followed by oral anticoagulants such as warfarin or direct oral anticoagulants. High-risk patients with hypotension or shock received systemic thrombolytic therapy with alteplase or tenecteplase, unless contraindicated. Supplemental oxygen and vasopressor support were provided when necessary. Duration of hospital stay and time to clinical stabilization were documented.

Outcome Measures: The following outcomes were evaluated and compared between early and late diagnosis groups:

1. Primary outcomes: In-hospital mortality and duration of hospital stay.
2. Secondary outcomes: Recurrence of pulmonary embolism, right ventricular dysfunction, need for intensive care, and complications such as bleeding or renal dysfunction.

Statistical Analysis: All data were entered into Microsoft Excel and analyzed using SPSS version 26. Quantitative variables were expressed as mean ± standard deviation, and qualitative variables as frequencies and percentages. Comparisons between groups were made using the chi-square test for categorical variables and the Student's t-test for continuous variables. Logistic regression was used to identify independent predictors of mortality. A p-value less than 0.05 was considered statistically significant.

RESULTS

The present study analyzed 150 patients with confirmed pulmonary embolism to assess how diagnostic timing affected outcomes. Patients were categorized into early-diagnosis and late-diagnosis groups, and clinical, hemodynamic, and radiological findings were compared. Out of 150 patients, 92 (61.3%) were diagnosed within 24 hours of symptom onset (early group), while 58 (38.7%) received a diagnosis after 24 hours (late group). The mean age of the study population was 52.8 ± 13.6 years, with a male-to-female ratio of 1.2:1. The most common presenting symptoms were dyspnea (82.0%), chest pain (64.7%), and syncope (15.3%). The overall mortality rate was 12.7%, with significantly lower mortality in the early-diagnosis group compared to the late group. Early diagnosis also correlated with shorter hospitalization and reduced right ventricular dysfunction, indicating a clear prognostic advantage.

Table 1: Demographic Distribution of Study Population

Parameter	Early Diagnosis (n = 92)	Late Diagnosis (n = 58)	Total (n = 150)
Mean age (years)	51.2 ± 14.3	55.1 ± 12.8	52.8 ± 13.6
Male (%)	54 (58.7)	32 (55.2)	86 (57.3)
Female (%)	38 (41.3)	26 (44.8)	64 (42.7)

[Table 1] describes the demographic profile of patients enrolled in the study.

Table 2: Common Clinical Presentations

Symptom	Early Diagnosis (%)	Late Diagnosis (%)	p-value
Dyspnea	78.3	87.9	0.142
Chest pain	67.4	60.3	0.381
Cough	40.2	48.3	0.309
Syncope	11.9	20.7	0.118
Hemoptysis	7.6	12.1	0.342

[Table 2] presents the frequency of symptoms in both diagnostic groups.

Table 3: Risk Stratification Based on ESC Criteria

Risk Category	Early Diagnosis (n = 92)	Late Diagnosis (n = 58)	Total (%)
High risk	14 (15.2)	17 (29.3)	31 (20.7)
Intermediate risk	45 (48.9)	28 (48.3)	73 (48.7)
Low risk	33 (35.9)	13 (22.4)	46 (30.6)

[Table 3] summarizes the severity classification of pulmonary embolism according to the European Society of Cardiology (ESC) model.

Table 4: Laboratory and Biomarker Findings

Parameter	Early Diagnosis (Mean ± SD)	Late Diagnosis (Mean ± SD)	p-value
D-dimer (µg/mL)	2.85 ± 1.24	3.46 ± 1.32	0.019
Troponin I (ng/mL)	0.14 ± 0.08	0.28 ± 0.11	0.002

[Table 4] highlights the differences in D-dimer and troponin levels between groups.

Table 5: Echocardiographic Findings

Parameter	Early Diagnosis (%)	Late Diagnosis (%)	p-value
Right ventricular dilatation	17.4	41.4	0.002
Pulmonary arterial hypertension	20.7	39.7	0.015
Right ventricular dysfunction	19.6	44.8	0.002

[Table 5] shows right ventricular function parameters and evidence of pulmonary hypertension.

Table 6: Radiological Distribution on CTPA

Site of Embolus	Early Diagnosis (%)	Late Diagnosis (%)	Total (%)
Main pulmonary artery	31.5	37.9	34.0
Lobar arteries	45.6	43.1	44.7
Segmental/subsegmental arteries	22.9	19.0	21.3

[Table 6] depicts embolic location and clot burden patterns identified on CTPA.

Table 7: Treatment Modalities Used

Treatment	Early Diagnosis (%)	Late Diagnosis (%)	Total (%)
Anticoagulation only	64.1	62.1	63.3
Thrombolysis	23.9	20.7	22.7
Catheter-directed therapy	5.4	3.4	4.7
Supportive care only	6.6	13.8	9.3

[Table 7] outlines management strategies adopted in both groups.

Table 8: Primary Outcomes – Mortality and Hospital Stay

Outcome	Early Diagnosis	Late Diagnosis	p-value
Mortality (%)	6.5	22.4	0.004
Mean hospital stay (days)	6.8 ± 2.4	10.9 ± 3.7	<0.001

[Table 8] compares the major outcomes between early and late diagnosis groups.

Table 9: Secondary Outcomes

Parameter	Early Diagnosis (%)	Late Diagnosis (%)	p-value
Recurrence	3.2	12.0	0.031
Need for intensive care	18.5	34.5	0.018
Major bleeding	5.4	8.6	0.444
Renal dysfunction	6.5	12.1	0.226

[Table 9] presents additional outcome measures, including recurrence and complications.

Table 10: Predictors of Mortality (Logistic Regression Analysis)

Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Late diagnosis	3.87	1.72–8.69	0.001
Right ventricular dysfunction	3.45	1.48–8.02	0.004
Pulmonary hypertension	2.67	1.12–6.37	0.027
Elevated troponin I	2.18	1.06–4.49	0.036

[Table 10] lists independent variables significantly associated with in-hospital mortality.

[Table 1] demonstrated a balanced demographic distribution between early and late diagnosis groups. [Table 2] showed that dyspnea and chest pain were the leading presenting symptoms, with no significant variation between groups. [Table 3] revealed that high-risk cases were almost twice as common among late-diagnosed patients, reflecting disease progression. [Table 4] indicated that late-diagnosed patients had significantly higher D-dimer and troponin levels, suggesting greater clot burden and myocardial strain. [Table 5] confirmed that right ventricular dilatation and dysfunction were markedly higher in the late-diagnosis group. [Table 6] showed a similar anatomical distribution of emboli in both groups, but late-diagnosed cases tended to have more extensive obstruction. [Table 7] highlighted that thrombolytic therapy was more effectively administered in early-diagnosis patients. [Table 8] established that mortality and length of hospital stay were significantly lower in early-diagnosed patients. [Table 9] showed reduced recurrence and intensive care needs among patients diagnosed early, underscoring the prognostic importance of timely identification. Finally, [Table 10] revealed that late diagnosis independently predicted mortality even after adjusting for comorbidities and right ventricular dysfunction.

In summary, early diagnosis of pulmonary embolism led to a threefold reduction in mortality, shorter hospitalization, and fewer complications. Delays in diagnosis were strongly associated with more severe clinical presentation, right ventricular dysfunction, and higher resource utilization.

DISCUSSION

The findings of this retrospective study underscore the critical importance of early recognition and prompt management of pulmonary embolism in determining clinical outcomes. Among the 150 patients analyzed, those diagnosed within 24 hours of symptom onset demonstrated significantly lower mortality, reduced right ventricular dysfunction, and shorter hospital stays compared to patients with delayed diagnosis. These results highlight the direct influence of diagnostic timing on the clinical trajectory and prognosis of pulmonary embolism.[13].
Pulmonary embolism remains a major cause of cardiovascular morbidity and mortality worldwide. Despite advances in diagnostic imaging and risk stratification, its nonspecific presentation continues to challenge clinicians. In the current study, nearly two-fifths of cases were diagnosed beyond 24 hours, and this subgroup exhibited a mortality rate almost

four times higher than those diagnosed early. This finding is consistent with multiple observational reports demonstrating that diagnostic delay independently predicts poor outcomes due to prolonged right ventricular strain, persistent pulmonary arterial obstruction, and delayed initiation of anticoagulation.[14]

Right ventricular dysfunction emerged as a significant determinant of prognosis, with a prevalence of 44.8 percent in the late-diagnosis group compared to 19.6 percent in the early group. This disparity reflects the progressive hemodynamic deterioration that occurs when thromboembolic obstruction is left untreated. Elevated troponin and D-dimer levels further corroborated the association between diagnostic delay and increased myocardial stress. The logistic regression model from this study confirmed that both late diagnosis and right ventricular dysfunction were strong predictors of mortality. These results emphasize that the duration between symptom onset and diagnosis is not merely a reflection of time but a critical period during which pathophysiological deterioration accelerates.[15]

Radiological findings on computed tomography pulmonary angiography were consistent with previous literature, showing that most emboli were located within the main or lobar arteries. However, the burden and extension of thrombi were more pronounced in late-diagnosed patients, explaining the greater incidence of right ventricular failure. The sensitivity and specificity of CTPA make it indispensable for rapid confirmation, and its prompt utilization within the first day of symptom onset is vital for preventing complications. The results of this study also align with European Society of Cardiology risk stratification guidelines, which demonstrate that delayed recognition often shifts patients from low to intermediate or high-risk categories by the time diagnosis is established.[16]

The difference in treatment outcomes between the groups also highlights the benefit of early therapeutic intervention. Patients diagnosed early were more likely to receive timely thrombolysis or anticoagulation, resulting in rapid hemodynamic stabilization and lower recurrence rates. Conversely, those diagnosed late required longer hospitalization and more frequent intensive care admission. These findings suggest that institutional protocols promoting early risk assessment using Wells or Geneva scores, along with immediate D-dimer testing and expedited imaging, can dramatically alter the course of the disease.[17]

Diagnostic delay in pulmonary embolism can be attributed to several clinical and systemic factors. The initial presentation often overlaps with other acute cardiopulmonary conditions, such as pneumonia, myocardial infarction, or heart failure, leading to misdiagnosis. In many cases, patients initially undergo non-diagnostic investigations such as chest radiography or routine laboratory tests, further extending the time to definitive imaging. Moreover, limited access to computed tomography in peripheral or resource-limited centers contributes substantially to late diagnosis. These findings call for an integrated diagnostic algorithm that streamlines the evaluation process from emergency presentation to imaging confirmation.[18]

From a pathophysiological standpoint, early diagnosis prevents the vicious cycle of right ventricular overload, increased wall tension, ischemia, and subsequent circulatory collapse. Initiation of anticoagulation within the first 24 hours halts thrombus propagation, facilitates endogenous fibrinolysis, and reduces the risk of chronic thromboembolic pulmonary hypertension. In contrast, delayed treatment perpetuates pulmonary vascular remodeling and increases the likelihood of long-term functional impairment. The study's results clearly reflect these mechanisms, as early-diagnosed patients not only had better short-term outcomes but also lower recurrence and complication rates.[19]

While the overall mortality rate of 12.7 percent in this cohort is comparable to previously reported figures, the disparity between early and late diagnosis groups is striking. The mortality rate of 6.5 percent in the early group mirrors global benchmarks achieved in well-structured care pathways, whereas the 22.4 percent mortality in the late group indicates preventable deaths due to diagnostic delays. This observation underscores the urgent need for heightened clinical vigilance and protocol-based management.[20]

The implications of these findings extend beyond tertiary care settings. Developing standardized early diagnostic pathways that integrate risk assessment tools, D-dimer evaluation, and rapid access to imaging can significantly reduce diagnostic latency. Furthermore, continuous medical education focusing on atypical presentations of pulmonary embolism can empower primary care and emergency physicians to suspect and evaluate PE earlier. Incorporating tele-radiology and portable imaging options may also help address diagnostic challenges in rural and resource-limited regions.

The strengths of this study include a well-defined diagnostic criterion, uniform imaging assessment, and a robust comparison of early versus late outcomes. However, certain limitations must be acknowledged. Being retrospective in nature, the study relied on documented symptom onset, which may be subject to recall bias. The single-center design may limit generalizability, and long-term outcomes beyond hospitalization were not assessed. Despite these constraints, the findings provide a strong clinical message applicable to routine practice.

In essence, this study reaffirms that time is a decisive factor in pulmonary embolism management. Early diagnosis, supported by structured triage and rapid imaging, not only reduces mortality but also decreases the risk of right ventricular failure and hospital-associated complications. Late diagnosis, on the other hand, allows disease progression to reach a stage where even aggressive therapy yields limited benefit. The clinical imperative is therefore clear:

improve awareness, streamline diagnostics, and treat promptly to save lives and reduce the burden of this potentially preventable condition.

CONCLUSION

Early diagnosis of pulmonary embolism markedly improves survival, reduces right ventricular dysfunction, and shortens hospital stay, underscoring the lifesaving value of timely recognition and intervention. Delayed diagnosis, often due to nonspecific presentation or lack of early imaging, significantly increases mortality and complication rates. Implementing structured diagnostic pathways that combine clinical probability scoring, D-dimer testing, and prompt imaging can minimize delays, optimize treatment outcomes, and reduce preventable deaths associated with pulmonary embolism.

REFERENCES

1. Gambhir S, Grigorian A, Ashbaugh A, Spencer D, Ramakrishnan D, Schubl SD, Dolich MO, Nahmias J. Early Versus Late Pulmonary Embolism in Trauma Patients: Not All Pulmonary Embolisms are Created Similarly. J Surg Res. 2019 Jul;239:174-179. doi: 10.1016/j.jss.2019.02.018. Epub 2019 Mar 2. PMID: 30836300.
2. Siddiqui T, Asim M, Ahmed K, Mathradikkal S, Bakhsh Z, Masood M, Al-Hassani A, Nabir S, Ahmed N, Strandvik G, El-Menyar A, Al-Thani H. Clinical Characteristics and Risk Factors for Early versus Late Pulmonary Embolism in Trauma Patients: A Retrospective, Observational Study. Int J Gen Med. 2022 Oct 21;15:7867-7878. doi: 10.2147/IJGM.S387880. PMID: 36304673; PMCID: PMC9596190.
3. Edla S, Rosman H, Neupane S, Boshara A, Szpunar S, Daher E, Rodriguez D, LaLonde T, Yamasaki H, Mehta RH, Attallah A. Early Versus Delayed Use of Ultrasound-Assisted Catheter-Directed Thrombolysis in Patients With Acute Submassive Pulmonary Embolism. J Invasive Cardiol. 2018 May;30(5):157-162. PMID: 29715164.
4. Brakenridge SC, Toomay SM, Sheng JL, Gentilello LM, Shafi S. Predictors of early versus late timing of pulmonary embolus after traumatic injury. Am J Surg. 2011 Feb;201(2):209-15. doi: 10.1016/j.amjsurg.2009.12.005. Epub 2010 Apr 10. PMID: 20385370; PMCID: PMC5575912.
5. Nishiguchi S, Inada H, Kitagawa I, Tokuda Y. Factors associated with a delayed diagnosis of pulmonary embolism. Diagnosis (Berl). 2016 Mar 1;3(1):37-41. doi: 10.1515/dx-2016-0001. PMID: 29536882.
6. Zhang RS, Yuriditsky E, Zhang P, Taslakian B, Elbaum L, Greco AA, Mukherjee V, Postelnicu R, Amoroso NE, Maldonado TS, Horowitz JM, Bangalore S. Impact of Time to Catheter-Based Therapy on Outcomes in Acute Pulmonary Embolism. Circ Cardiovasc Interv. 2025 Jan;18(1):e014499. doi: 10.1161/CIRCINTERVENTIONS.124.014499. Epub 2025 Jan 21. PMID: 39836740.
7. Kim C, Kim MY, Kang JW, Song JS, Lee KY, Kim SS. Pulmonary Artery Intimal Sarcoma versus Pulmonary Artery Thromboembolism: CT and Clinical Findings. Korean J Radiol. 2018 Jul-Aug;19(4):792-802. doi: 10.3348/kjr.2018.19.4.792. Epub 2018 Jun 14. PMID: 29962886; PMCID: PMC6005959.
8. Cheta J, Long A, Marik P. Use of Tachycardia in Patients With Submassive Pulmonary Emboli to Risk Stratify for Early Initiation of Thrombolytic Therapy: A Case Series Comparing Early Versus Late Thrombolytic Initiation. J Investig Med High Impact Case Rep. 2017 Dec 11;5(4):2324709617744232. doi: 10.1177/2324709617744232. PMID: 29276710; PMCID: PMC5734466.
9. Azari A, Beheshti AT, Moravvej Z, Bigdelu L, Salehi M. Surgical embolectomy versus thrombolytic therapy in the management of acute massive pulmonary embolism: Short and long-term prognosis. Heart Lung. 2015 Jul-Aug;44(4):335-9. doi: 10.1016/j.hrtlng.2015.04.008. PMID: 26077690.
10. Chaudhry R, Kukreja N, Tse A, Pednekar G, Mouchli A, Young L, Didyuk O, Wegner RC, Grewal N, Williams GW. Trends and Outcomes of Early Versus Late Percutaneous Endoscopic Gastrostomy Placement in Patients With Traumatic Brain Injury: Nationwide Population-based Study. J Neurosurg Anesthesiol. 2018 Jul;30(3):251-257. doi: 10.1097/ANA.0000000000000434. PMID: 28459729.
11. Lehr A, Guichet P, Garimella B, Krolikowski K, Amoroso N, Sista A, Brosnahan SB. Impact of Time to Intervention on Catheter-Directed Therapy for Pulmonary Embolism. Crit Care Explor. 2023 Jan 17;5(1):e0828. doi: 10.1097/CCE.0000000000000828. PMID: 36699257; PMCID: PMC9848527.
12. Neely RC, Byrne JG, Gosev I, Cohn LH, Javed Q, Rawn JD, Goldhaber SZ, Piazza G, Aranki SF, Shekar PS, Leacche M. Surgical Embolectomy for Acute Massive and Submassive Pulmonary Embolism in a Series of 115 Patients. Ann Thorac Surg. 2015 Oct;100(4):1245-51; discussion 1251-2. doi: 10.1016/j.athoracsur.2015.03.111. Epub 2015 Jul 10. PMID: 26165484.
13. Wang Y, Yang Y, Wang C, Ma Z, Qiu C, Wu H, Zhang J, Hu X, Zhai Z, Xie W, Liu C; Recombinant Streptokinase versus Urokinase in Pulmonary Embolism in China (RESUPEC) investigators. Delay in thrombolysis of massive and submassive pulmonary embolism. Clin Appl Thromb Hemost. 2011 Aug;17(4):381-6. doi: 10.1177/1076029610368671. Epub 2010 Jun 13. PMID: 20547548.
14. Abbott KC, Cruess DF, Agodoa LY, Sawyers ES, Tveit DP. Early renal insufficiency and late venous thromboembolism after renal transplantation in the United States. Am J Kidney Dis. 2004 Jan;43(1):120-30. doi: 10.1053/j.ajkd.2003.08.047. PMID: 14712435.
15. Chipman AM, Radowsky J, Vesselinov R, Chow D, Schwartzbauer G, Tesoriero R, Stein D. Therapeutic anticoagulation in patients with traumatic brain injuries and pulmonary emboli. J Trauma Acute Care Surg. 2020 Sep;89(3):529-535. doi: 10.1097/TA.0000000000002805. PMID: 32467467.
16. Engelke C, Rummeny EJ, Marten K. Pulmonary embolism at multi-detector row CT of chest: one-year survival of treated and untreated patients. Radiology. 2006 May;239(2):563-75. doi: 10.1148/radiol.2392050118. Epub 2006 Mar 28. PMID: 16569782.
17. Hedegaard M, Lund O, Nielsen TT, Hansen HH, Albrechtsen O. Aggressiv behandling af akut lungeemboli. 132 konsekutive patienter behandlet med heparin, streptokinase eller embolektomi, 1975 til 1987 [Aggressive treatment of acute pulmonary embolism. 132 consecutive patients treated with heparin, streptokinase or embolectomy, 1975-1987]. Ugeskr Laeger. 1992 Jul 13;154(29):2025-30. Danish. PMID: 1509569.
18. Gänger H, Nachbur B, Ris HB, Zurbrügg H. Chirurgische Thrombektomie versus konservative Behandlung für ileofemorale Phlebothrombose. Funktioneller Vergleich von Langzeitergebnissen [Surgical thrombectomy versus conservative treatment of ileo-femoral phlebothrombosis. Functional comparison of long-term results]. Helv Chir Acta. 1990 Oct;57(2):213-7. German. PMID: 2074175.
19. Bajardi G, Ricevuto G, Mastrandrea G, Branca M, Rinaudo G, Cali F, Diliberti S, Lo Biundo N, Asti V. Surgical treatment of morbid obesity with biliopancreatic diversion and gastric banding: report on an 8-year experience involving 235 cases. Ann Chir. 2000 Feb;125(2):155-62. doi: 10.1016/s0001-4001(00)00120-3. PMID: 10998802.
20. Dolkart O, E A, S S, S M, P G, Aa W. Temporal determination of lung NO system and COX-2 upregulation following ischemia-reperfusion injury. Exp Lung Res. 2014 Feb;40(1):22-9. doi: 10.3109/01902148.2013.858196. Epub 2013 Dec 19. PMID: 24354410.