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HEALTH AND REHABILITATION

DIAGNOSTIC ACCURACY OF RV/LV RATIO AS A PREDICTOR OF SHORT TERM MORTALITY IN PATIENTS PRESENTING WITH ACUTE PULMONARY EMBOLISM USING MULTI DETECTOR CT-PULMONARY ANGIOGRAPHY

Original Research

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Acknowledgement: We want to express our gratitude to the Radiology staff and our supervisor for their ongoing support throughout the research tenure.

Conflict of Interest: None   Grant Support & Financial Support: None

ABSTRACT

Objective: To determine the diagnostic accuracy of the RV/LV ratio for short-term mortality in patients presenting with acute pulmonary embolism using multi-detector CT-pulmonary angiography

Study Design: Cross-sectional validation study

Place and Duration of Study: Shifa International Hospital, Islamabad; Feb 2021 to December 2022

Methodology: The study employed a consecutive sampling technique to include 176 patients. Patients with a confirmed diagnosis of acute PE on CTPA and high-quality imaging suitable for accurate measurement of right and left ventricular diameters were included. Two blinded radiologists assessed the RV and LV diameters to calculate the RV/LV ratio, with a ratio of >1.1 indicating right ventricular dysfunction. Short-term mortality within 30 days was determined through hospital records and follow-up calls.

Results: Among 176 patients, in-hospital mortality was 45(25.6%). Non-survivors had significantly higher RV diameter (42.22±7.68 mm vs. 35.69±7.68 mm, $p<0.001$) and RV/LV ratio (1.18±0.24 vs. 0.95±0.25, $p<0.001$). Among non-survivors, 37(75.5%) patients had RV/LV Ratio >1.1. ROC analysis showed good diagnostic accuracy of the RV/LV ratio for short-term mortality with an AUC of 0.753 (95% CI: 0.675–0.832). The optimal cut-off value was 1.1, yielding a 75.5% sensitivity and 65.4% specificity, 45.7% positive predictive value and 87.4% negative predictive value.

Conclusion: The RV/LV ratio measured on multi-detector CT-pulmonary angiography demonstrates good diagnostic accuracy in predicting short-term mortality among patients with acute pulmonary embolism.

Keywords: Mortality, Multi-Detector CT-Pulmonary Angiography, Pulmonary Embolism, RV/LV Ratio.

INTRODUCTION

Right ventricular (RV) systolic enlargement and dysfunction are clinically significant markers that reflect underlying pathophysiological alterations in the pulmonary vasculature and lung parenchyma.[1] These changes often arise from conditions that increase RV afterload, including pulmonary hypertension, acute respiratory distress syndrome, and, most critically, acute pulmonary embolism (PE). PE remains a serious clinical emergency and ranks as the third leading cause of cardiovascular-related mortality,[2,3] in North America. [4]

Due to its abrupt onset and diverse clinical manifestations, PE poses challenges in diagnosis and management. Early identification of patients at risk of deterioration is crucial for informing decisions on the level of monitoring and the necessity of interventions such as thrombolysis or intensive care admission. However, significant discrepancies in risk classification and treatment thresholds among major clinical guidelines contribute to variability in practice, underscoring the need for reliable prognostic markers.

Multi-detector computed tomography pulmonary angiography (CTPA) is a first-line imaging modality in acute PE due to its diagnostic accuracy, speed, and ability to assess RV structure.[5,6] A key prognostic marker derived from CTPA is the RV to left ventricular (LV) diameter ratio, which has been associated with RV strain and poor short-term outcomes, including early mortality.[7] Regardless of emerging evidence supporting the RV/LV ratio as a potential prognostic tool, its clinical utility remains constrained by the lack of standardisation. Studies vary in methodology, patient populations, and outcome definitions, resulting in inconsistent cut-off values and limited integration into routine care. This study seeks to evaluate the diagnostic accuracy of the RV/LV ratio on multi-detector CTPA in predicting short-term mortality in patients with acute PE. By clarifying its prognostic value and identifying an optimal threshold, the study aims to support more effective and individualised risk-stratification strategies in the acute care of pulmonary embolism.

METHODOLOGY

We conducted a prospective, cross-sectional study at the Shifa International Hospital in Islamabad. Ethical approval was obtained from the Institutional Ethical Review Board (IERB). The sample size was determined as n = 142 using the Sensitivity/Specificity Sample Size Calculator, based on the 100% and 54% sensitivity and specificity of RV/LV ratio >1.1 and 24.8% prevalence of mortality in patients with pulmonary embolism,[8] a 95% confidence level, an estimated margin of error of 10% and a 10% drop-out rate. However, in the present study, data were collected from 211 patients who were clinically suspected of having acute pulmonary embolism and presented between February 2021 and December 2022. They were selected using a non-probability, consecutive sampling technique, ensuring they met the study's inclusion criteria. After excluding patients who did not meet the inclusion criteria, the final sample consisted of 176 patients, as shown in the flowchart (Figure 1).

Inclusion Criteria: The study included adult patients (regardless of gender) aged 18 years and above who presented to the emergency department with clinical suspicion of acute pulmonary embolism and were subsequently diagnosed with acute PE using multi-detector computed tomography pulmonary angiography (MDCT-PA). Only those with a confirmed diagnosis of acute PE on CTPA and high-quality imaging suitable for accurate measurement of right and left ventricular diameters were included.

Exclusion Criteria: Patients were excluded if they had evidence of chronic pulmonary embolism, poor-quality or non-diagnostic CTPA scans, or pre-existing structural heart diseases such as known cardiomyopathies that could affect ventricular dimensions. Those who were hemodynamically unstable and could not undergo CT imaging, as well as patients with incomplete clinical or radiological data, were also excluded from the study. Additionally, individuals who were lost to follow-up within 30 days of diagnosis were excluded from the final analysis.

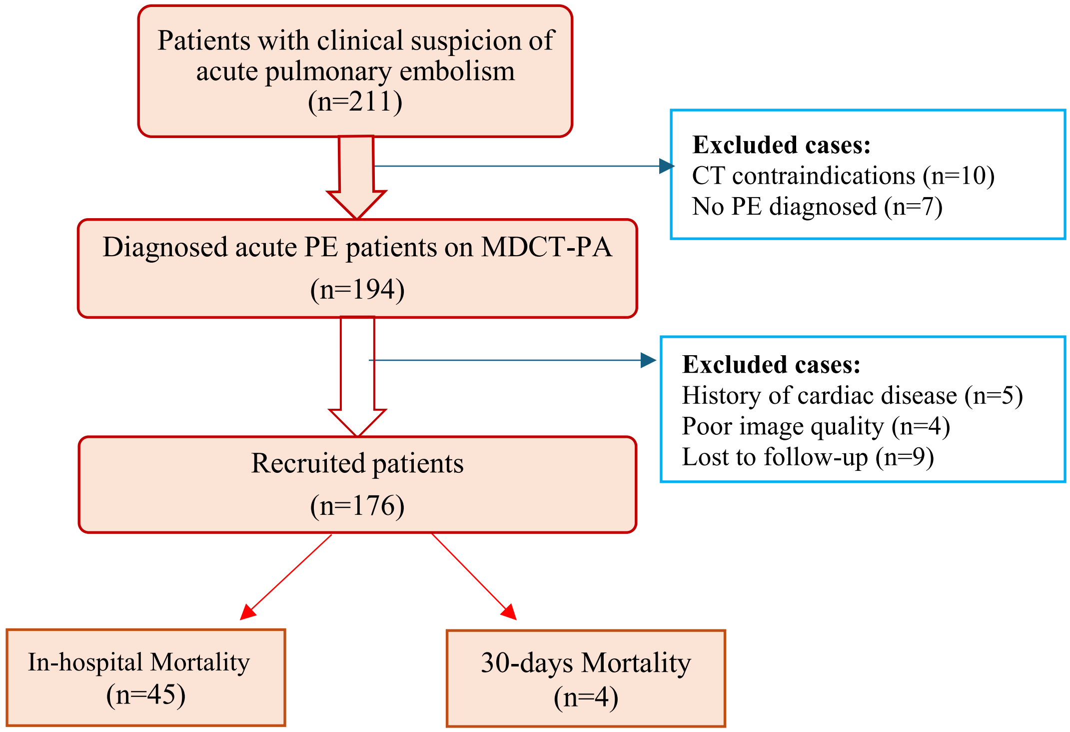

Figure 1 Diagnosed PE patients' recruitment (n=176)

Written informed consent was obtained from eligible patients prior to data collection. Patients who presented to the emergency department with clinical suspicion of PE were evaluated using the hospital's standard diagnostic protocols. Those diagnosed with acute PE through MDCT-PA were considered for inclusion.

CTPA images of all eligible patients were reviewed by two independent radiologists who were blinded to the clinical outcomes. The RV and LV diameters were measured at end-diastole in the axial plane, perpendicular to the long axis of the heart. The RV/LV ratio was calculated by dividing the maximum diameter of the RV by that of the LV. An RV/LV ratio of >1.1 was considered indicative of right ventricular dysfunction.

Clinical and demographic data were extracted from the hospital's electronic medical records. This included age, gender, presenting symptoms, and comorbidities. Follow-up data on short-term mortality, defined as death from any cause within 30 days of diagnosis, were obtained from patient records and, when necessary, through follow-up phone calls to families or caregivers.

All collected data were anonymised and entered into the Statistical Package for the Social Sciences, version 28. Routine quality checks were conducted to ensure accuracy and completeness of the data. Inter-observer variability in RV/LV measurements was assessed, and any discrepancies were resolved through consensus or by consultation with a third radiologist. The data were then prepared for statistical analysis to evaluate the diagnostic accuracy of the RV/LV ratio in predicting short-term mortality among patients with acute PE.

Frequencies and percentages, as well as means and standard deviations, were assessed for categorical and quantitative data, respectively. For continuous variables, independent t-test was applied to compare differences in RV/LV ratios between patients who survived and those who died. A receiver operating characteristic (ROC) curve analysis was performed to determine the area under the curve (AUC), which quantified the overall diagnostic accuracy of the RV/LV ratio. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy was calculated using 2x2 table. Results were considered statistically significant at a p-value ≤ 0.05.

RESULTS:

Our study comprised 176 patients diagnosed with PE. The majority of the patients were male, comprising 114 (64.8%) of the total sample, while females accounted for 62 (35.2%). The mean age of participants was 57.04 ± 8.17 years. Regarding presenting symptoms, dyspnoea was the most frequently reported symptom, observed in 59 (33.5%) individuals, and 5 (2.8%) patients presented with all three symptoms simultaneously. Hypertension was highly prevalent, affecting 114 (64.8%) patients, and dyslipidemia was less common, reported in 27 (15.3%) patients. Cardiac chamber measurements obtained through CTPA revealed a very slight difference in mean right ventricular (RV) diameter and left ventricular (LV) diameter (37.50 ± 8.20 mm and 37.82 ± 5.58 mm, respectively). The average RV/LV ratio was 1.02 ± 0.264, suggesting a trend toward right ventricular enlargement. Majority of the patients 95(54.0%) had RV/LV ratio ≤1.1. The overall in-hospital mortality rate was 45 (25.6%), whereas the 30-day mortality rate was relatively low at 4 (2.3%). (Table I)

Table I: Baseline Characteristics of Study Participants (n=176)

Variables		**Frequency (%)**	**Mean±SD**
Demographics			
Gender	Male	114(64.8)	
	Female	62(35.2)	
Age (years)			57.04±8.17
Presenting Symptoms			
Chest Pain		36(20.4)	
Dyspnoea		59(33.5)	
Syncope		14(7.9)	
Chest Pain + Dyspnoea		25(14.2)	
Chest Pain + Syncope		8(4.5)	
Dyspnoea + Syncope		8(4.5)	
Chest Pain + Dyspnoea + Syncope		5(2.8)	
Comorbids			
Hypertension		114(64.8)	
Diabetes Mellitus		53(30.1)	
Smoker		91(51.7)	
Dyslipidemia		27(15.3)	
Cardiac Chamber Measurements on CTPA			
RV Diameter (mm)			37.50±8.20
LV Diameter (mm)			37.82±5.58
RV/LV Ratio			1.02±0.264
RV/LV Ratio ≤1.1		95(54.0)	
RV/LV Ratio >1.1		81(46.0)	

Clinical Outcome	
In-hospital Mortality	45(25.6)
30-days Mortality	4(2.3)
RV=Right ventricle; LV=Left Ventricle	

According to the findings presented in Table II, age was significantly associated with mortality; non-survivors were older, with a mean age of 60.86±9.26 years, compared to 55.57±7.23 years in survivors (p=0.001). The gender distribution did not differ substantially between the deceased and living patients (p<0.05). Notable differences in presenting symptoms were observed (p<0.001). In contrast, chest pain alone occurred with similar frequency in both groups (20.4% vs. 20.5%). Among comorbidities, smoking showed a strong and statistically significant association with mortality, present in 37(75.5%) non-survivors versus 54(42.5%) survivors (p<0.001). Cardiac chamber measurements on CTPA also showed a significant mean difference across dead and alive cases. Non-survivors had a notably larger RV diameter (42.22±7.68 mm vs. 35.69±7.68 mm, p<0.001) and a smaller LV diameter (36.43±4.91 mm vs. 38.5±5.75 mm, p=0.04) than survivors. Consequently, the RV/LV ratio was significantly elevated in non-survivors compared to survivors (1.18±0.24 vs. 0.95±0.25; p<0.001). Moreover, a considerably higher number of dead patients had an RV/LV ratio more than 1.1 (75.5% vs. 34.6%; p<0.001).

Table II: Association of patients' characteristics across survivors and non-survivors (n=176)

Variables		**Mortality**		**p-value**
		Yes (n=49)	**No (n=127)**	
Demographics				
Gender	Male	32(65.3%)	82(64.6%)	1.00
	Female	17(34.7%)	45(35.4%)	
Age (years)		60.86±9.26	55.57±7.23	0.001
Presenting Symptoms				
Chest Pain		10(20.4%)	26(20.5%)	<0.001
Dyspnoea		7(14.3%)	52(40.9%)	
Syncope		3(6.1%)	11(8.7%)	
Chest Pain + Dyspnoea		12(24.5)	13(10.2%)	
Chest Pain + Syncope		3(6.1%)	5(3.9%)	
Dyspnoea + Syncope		7(14.3%)	1(0.8%)	
Chest Pain + Dyspnoea + Syncope		5(10.2%)	0(0.0%)	
Comorbids				
Hypertension		33(67.3%)	81(63.8%)	0.789
Diabetes Mellitus		15(30.6%)	38(29.9%)	1.00
Smoker		37(75.5%)	54(42.5%)	<0.001

Hyperlipidemia	8(16.3%)	19(15.0%)	1.00
Cardiac Chamber Measurements on CTPA			
RV Diameter (mm)	42.22±7.68	35.69±7.68	<0.001
LV Diameter (mm)	36.43±4.91	38.5±5.75	0.04
RV/LV Ratio	1.18±0.24	0.95±0.25	<0.001
RV/LV Ratio ≤1.1	12(24.5%)	83(65.4%)	<0.001
RV/LV Ratio >1.1	37(75.5%)	44(34.6%)	

RV=Right ventricle; LV=Left Ventricle

The ROC curve for predicting short-term mortality based on the RV/LV ratio has been illustrated in Figure 2. The area under the curve (AUC) was 0.753(95% CI: 0.675–0.832), indicating good discriminative ability of the RV/LV ratio in predicting mortality. Based on the highest Youden Index (J = 0.409), the optimal cut-off value was identified as 1.105, with a sensitivity of 75.5% and a specificity of 65.4%. PPV and NPV were found to be 45.7% and 87.4% respectively and diagnostic accuracy as 68.2%. Thus, an RV/LV ratio >1.1 can effectively identify patients at increased risk of short-term mortality, particularly with a high sensitivity for early detection.

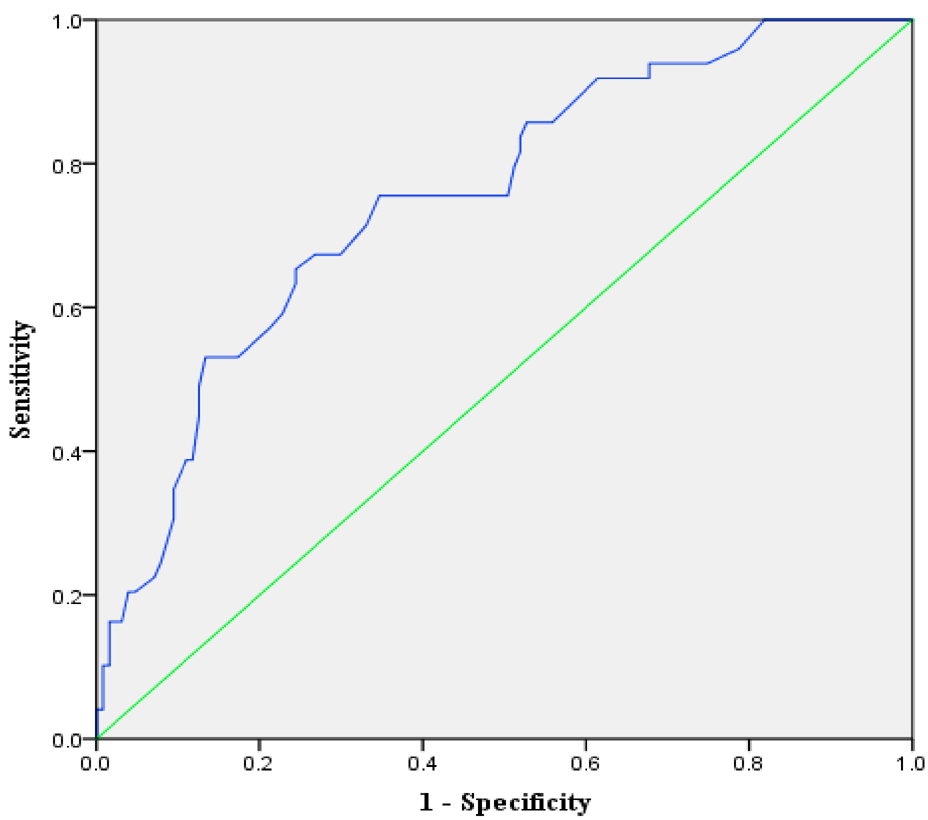

Figure 2 Receiver Operative Characteristics (ROC) Curve for Predicting Short-Term Mortality Based on RV/LV Ratio

DISCUSSION:

In this study, we evaluated the diagnostic accuracy of the RV/LV ratio measured on CTPA as a predictor of short-term mortality in patients presenting with acute PE. Our findings revealed that non-survivors had significantly higher RV diameters and RV/LV ratios compared to survivors. 75.5% mortality cases had an RV/LV ratio >1.1. RV/LV cut-off value of >1.1 yielded high sensitivity (75.5%) and specificity (65.4%) for predicting in-hospital mortality. The area under the ROC curve (AUC) of 0.753 indicated good discriminative performance. These results demonstrate the prognostic utility of the RV/LV ratio as a readily available, non-invasive imaging marker in patients with acute PE. The implications of these findings are discussed in the context of existing literature, highlighting both their clinical relevance and the potential for integration into risk stratification protocols.

A previous study by Ayoz et al. reported that 87.5% of patients who died from pulmonary embolism had an RV/LV ratio ≥1, highlighting the strong association between elevated RV/LV ratio and mortality. This finding is comparable to our study, where 75.5% of non-survivors also had an RV/LV ratio exceeding 1.1. [9] A systematic review by Hanmandlu et al. reported that the most commonly used and clinically effective RV/LV ratio cut-off values were 0.9 and 1.0. Their analysis also highlighted that the most widely adopted measurement approach involved assessing RV and LV diameters on the same axial slice, using both standard 2D axial and reconstructed four-chamber (4-Ch) views. Interestingly, the choice between axial and 4-Ch views influenced the predictive accuracy of the RV/LV ratio for specific outcomes, such as 30-day mortality. These findings align with our study, in which an axial-slice-based RV/LV ratio of >1.1 demonstrated good sensitivity in predicting short-term mortality. This reinforces the importance of standardised imaging protocols and optimal threshold selection to enhance prognostic value in clinical practice. [10]

Expanding on this, evidence from a larger meta-analysis demonstrated that an elevated RV/LV ratio was a reliable predictor of all-cause mortality, PE-related mortality, and composite adverse clinical outcomes. The prognostic performance was found to be comparable across two imaging planes, axial slices and reconstructed four-chamber (4-Ch) views, underscoring the significance of the RV/LV ratio as a non-invasive risk stratification tool regardless of the measurement approach. This supports the broader applicability of our findings and emphasises the clinical value of incorporating RV/LV ratio assessment into routine CTPA interpretation for patients with acute pulmonary embolism.[11]

In our study, the RV/LV diameter ratio demonstrated good discriminatory ability for predicting 30-day mortality in patients with acute pulmonary embolism, with an area under the ROC curve (AUC) of 0.753 (95% CI: 0.675–0.832). This suggests a strong prognostic potential for this radiological parameter in identifying individuals at high risk. Consistent with our findings, Lu et al., also evaluated the predictive value of the RV/LV ratio and reported an AUC of 0.66 for all-cause mortality, with a sensitivity of 75% and a lower specificity of 11%. While their diagnostic performance metrics were more modest, particularly in terms of specificity, the trend supports the utility of the RV/LV ratio as a valuable, non-invasive indicator of adverse outcomes.[12] Another recent study on PE patients demonstrated 25 deaths out of 101 study subjects and RV/LV ratio of 1.18 showed 100% sensitivity and 54% specificity with an AUC of 0.77(95%CI: 0.622-0.99) for 30-days mortality.[8] Cho et al, reported 80.6% sensitivity, 58.6% specificity, 87.3% NPV and 46.2% PPV values for RV/LV ratio >1.0, which are more closely resembled with our study findings.[13] Our study found sensitivity and specificity as 75.5% and 65.4% respectively at RV/LV ratio 1.105. AUC of 0.753(95% CI: 0.67-0.83) was noted. The variation in AUC and diagnostic parameters across studies may reflect differences in population characteristics, imaging protocols, and endpoint definitions. Nonetheless, the cumulative evidence highlights the clinical relevance of incorporating RV/LV ratio measurements into early risk assessment strategies for patients with acute PE.

A recent study by Chaosuwannakit et al. further supports the prognostic value of right ventricular (RV) strain and chamber dimensions in patients with pulmonary embolism. Their analysis revealed significantly greater RV strain among non-survivors, with a median value of 1.93 (IQR: 1.20–3.23) compared to 0.99 (IQR: 0.58–2.54) in survivors ($p < 0.001$). In addition, non-survivors demonstrated a markedly larger RV diameter [57.2 mm (47.8–67.8)] and smaller left ventricular (LV) diameter [29.3 mm (18.9–44.3)], compared to survivors who had an RV diameter of 40.9 mm (22.1–68.3) and an LV diameter of 38.2 mm (18.6–60.5), respectively ($p < 0.001$ for both comparisons).[14] These findings align closely with our results, which also showed that non-survivors had significantly increased RV diameter and RV/LV ratio, along with reduced LV diameter. Such consistent observations across studies support the significance of right heart strain markers on CTPA as robust predictors of short-term mortality in patients with acute PE.

It is essential to recognise that several patient-related factors, including advanced age, chronic lung disease, and underlying cardiovascular conditions, can influence the RV/LV ratio.[15,16] In elderly individuals, the prevalence of cardiopulmonary comorbidities tends to be higher, which can confound the interpretation of RV/LV measurements.[17,18] Moreover, distinguishing between acute and

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chronic pulmonary embolism (PE) remains a clinical challenge, as chronic thromboembolic features can mimic acute changes on CT despite the presence of specific distinguishing imaging findings. In a study by Ayoz et al., [9] comorbid conditions were significantly more common in patients who experienced all-cause mortality, and these individuals were generally older, highlighting the impact of age and multi-morbidity on clinical outcomes in acute PE. This is consistent with well-established evidence indicating that both advanced age and the presence of comorbidities are associated with increased mortality in patients with acute pulmonary thromboembolism. Furthermore, past studies have reaffirmed that an elevated RV/LV diameter ratio is strongly associated with adverse outcomes in patients with PE, underscoring its utility as a prognostic imaging marker, especially when interpreted in conjunction with the patient's clinical context.[19–21]

LIMITATIONS OF THE STUDY:

This study was conducted at a single centre, which may limit the generalizability of the findings. Additionally, short-term mortality was assessed primarily in terms of in-hospital and 30-day mortality, without accounting for long-term outcomes. Potential confounding factors such as treatment variations, hemodynamic parameters, and thrombus burden were not controlled for.

CONCLUSION:

The RV/LV ratio measured on multi-detector CT-pulmonary angiography demonstrates good diagnostic accuracy in predicting short-term mortality among patients with acute pulmonary embolism. An RV/LV ratio >1.1 is a sensitive indicator of adverse outcomes and may aid in early risk stratification and clinical decision-making.

AUTHOR CONTRIBUTION

Author	Contribution
Saira Shafiq*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hafiza Rimsha Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Misnad Shafiq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Hafsa Jamal	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Waleed Abbasi	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Nadeem Shahzad	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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