Role of Computed Tomography of the Chest in Differentiating Cardiogenic and Non-Cardiogenic Pulmonary Edema

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Abstract

Background: Acute pulmonary edema is a common cause of respiratory distress, and distinguishing cardiogenic from non-cardiogenic etiologies is critical because treatment strategies differ substantially.

Objective: To assess the diagnostic utility of chest computed tomography in differentiating cardiogenic from non-cardiogenic pulmonary edema.

Materials and Methods: A retrospective observational analysis was performed on 103 patients who underwent CT chest for evaluation of acute pulmonary edema. Imaging findings were systematically assessed and correlated with clinical presentation and echocardiographic parameters to determine the underlying etiology.

Results: Cardiogenic pulmonary edema was significantly associated with cardiomegaly, bilateral pleural effusions, smooth interlobular septal thickening and predominantly central ground-glass opacities. In contrast, non-cardiogenic pulmonary edema commonly demonstrated diffuse or peripheral ground-glass opacities with patchy areas of consolidation and minimal cardiac or pleural involvement.

Conclusion: Chest CT serves as a valuable diagnostic tool in differentiating cardiogenic from non-cardiogenic pulmonary edema by identifying characteristic distribution patterns and associated extracardiac findings.

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Keywords: Acute pulmonary edema; Cardiogenic pulmonary edema; Non-cardiogenic pulmonary edema; Chest computed tomography; Ground-glass opacities.

Introduction

Pulmonary edema results from abnormal fluid accumulation within the pulmonary interstitium and alveolar spaces, leading to impaired gas exchange and acute respiratory symptoms [1]. Based on the underlying mechanism, pulmonary edema is broadly categorized into cardiogenic and non-cardiogenic types. Accurate etiological differentiation is essential, as management approaches and prognostic outcomes vary considerably between these two entities [1, 2, 8].

Conventional diagnostic modalities such as chest radiography and echocardiography are routinely employed in clinical practice; however, overlapping clinical and imaging features may reduce diagnostic certainty, particularly in critically ill patients [3,9]. Computed tomography (CT) of the chest provides superior spatial resolution and allows detailed assessment of lung parenchyma, cardiac size, pulmonary vasculature, and pleural spaces within a single examination [3, 7]. This study aims to evaluate the role of

Materials and Methods

Study design: This retrospective observational study was conducted over a two-year period from December 2023 to November 2025 and included 103 adult patients.

Inclusion Criteria

- Age ≥18 years
- CT chest performed within 48 hours of onset of acute respiratory symptoms
- Clinical suspicion of pulmonary edema

Exclusion Criteria

- Known interstitial lung disease
- Evidence of active pulmonary infection at presentation
- History of pulmonary malignancy

CT protocol: CT examinations were performed using a multidetector CT scanner with thin- section reconstruction. Non-contrast scans were primarily evaluated, as recommended in prior radiological literature for pulmonary edema assessment.

Institutional ethics committee approval was obtained, and patient confidentiality was maintained.

CT chest in distinguishing cardiogenic pulmonary edema from non-cardiogenic pulmonary edema.CT examinations were independently reviewed by two radiologists blinded to the final diagnosis. Imaging parameters analyzed included distribution and pattern of ground-glass opacities, presence of consolidation, interlobular septal thickening, cardiac size, pulmonary vein prominence, and pleural effusion. The final classification into cardiogenic or non-cardiogenic pulmonary edema was based on integration of imaging findings with clinical assessment and echocardiographic results.

Categorical variables were compared using the Chi-square test, with $p < 0.05$ considered statistically significant

Results

Among the 103 patients analyzed, 58 patients (56.3%) were diagnosed with cardiogenic pulmonary edema, while 45 patients (43.7%) were categorized as having non-cardiogenic pulmonary edema.

Table 1: Distribution of Patients According to Etiology of Acute Pulmonary Edema

Type of Pulmonary Edema	Number of Patients (n)	Percentage (%)
Cardiogenic pulmonary edema	58	56.3
Non-cardiogenic pulmonary edema	45	43.7
Total	103	100

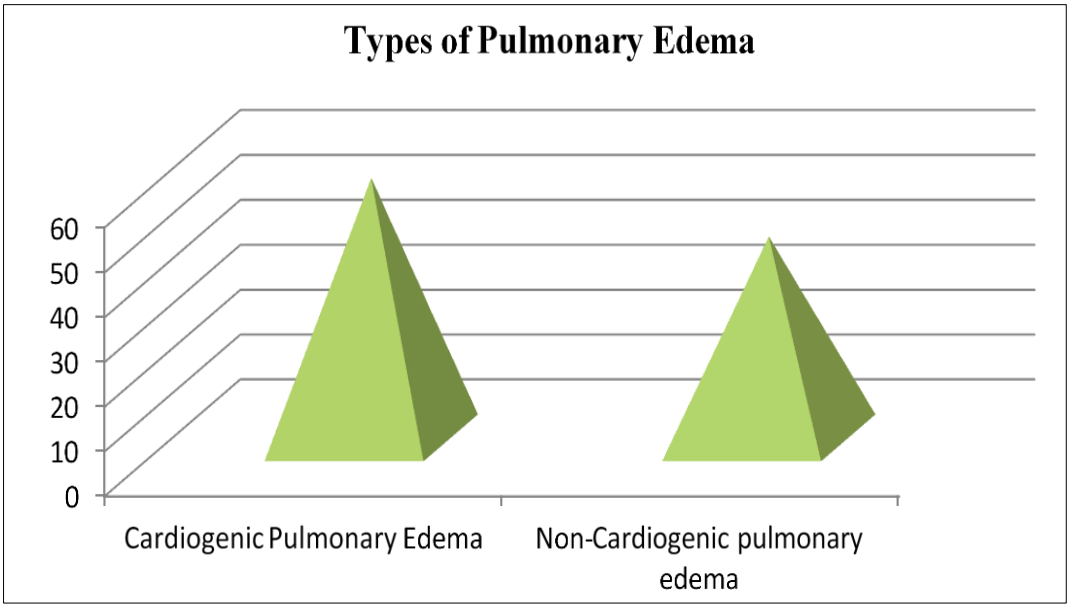
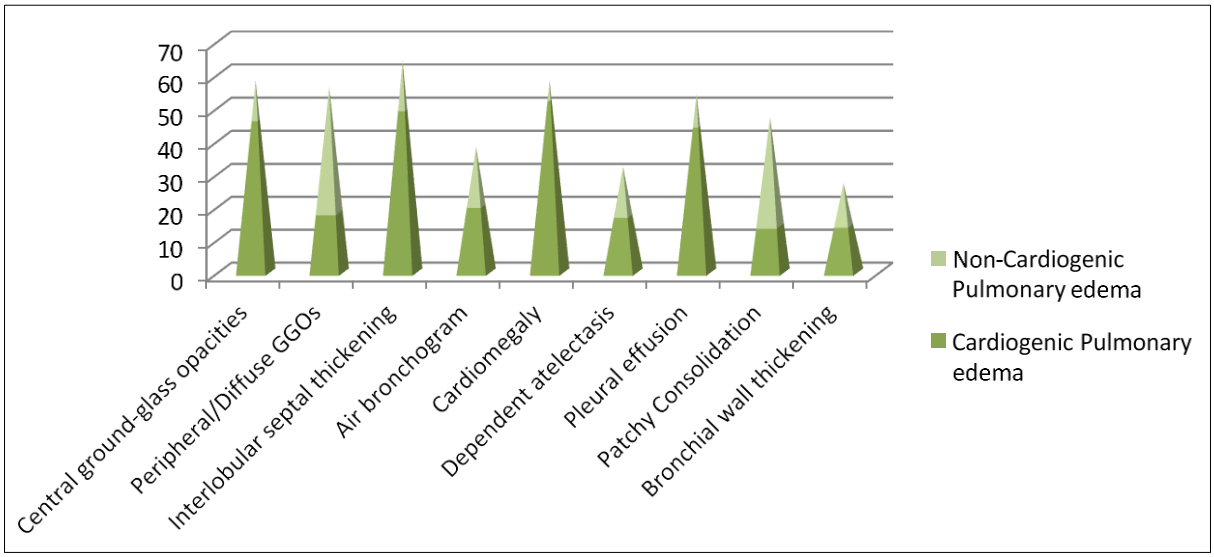


Table 2: Comparison of CT findings between cardiogenic and non-cardiogenic pulmonary edema

Peripheral/diffuse GGOs	18 (31.0%)	38 (84.4%)	<0.001
Interlobular septal thickening	49 (84.5%)	15 (33.3%)	<0.001
Air bronchogram	20 (34.5%)	18 (40.0%)	>0.05
Cardiomegaly	52 (89.7%)	6 (13.3%)	<0.001
Dependent atelectasis	17 (29.3%)	15 (33.3%)	>0.05
Pleural effusion	44 (75.9%)	10 (22.2%)	<0.001
Patchy consolidation	14 (24.1%)	33 (73.3%)	<0.001
Bronchial wall thickening	14 (24.1%)	13 (28.9%)	>0.05



Cardiogenic pulmonary edema showed a significantly higher prevalence of cardiomegaly, smooth interlobular septal thickening, pleural effusions and centrally distributed ground-glass opacities. Conversely, non-cardiogenic pulmonary edema more frequently demonstrated diffuse or peripheral ground-glass opacities and patchy consolidation, with relatively preserved cardiac size and minimal pleural fluid. The differences in imaging features between the two groups were statistically significant ($p < 0.001$).

Figures

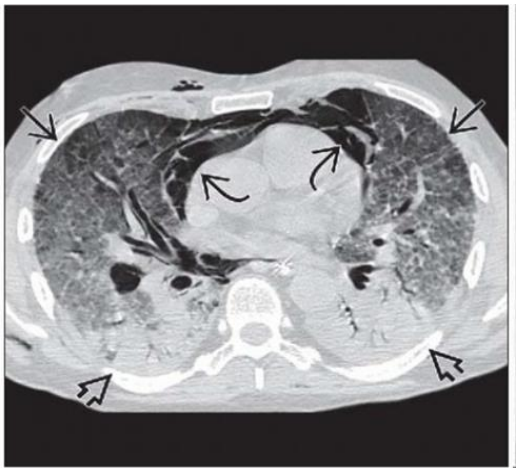


Fig 1: The axial CT image shows bilateral symmetric ground-glass opacities with interlobular septal thickening, predominantly central and perihilar, creating a bat-wing distribution. There is cardiomegaly (curved arrows) and bilateral pleural effusions (peripheral arrows), with dependent increased attenuation.

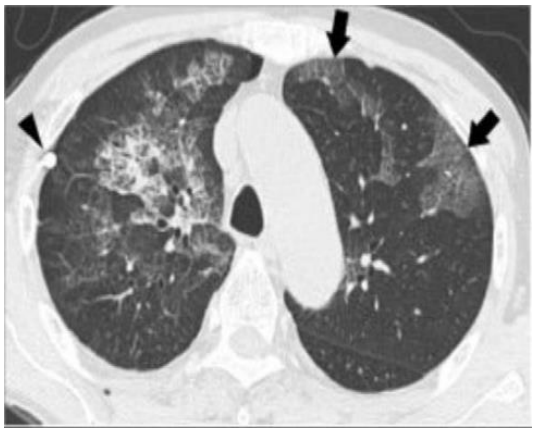


Fig 2: The axial HRCT image demonstrates bilateral ground-glass opacities with superimposed interlobular septal thickening, producing a“crazy-paving”pattern (indicated by arrows).The involvement is relatively diffuse and peripheral, without obvious cardiomegaly or pleural effusion.

Discussion

Acute pulmonary edema represents a frequent diagnostic challenge in emergency and intensive care settings. Distinguishing between cardiogenic and non-cardiogenic causes is of paramount importance, as therapeutic interventions differ substantially and inappropriate management may adversely affect outcomes.

In this study, cardiogenic pulmonary edema was characterized by imaging findings consistent with elevated pulmonary venous pressure, including cardiomegaly, smooth septal thickening, pleural effusions, and predominantly central ground-glass opacities [2, 3, 7, 8]. These features reflect hydrostatic fluid transudation into the pulmonary interstitium and alveolar spaces secondary to left ventricular dysfunction. In contrast, non-cardiogenic pulmonary edema demonstrated imaging patterns suggestive of increased alveolar-capillary membrane permeability. Diffuse or peripheral ground-glass opacities and patchy consolidation were the dominant features, often occurring in the absence of cardiomegaly or significant pleural effusion [1,4,7]. These findings are commonly encountered in conditions such as acute respiratory distress syndrome, sepsis, aspiration, and trauma [1, 4].

The results of this study align with previously published literature emphasizing the role of CT in evaluating the distribution of parenchymal abnormalities and associated cardiac findings [3, 6, 9]. Beyond differentiation of pulmonary edema subtypes, CT chest also facilitates detection of alternative or concurrent pathologies, including pneumonia, pulmonary embolism, and acute lung injury, which may significantly influence clinical decision-making [3, 7].

The statistically significant imaging differences observed between cardiogenic and non- cardiogenic groups highlight the diagnostic value of CT chest, particularly in scenarios where clinical assessment and echocardiography yield equivocal results.

Limitations

The primary limitations of this study include its retrospective nature and single-center design. Potential selection bias and absence of longitudinal follow-up data may also limit generalizability. Larger prospective multicenter studies are warranted to further substantiate these findings.

Conclusion

Computed tomography of the chest is a reliable and effective modality for differentiating cardiogenic from non-cardiogenic pulmonary edema. Identification of characteristic imaging patterns enables radiologists to suggest the most probable etiology, thereby supporting timely and targeted clinical management [3, 7, 9].

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