

Study of High Resolution Computed Tomography Chest in The Evaluation of Pulmonary Edema

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Abstract

Background: Pulmonary edema is a pathological state marked by the accumulation of fluid within the lung's extravascular compartments, leading to impaired gas exchange and potentially respiratory failure. It is a common pathology seen in usually bedridden patients. Two main causes of pulmonary edema include cardiogenic and non-cardiogenic. Radiologically, High resolution chest CT is gold standard for diagnosis, however Chest Xray and Lung Ultrasound can be used as an adjunct.

Materials & Methods: A prospective analysis of 60 patients who presented with symptoms and signs of pulmonary edema had undergone High resolution computed tomography of the Chest for assessing pulmonary imaging features of acute pulmonary edema, its manifestations and complications.

Results & Discussion: Out of 60 cases of pulmonary edema, the imaging findings were Ground glass opacities (91.7%), Interlobular septal thickening (100%), Air space consolidation (83.3%), Pleural effusion (76.7%), Cardiomegaly (30%), RV:LV ratio elevation (10 %), Pulmonary artery dilatation (21.7 %) and Atelectasis (61.7 %).

These cases show different spectrum of signs on HRCT.

Conclusions: CT is the modality of choice for early diagnosis of pulmonary edema, assessment of its complications and serial follow ups for progression of complications.

Keywords: Acute pulmonary edema, Ground glass opacities, Interlobular septal thickening, Cardiomegaly, Pleural effusion.

Introduction

Pulmonary edema is a pathological state marked by the accumulation of fluid within the lung's extravascular compartments, leading to impaired gas exchange and potentially respiratory failure. It arises primarily from two mechanisms: cardiogenic causes such as left ventricular dysfunction and non-cardiogenic processes like acute lung injury or sepsis, leading to increased vascular permeability. Clinically, it presents with progressive dyspnea, hypoxia, and characteristic auscultatory findings ¹.

Radiological imaging plays a critical role in diagnosing and evaluating pulmonary edema. While chest X-ray (CXR) and lung ultrasound (LUS) are widely used, they have limitations in specificity and quantification. High-Resolution Computed Tomography (HRCT) offers a detailed visualization of lung architecture and better sensitivity for early or subtle changes such as ground-glass opacities (GGOs), interlobular septal thickening, and associated features like pleural effusion or cardiomegaly.

Despite its proven utility, limited studies exist on the application of HRCT in Indian tertiary care settings. This study was conducted to assess the diagnostic and evaluative role of HRCT in pulmonary edema ².

Aims and Objectives

Aim

To evaluate the role of HRCT chest in patients presenting with clinical features of pulmonary edema.

Objectives

- To identify the patterns (diffuse or localized) of involvement in pulmonary edema on HRCT.
- To detect any local pathological etiologies.
- To evaluate dimensions and dilatation of the pulmonary artery.

- To assess associated pleural and cardiac abnormalities.

Materials & Methods

Study Design: Prospective observational study at the Department of Radiodiagnosis, MGM Medical College, Navi Mumbai.

Duration: November 2022 – December 2023

Sample Size: 60 patients, aged 18–70 years, presenting with signs of pulmonary edema and confirmed HRCT findings.

Inclusion Criteria

- Clinical suspicion of pulmonary edema
- HRCT-confirmed pulmonary edema
- Informed consent

Exclusion Criteria

- Age <18 or >70 years
- Pregnant women
- HRCT negative for pulmonary edema

Materials

HRCT Protocol: CT chest using Toshiba 16-slice and Fujifilm 128-slice machines. Parameters included: 150kV, 200mA, 0.35s rotation, 5 mm slice thickness, with 1mm reconstructions.

Data Analysis: GraphPad in Stat v3.0. Statistical significance set at $p < 0.05$.

Results & Discussion

Demographics

- Mean age: 61.7 ± 8.6 years
- Gender: 61.7% male (n=37), 38.3% female
- Most patients (51.7%) aged between 61-70 years

Comorbidities

- Hypertension: 20%
- Diabetes: 13.3%
- Chronic Kidney Disease: 11.7%
- Liver Disease: 6.7%

Clinical Features

- Breathlessness: 78.3%
- Cough: 36.7%
- Chest pain: 18.3%
- Respiratory distress: 11.7%

HRCT Findings

- **Ground Glass Opacities (GGO):** Seen in 91.7%
 - Dependent: 65%
 - Perihilar: 23.3%
 - Scattered: 11.7%
- **Interlobular Septal Thickening:** 100%
- **Airspace Consolidation:** 83.3%
- **Pleural Effusion:** 76.7%
- **Cardiomegaly:** 30%
 - Mild: 25%
 - Moderate: 5%
- **RV:LV ratio elevation:** 10%
- **Pulmonary Artery Dilatation:** 21.7%
- **Atelectasis:** 61.7%

Statistical Associations

- Strong association between hypertension and cardiomegaly ($p = 0.0001$)
- Strong association between hypertension and pulmonary artery dilatation ($p = 0.0001$)

Out of 60 cases of pulmonary edema, the imaging findings were ground glass opacities (91.7%), Interlobular septal thickening (100%), Air space consolidation (83.3%), Pleural effusion (76.7%), Cardiomegaly (30%), RV: LV ratio elevation (10 %), Pulmonary artery dilatation (21.7 %) and Atelectasis (61.7 %).

These cases show different spectrum of signs on HRCT.

- **Ground glass opacity (GGO)** on a HRCT scan of the lungs refers to a hazy, increased density in the lung tissue, without obscuring the underlying bronchial structures or blood vessels

- **Air space consolidation** is described as increased lung attenuation sufficient to obscure bronchial walls and blood vessels (on non-enhanced CT). Patent airways can be identified by the endoluminal gas as an air bronchogram. Consolidation can be caused by any process that evacuates alveolar air such as pneumonia
- **Interlobular septal thickening** is defined as the abnormal thickening of the connective tissue walls (septa) that separate adjacent secondary pulmonary lobules and indicates various underlying lung conditions, including edema, venous congestion, or infiltrative diseases.
- **Pleural effusions** are abnormal accumulations of fluid within the pleural space. On Xray, there is obscuration of Costo-phrenic angles and on CT it shows low attenuation (HU= 0-20)
- **Passive atelectasis** is usually seen associated with pleural effusion.
- **Cardiomegaly** is classified as mild, moderate and gross cardiomegaly, which on Xray is evaluated by cardiothoracic ratio. Cardiomegaly with pulmonary arterial hypertension is usually associated with cardiogenic causes of pulmonary edema

Discussion

This study reaffirms HRCT's robust sensitivity in detecting pulmonary edema. Ground-glass opacities and septal thickening were prominent features, consistent with findings in the literature. Nearly all patients exhibited GGOs or septal thickening, supporting HRCT's advantage in identifying early and subtle changes compared to CXR.⁵

Cardiac findings such as cardiomegaly and RV: LV ratio alterations align with the cardiogenic nature of pulmonary edema in many subjects. HRCT also enabled identification of associated conditions like atelectasis,

underscoring the secondary effects of alveolar fluid overload.

Comparison with other studies:

- Komiya et al. (2013) and Brasileiro et al. (2005) noted similar HRCT features such as perihilar GGOs and pleural effusions, particularly in CPE.
- Baik et al. found patchy GGOs and septal thickening typical of REPE (re-expansion pulmonary edema), consistent with present observations.

Advantages of HRCT

- Offers anatomical detail lacking in X-rays or LUS
- Detects early or atypical presentations
- Identifies coexisting pathologies (e.g., fibrosis, infection, atelectasis)

Measures pulmonary artery size and assesses vascular involvement

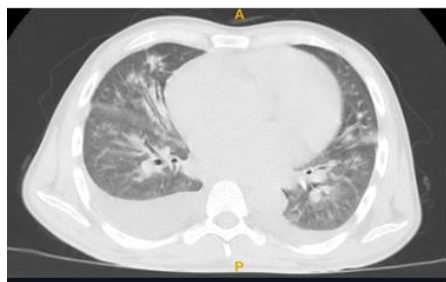


Image 1: Perihilar patchy areas of ground glass attenuation and interstitial septal thickening and bilateral pleural effusions

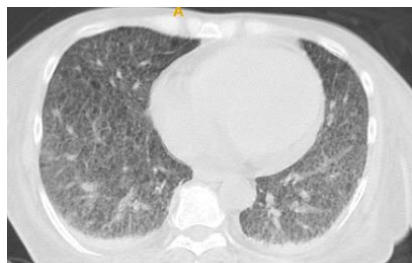


Image 2: Diffuse area of ground glass attenuation and interstitial septal thickening, with bilateral pleural effusions.

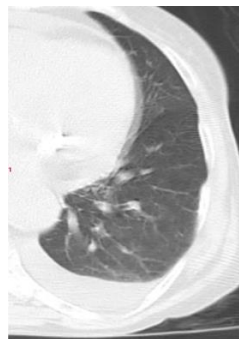


Image 3: Pleural effusion with adjacent interstitial septal thickening

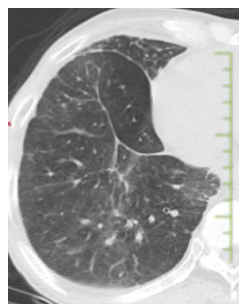


Image 4: Patchy areas of ground glass attenuation and interstitial septal thickening

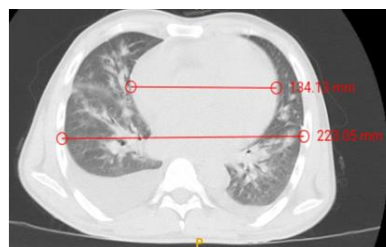


Image 5: Cardiogenic pulmonary edema - Perihilar ground glass attenuation and interstitial septal thickening, with bilateral pleural effusions and associated cardiomegaly

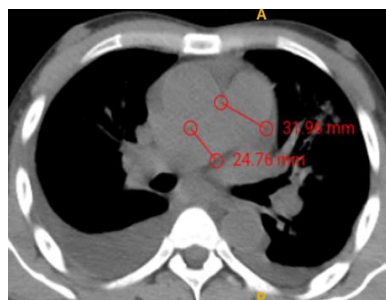


Image 6: In addition to the abovementioned (Image 5) features, same patient showed pulmonary artery hypertension

Table 1: HRCT chest imaging findings in pulmonary edema

No.	HRCT Chest imaging findings	Total No. of cases	Percentage %
1	Ground glass opacities	55	91.7
2	Interlobular septal thickening	60	100
3	Air space consolidation	50	83.3
4	Pleural effusion	46	76.7
5	Cardiomegaly	18	30
6	RV:LV ratio elevation	6	10
7	Pulmonary artery dilatation	13	21.7
8	Atelectasis	41	61.7

Conclusion

HRCT chest is a powerful non-invasive tool for the assessment of pulmonary edema. It:

- Provides accurate anatomical detail of parenchymal changes
- Differentiates between cardiogenic and non-cardiogenic edema
- Detects associated cardiac and pleural changes
- Offers diagnostic confidence in equivocal or atypical cases

Given the high prevalence of comorbidities such as hypertension, HRCT also aids in correlating structural cardiac alterations with clinical findings

References

1. Starling EH. On the absorption of fluid from the connective tissue spaces. *J Physiol* 1896; 19:312-17.

2. Ketai LH, Goodwin JD. A new view of pulmonary edema and acute respiratory distress syndrome: state of the art. *J Thorac Imaging* 1998;13:147-71.

3. Milne ENC, Pistolesi M. Reading the chest radiograph: a physiologic approach St Louis, Mo: Mosby-Year Book, 1993;9-50.

4. Ely EW, Haponik EF. Using the chest radiograph to determine intravascular volume status: the role of vascular pedicle width. *Chest*. 2002;121(3):942-50.

5. Thomason JW, Ely EW, Chiles C, Ferretti G, Freimanis RI, Haponik EF. Appraising pulmonary edema using supine chest roentgenograms in ventilated patients. *Am J Respir Crit Care Med*. 1998;157(5):1600-8.

6. Knudsen CW, Omland T, Clopton P, Westheim A, Abraham WT, Storror AB, et al. Diagnostic value of B-Type natriuretic peptide and chest radiographic findings in patients with acute dyspnea. *Am J Med*. 2004;116(6):363-8.

7. Snashall PD, Keyes SJ, Morgan BM. The radiographic detection of acute pulmonary oedema. A comparison of radiographic appearances, densitometry and lung water in dogs. *Br. J. Radiol*. 1981;54(640):277-88.

8. Lichtenstein D, Mézière G, Biderman P, Gepner A, Barré O. The comet-tail artifact. An ultrasound signs of alveolar-interstitial syndrome. *Am J Respir Crit Care Med* 1997; 156:1640-46.

9. Volpicelli G, Mussa A, Garofalo G, Cardinale L, Casoli G, Perotto F, et al. Bedside lung ultrasound in the assessment of alveolar-interstitial syndrome. *Am J Emerg Med* 2006; 24:689-96.

10. Rosenblum LJ, Mauerer RA, Wellenstein DE, Thomas FD, Bassano DA, Raasch BN, et al. Density patterns in the normal lung as determined by

- computed tomography. *Radiology*. 1980;137(2):409-16.
11. Kato SNT. Reproducibility of measurement and normal value of regional pulmonary CT number by sign of region of interest. *Respir. Res.* 1987;6:1115–22.
12. Morooka N, Watanabe S, Masuda Y, Inagaki Y. Estimation of pulmonary water distribution and pulmonary congestion by computed tomography. *Jpn Heart J.* 1982;23(5):697-709.
13. Murray JF. Pulmonary edema: pathophysiology and diagnosis. *Int J Tuberc Lung Dis.* 2011;15(2):155-60
14. Ghofrani HA. [Pulmonary edema]. *Internist (Berl).* 2004;45(5):565-72.