Role of Dual Energy Computed Tomography in Detection of Pulmonary Thromboembolism - A Prospective Observational Study in a Tertiary Care Centre of Central India

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Abstract: ***This study evaluates the diagnostic effectiveness of dual energy computed tomography pulmonary angiography DECTPA in detecting pulmonary embolism PE. PE is a critical cardiovascular condition with significant mortality risk, making early diagnosis essential. DECTPA provides enhanced imaging by using dual Xray energy spectra, allowing for detailed visualization of both emboli and lung perfusion defects. This crosssectional study included 136 patients clinically suspected of PE, and the results demonstrated that DECTPA has high sensitivity 95.12% and specificity 92.31% in diagnosing PE. The right lower lobe and the right pulmonary artery were most commonly affected. Additionally, the study highlights the potential of DECTPA in predicting right ventricular dysfunction, which can guide therapeutic decisions. Overall, the findings support DECTPA as a valuable tool in improving diagnostic accuracy and patient outcomes in pulmonary embolism cases.***

Keywords: Pulmonary embolism, Dual - energy computed tomography (DE - CTPA), Perfusion defects

1. Introduction

Pulmonary embolism (PE) is a leading cause of cardiovascular - related mortality, with an incidence of 112.3 per 100, 000 and a 3 - month mortality rate of 3.9% to 15.3%. Early diagnosis and treatment are crucial, as delays can significantly increase mortality rates. Currently, multidetector computed tomography (MDCT) is the standard imaging modality for PE, providing high diagnostic accuracy while minimizing radiation exposure. (1)

Dual - energy computed tomography (DECT) enhances this process by simultaneously offering morphological and functional insights into the lungs. By utilizing two X - ray energy spectra, DECT can identify iodine components, allowing for the visualization of both emboli and related perfusion defects without additional radiation. Recent studies indicate DECT improves the detection of small segmental and subsegmental PEs, with sensitivity ranging from 60% to 90% and specificity from 88% to 99%. (1)

As non - invasive alternatives to traditional pulmonary angiography, DECT shows promise in accurately diagnosing PE and assessing its severity. Research demonstrates that the volume of lung perfusion defects detected by DECT correlates with patient prognosis, underscoring its potential role in enhancing clinical outcomes for PE patients. (1)

Aims and Objectives

1) To evaluate the diagnostic value of dual energy CT pulmonary angiography in pulmonary embolism patients.
2) To demonstrate the utility of iodine mapping and lung perfusion defects in the diagnosis of segmental and sub - segmental clots.
3) To demonstrate the prognostic value of iodine maps

2. Materials and Methods

Source of Patients

This cross - sectional study included hemodynamically stable patients with clinically diagnosed pulmonary embolism (PE) referred from various clinical departments in a tertiary care hospital.

Inclusion Criteria

- Male and female patients aged 18 years or older with acute cardiopulmonary symptoms presenting to the emergency department and advised to undergo CTPA.
- Patients willing to provide informed consent.

Exclusion Criteria

- Patients not suspected of having PE.
- Those with contraindications for contrast injection (e. g., renal failure, allergies).
- Pregnant or debilitated patients unable to undergo CTPA.
- Patients unwilling to participate.

Data Collection

After obtaining ethical approval and informed consent, a complete clinical evaluation was conducted. A total of 136 patients suspected of PE were enrolled over 21 months (April 2022 to January 2024).

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Scanning Technique

CT imaging was performed using a Siemens 128 - slice dual - energy CT scanner. Patients were positioned supine, and sedation was administered when necessary. The dual - energy protocol involved:

- Tube voltages of 80 kV and 140 kV.
- Iodinated contrast medium administered via an automated injector at a flow rate of 5 ml/s, followed by a saline chaser.

Data Analysis

Data were analyzed for correlations between imaging findings and clinical outcomes, using appropriate statistical methods. No conflicts of interest or risk factors were reported.

3. Observations and Results

1) Distribution of Cases by Age and Sex

Table 2: Distribution of Cases according to Age and Sex

Age (years)	No. of cases in Males	No. of cases in Females	Total	Percentage (%)
0 to 30	06	02	08	6.15
30 to 60	42	31	73	53.84
> 60	42	13	55	40.0
Total	90	46	136	100

2) Presenting Complaints and Clinical History

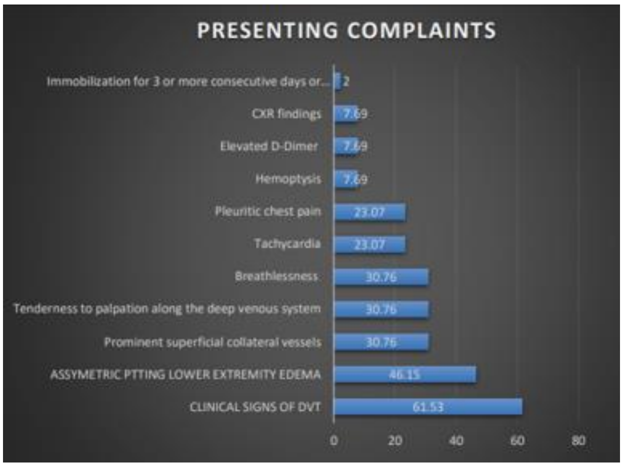


Chart 2: Distribution of cases according to presenting companies and clinical history

3) Risk Factors and Comorbidities

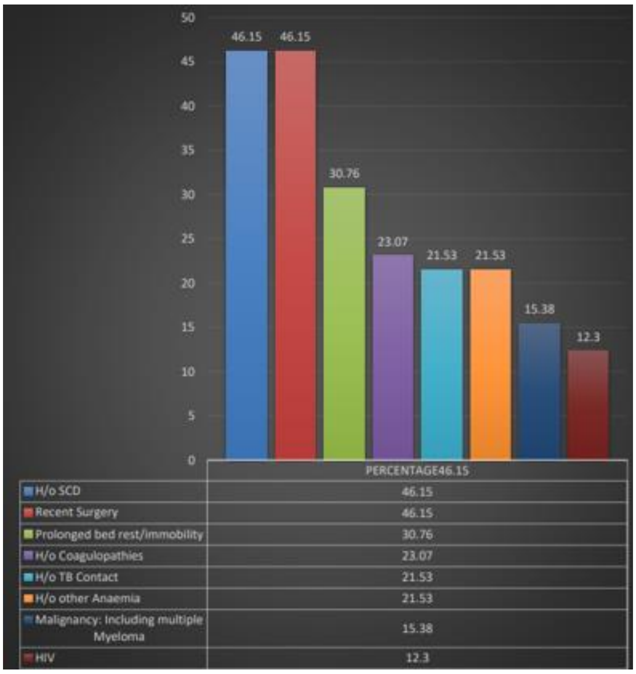


Chart 3: Distribution of cases according to risk factors and comorbidities

4) Clinical Diagnosis

Clinical Diagnosis	Frequency (n= 136)	Percentage (%)
DVT	73	53.84
Pulmonary Embolism	52	38.46
Idiopathic	11	7.69
Total	136	100

5) Need for Sedation

Table 6: Distribution of cases according to need of sedation by anaesthesist

Sedation by anaesthesist required	Frequency (n= 136)	Percentage (%)
No	123	90.76
Yes	13	10.76
Total	136	100

6) Filling Defect on CT Pulmonary Angiography

Table 7: Distribution of cases according to positive findings on pulmonary angiography

Filing Defect on Dual Energy CT pulmonary angiography	Frequency (n= 136)	Percentage (%)
Present	123	90.4
Absent	13	9.5

7) Laterality of Lesion

Table 8: Distribution of cases according to Laterality of Lesion

Imaging Diagnosis	Frequency (n= 136)			
	Right	Left	Bilateral	Total
Pulmonary Embolism	52	42	11	105
Non- Pulmonary Embolism	15	13	3	31
Total	67	55	14	136

8) Lobe of Lung Involved

The right lower lobe was the most affected (42 cases).

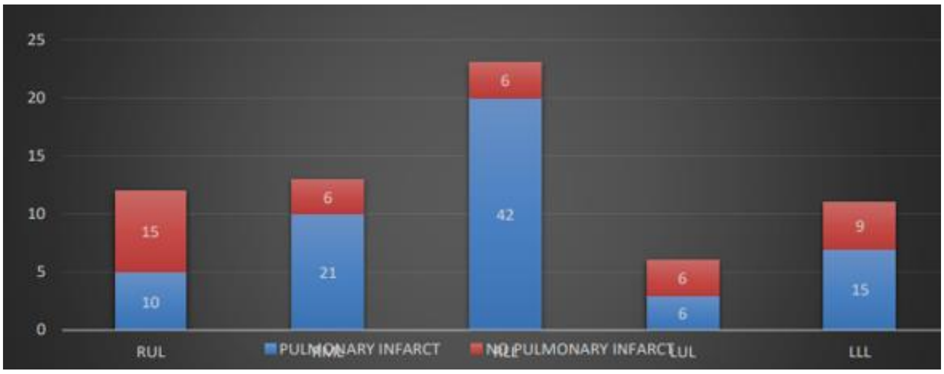


Table 9: Distribution of cases according to Lobe of Lung involved

9) Vessel Involvement

The right pulmonary artery was most frequently involved (46.15%).

Table 10: Distribution of Pulmonary Embolism Cases according to vessel Involvement

Vessel Involved	Frequency (n= 136)	Percentage (%)
MPA	15	10.76
RPA	63	46.15
LPA	31	23.07
Lobar Branches	21	15.38
Subsegmental Branches	6	4.61

10) Etiology of Pulmonary Embolism

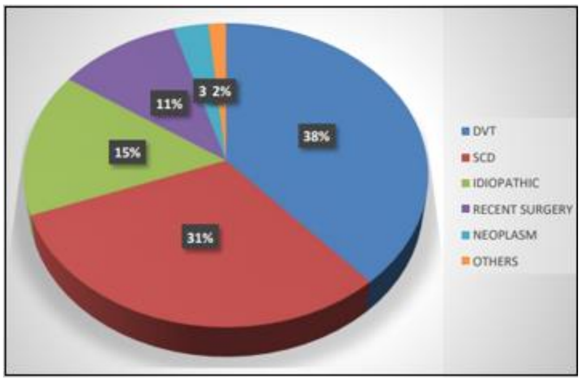


Chart 10: Distribution of Pulmonary Embolism cases according to Etiology

11) Occlusion Pattern

Table 12: Distribution of Pulmonary Embolism Cases based on Occlusion Pattern

Occlusion Pattern	Frequency (n= 136)	Percentage (%)
Occlusive	109	88.9
Non-Occlusive	14	11.1
Total	123	100

12) Perfusion Defects

Table 13: Distribution of Cases based on Perfusion Defects

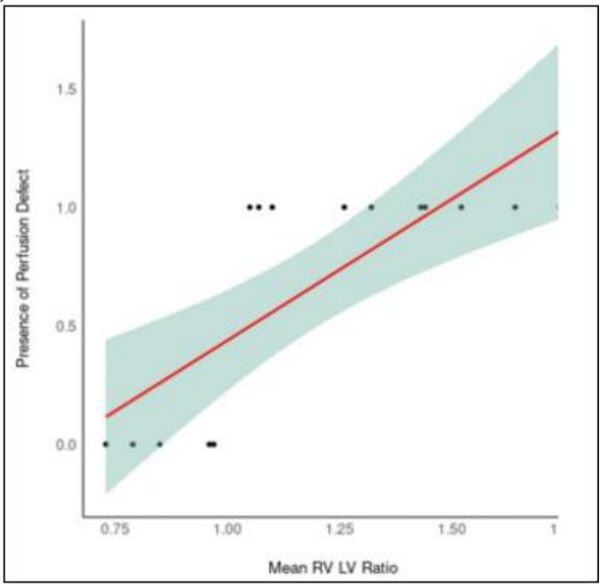
Perfusion Defects	Frequency (n= 136)	Percentage (%)
Present	109	80.14
Absent	27	19.8
Total	136	100

13) Final Diagnosis

Table 14: Distribution of Cases according to Final Diagnosis

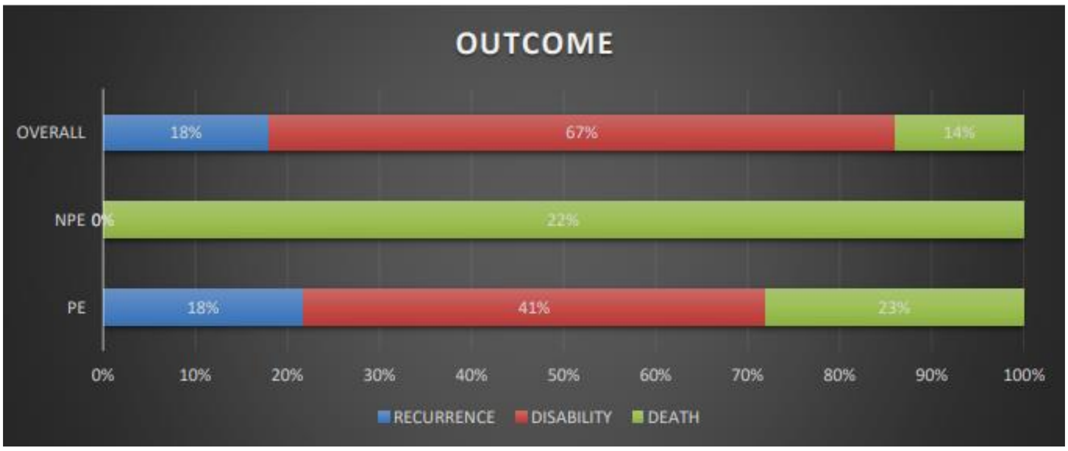
Final Diagnosis	Frequency (n= 136)	Percentage (%)
Pulmonary Embolism	117	86.09
Not- Pulmonary Embolism/ Pulmonary Embolism Mimic	19	13.97

14) Correlation of Mean RV/LV Ratio



Graph 1 and 2: Scatter Graph showing positive Correlation of Mean RV: LV Ratio and presence of perfusion defect

Outcome Distribution



Statistical Analysis

CTPA showed a sensitivity of 95.12% and specificity of 92.31% in diagnosing pulmonary embolism, with an overall accuracy of 94.85%.

4. Summary and Discussion

The study on pulmonary embolism (PE) identified a bimodal age distribution, primarily affecting individuals aged 30 - 60 and those over 60, with a mean presentation age of 45 years. A significant male predominance was observed, with males accounting for 66.15% of cases, highlighting a higher incidence of PE in men. The most common presenting complaint was clinical signs of deep vein thrombosis (DVT), seen in approximately two - thirds of patients, indicating a strong overlap between DVT and PE symptoms. (2, 3)

Key risk factors identified included sickle cell disease and recent surgical history, both present in nearly half of the patients. CT pulmonary angiography (CTPA) confirmed PE in 123 out of 136 patients, demonstrating high sensitivity (95.12%) and specificity (92.31%). (3) The right lower lobe was the most frequently involved area, consistent with existing literature. Furthermore, a notable correlation (0.745) was found between the presence of lung perfusion defects and the RV ratio, suggesting that perfusion defects could serve as a prognostic indicator for right ventricular dysfunction in PE patients. (2 - 6) Overall, the findings underscore the importance of timely diagnosis and the role of imaging techniques in managing PE effectively. (13)

5. Conclusion

The study emphasizes the critical role of dual - energy computed tomography pulmonary angiography (DE - CTPA) in diagnosing pulmonary thromboembolism (PTE). Conventional imaging often struggles to distinguish between PTE and its mimics, leading to potential misdiagnosis and significant morbidity. DE - CTPA enhances diagnostic accuracy by providing superior visualization of pulmonary arteries and better differentiation between thromboembolic and non - thromboembolic causes.

Key advantages of DE - CTPA include improved image quality, reduced artifacts, and the ability to quantify clot burden and assess pulmonary infarcts. Furthermore, it can predict right ventricular dysfunction, thus informing therapeutic decisions. DE - CTPA is also more effective in diagnosing subsegmental clots, enhancing radiologist confidence. (7 - 10)

Overall, DE - CTPA represents a major advancement in imaging technology, leading to more precise diagnosis and improved patient outcomes. Future research should aim to validate these findings across varied clinical settings to establish DE - CTPA as a standard diagnostic tool for PTE.

Few Cases:

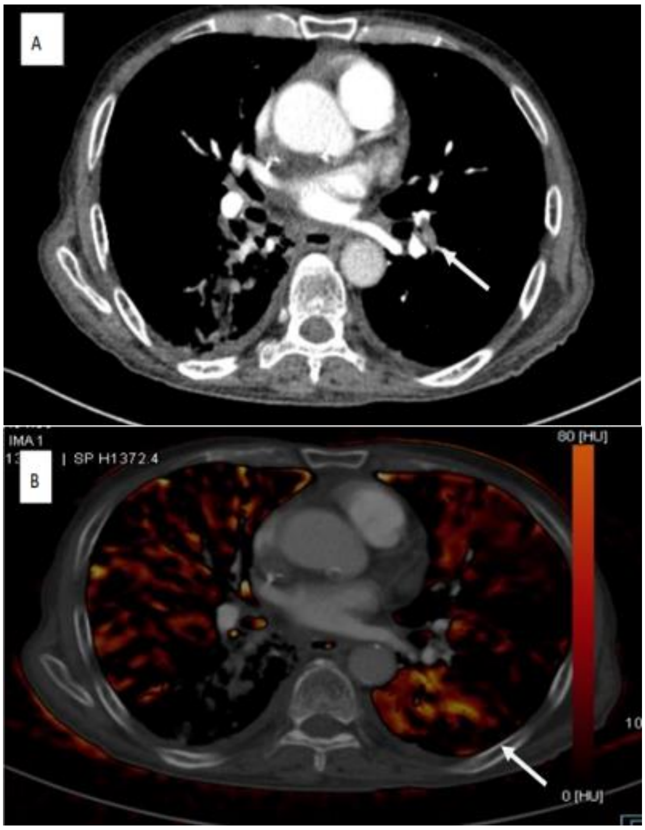


Figure 27: (A) Conventional CTPA image showing eccentric thrombus in left lower lobar artery extending into its superior and anteromedial branches. Iodine maps (B) generated from dual energy CTPQ study lung perfusion defect corresponding with the mentioned thrombus

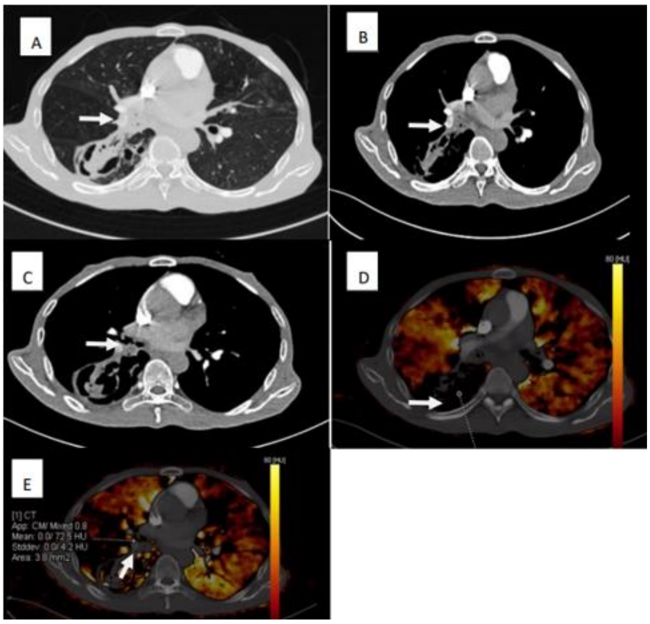


Figure 29: (A, B, C) Conventional CTPA shows a near complete lumen occluding thrombus in right lower lobar segmental artery. HRCT thorax shows pulmonary infarct with cavitatory changes

(D, E) om iodine maps there is a corresponding large perfusion defect seen in the area of pulmonary infarct with cavitation.

The mean iodine concentration in the region of thrombus is 0 as seen on iodine maps.

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