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Computed Tomographic Pulmonary Angiography Findings in Patients with Suspected Pulmonary Embolism

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A B S T R A C T

Background: A workup should be initiated if certain symptoms, even general ones, that are not explained by another illness raise the possibility of pulmonary embolism (PE). The primary imaging procedure that is advised for an individual with suspected pulmonary embolism is computed tomographic pulmonary angiography (CTPA). This diagnostic tool (CTPA) is much more sensitive than a standard chest X-ray in identifying a variety of abnormalities that a basic chest X-ray film may easily overlook.

Objective: This study aims to determine the incidence of pulmonary embolism and any other abnormalities noted on CTPA in patients who were suspected to have PE on clinical grounds and underwent CTPA.

Methodology: This is a retrospective investigation conducted from January 2020 to December 2022 at Dr. Ziauddin University Hospital in Karachi, Pakistan.

Results: This study involved 194 patients in total, of which 99 (51%) were men. CTPA confirmed PE in 38(19.6%) patients of those with clinical suspicion. Other CTPA findings included atelectasis 59(30.4%), pleural effusion 54(27.8%), pulmonary fibrosis 35(18%), lymphadenopathy 32(16.5%) and consolidation 61(31.4%). Granulomas were frequently discovered in people who were elderly.

Conclusion: CTPA is a very useful tool in identifying patients with PE and may also show findings other than PE which may explain the symptoms or establish other diagnosis. Also, certain incidental findings may necessitate further work up or investigation.

Keywords: CTPA; Pulmonary Embolism; Pleural Effusion; Lymphadenopathy; Consolidation

Introduction

Pulmonary embolism (PE) is a life-threatening condition characterized by the obstruction of pulmonary arteries by blood clots, typically originating from the deep veins of the legs. Timely and accurate diagnosis of PE is crucial for initiating appropriate treatment and preventing potentially fatal outcomes. Computed Tomographic Pulmonary Angiography (CTPA) has emerged as a valuable diagnostic tool in the evaluation of patients with suspected pulmonary embolism, offering high sensitivity and specificity in detecting vascular abnormalities within the pulmonary circulation.[1,2]

Pulmonary embolism represents a significant medical challenge due to its diverse clinical presentation and potential for rapid deterioration. Common symptoms such as dyspnea, chest pain, and hemoptysis are non-specific and can be attributed to various respiratory and cardiovascular conditions. Consequently, the accurate and prompt identification of PE remains a diagnostic challenge, necessitating advanced imaging techniques like CTPA for definitive evaluation.[3]

CTPA has gained prominence as a first-line imaging modality for suspected PE due to its non-invasive nature and ability to provide detailed anatomical information of the pulmonary vasculature. The technique involves acquiring cross-sectional images of the chest after the intravenous administration of contrast material, allowing for the visualization of pulmonary arteries and identification of thromboembolic obstructions. Compared to traditional imaging methods, such as ventilation-perfusion scanning or pulmonary angiography, CTPA offers superior spatial resolution and has become the preferred choice for diagnosing PE.[4]

Certain radiographic signs such as the Westermarck sign (dilation of pulmonary arteries and a sharp cutoff), atelectasis, minor pleural effusion, and a raised diaphragm may occasionally be present on a plain chest radiograph. In general, chest radiographs cannot be utilized to definitively confirm or rule out pulmonary embolism. With modern multi-detector CT scanners, pulmonary emboli diagnosis has been revolutionized. CTPA is a rapid and reliable imaging technique that can rule out pulmonary embolism in patients with suspicious symptoms. While requesting a CTPA, the radiation hazards, contrast-induced nephropathy and cost must always be considered. In addition to aiding in diagnosing pulmonary embolism, the CTPA may also aid in identifying other thoracic anomalies or diagnoses. These abnormalities may have clinical significance and explain the patient's symptoms, but they may also be incidental and irrelevant to the clinical scenario. Once detected, these anomalies or incidental discoveries may demand more study and treatment.

Numerous studies have demonstrated the high sensitivity and specificity of CTPA in detecting pulmonary embolism. The technique excels in identifying not only large central emboli but also smaller peripheral emboli, contributing to its overall diagnostic accuracy. The ability to visualize the entire pulmonary vasculature in a single imaging session has significantly enhanced the diagnostic yield of CTPA, making it an indispensable tool for clinicians in the evaluation of patients with suspected PE.[5,6]

While CTPA is a powerful diagnostic tool, it is essential to acknowledge its limitations and potential challenges. Radiation exposure, particularly in young individuals, remains a concern, and efforts are ongoing to optimize imaging protocols to minimize radiation dose without compromising diagnostic accuracy. Additionally, the presence of artifacts, patient contraindications to contrast material, and renal insufficiency are factors that may hinder the widespread use of CTPA in certain populations.

Objective

This study aims to determine the incidence of pulmonary embolism and any other abnormalities noted on CTPA in patients who were suspected to have PE on clinical grounds and underwent CTPA.

Methodology

This retrospective observational study spanned the period from January 2020 to December 2022, conducted at Dr Ziauddin University Hospital in Karachi, Pakistan.

Patients aged 15 and above who underwent computed tomography pulmonary angiography (CTPA) for suspected pulmonary embolism during the specified timeframe were included. Exclusion criteria comprised patients below 15 years old and those with incomplete medical records. Additionally, cases lacking chest X-rays before CTPA at the facility were excluded.

Data collection included information on patient demographics, admission details such as location and specialty, and reports from chest X-rays and CTPA scans. The study team meticulously documented cases with confirmed pulmonary embolism and any additional diagnostic or incidental findings.

To ensure accuracy, reports from chest X-rays and CTPA scans were cross-referenced with medical notes, electronic discharge summaries, and pathology results when applicable. This comprehensive approach aimed to enhance the reliability and completeness of the data.

The collected data were subjected to statistical analysis using IBM SPSS version 26. Descriptive statistics were employed to summarize patient demographics and clinical characteristics. For comparative analyses, a significance level of $p < 0.05$ was adopted.

Table 1. Demographic characteristics of patients

Comorbidities	n=number (Percentage)
Diabetes Mellitus	57 (29.4)
Hypertension (HTN)	74 (38.1)
Chronic Kidney Disease (CKD)	8 (4.1)
End Stage Renal Disease (ESRD)	4 (2.1)
Chronic Liver Disease (CLD)	3 (1.5)
Ischemic Heart Disease (IHD)	13 (6.7)
Interstitial Lung Disease (ILD)	3 (1.5)
Chronic Obstructive Pulmonary Bronchitis (COPD)	6 (3.1)
Malignancy	22 (11.3)
Hypercoagulable	2 (1.0)
Pregnancy	7 (3.6)

The study adhered to ethical guidelines, and patient confidentiality was strictly maintained. Approval from the institutional review board or ethics committee of Dr Ziauddin University Hospital was obtained prior to the commencement of data collection.

Results

A total of 194 patients were included in this study. Of them, 99 (51%) were male, and 95 (49%) were female Figure-01. 59 (34%) patients were under 45 years of age, 67 (40.7%) patients were between 45 and 65 years of age,

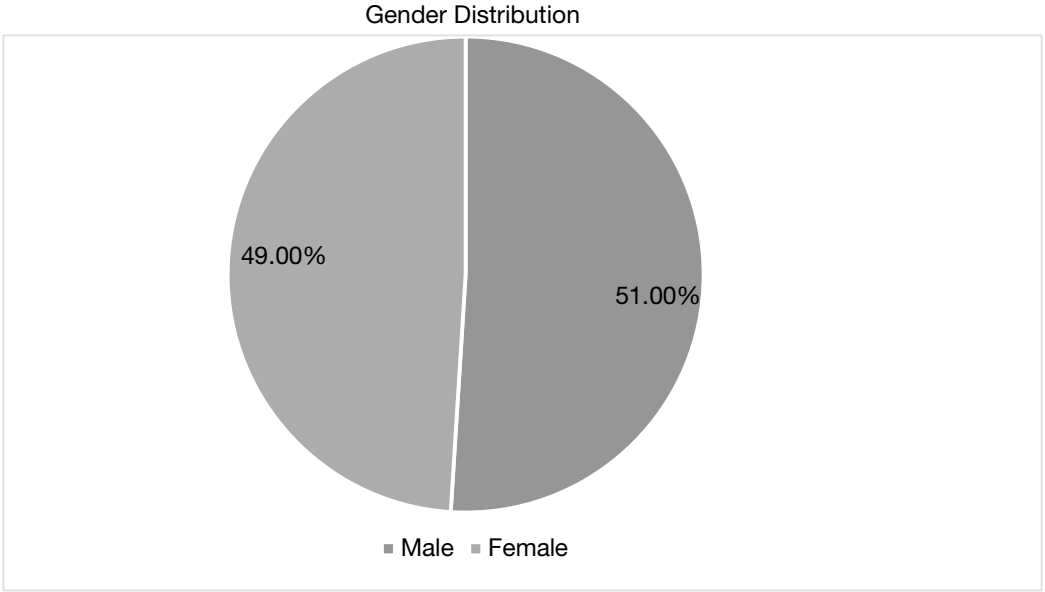

Figure 1. Gender distribution of study cases

Table 2. Frequency of PE according to comorbid illness

Comorbidities	PE n (percentage)	No PE n (percentage)	P-value
Diabetes Mellitus	10 (26.3)	47 (30.1)	.402
Hypertension (HTN)	16 (42.1)	58 (37.2)	.351
Chronic Kidney Disease (CKD)	0	8 (5.1)	.169
End Stage Renal Disease (ESRD)	0	4 (2.6)	.415
Chronic Liver Disease (CLD)	2 (5.3)	1 (0.6)	.099
Ischemic Heart Disease (IHD)	1 (2.6)	12 (7.7)	.235
Interstitial Lung Disease (ILD)	0	3 (1.9)	.518
Chronic Obstructive Pulmonary Bronchitis (COPD)	0	6 (3.8)	.265
Malignancy	6 (15.8)	16 (10.3)	.241
Hypercoagulable	1 (2.6)	1 (0.6)	.354
Pregnancy	1 (2.6)	6 (3.8)	.587

and 56 (28.9%) were above 66 years of age Figure-02.74 (38.1%) patients were Hypertensive, 57 (29.4%) patients were Diabetic, 22(11.3%) had underlying malignancy, 13 (6.7%) were known cases of Ischemic Heart Disease and 8(4.1%) had CKD Table-01. Besides, there was no significant statistical difference in the occurrence of PE in patients with different underlying comorbid conditions Table-02. Figure-03 describes the occurrence of PE according to admitting speciality. Pulmonary embolism was found in 38(19.6%) of patients. Besides, consolidation was the most common CTPA finding in 61(31.4%) patients. Other common findings included atelectasis

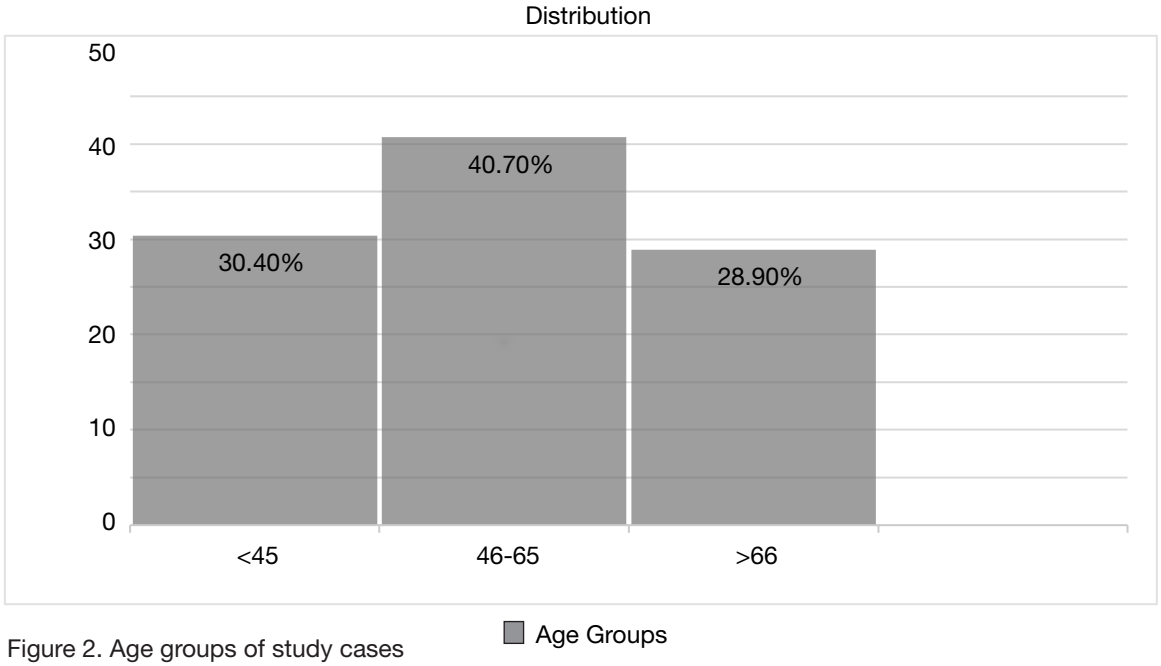

Figure 2. Age groups of study cases

Table 3. CTPA Findings among study cases

CTPA Findings	n=number (Percentage)
Pulmonary Embolism	38 (19.6)
Consolidation	61 (31.4)
Lymphadenopathy	32 (16.5)
Cavitation	7 (3.6)
Mass	7 (3.6)
Granulomas	20 (10.3)
Pleural Effusion	54 (27.8)
Pulmonary Edema	7 (3.6)
Pulmonary Fibrosis	35 (18.0)
Pneumothorax	2 (1.0)
Atelectasis	59 (30.4)
Emphysema	9 (4.6)
Normal CTPA	38 (19.6)

59(30.4%), pleural Effusion 54(27.8%), pulmonary fibrosis 35(18%) and lymphadenopathy 32(16.5%) Table-03. Furthermore, CTPA was reported normal in 38 (19.6%). 11(18.6%) patients with Pulmonary Embolism were 16-45 years of age, 15(19%) were 46-65 years of age, and 12(21.4%) were greater than 65 years of age Table-04. Normal CTPA was reported commonly in younger age groups. Granulomas were found commonly in patients greater than 66 years of age, with a p-value of 0.030. Pulmonary Edema was found commonly in the younger age group. Pulmonary Fibrosis was common in elderly 66yrs or older with a p-value of 0.015. There was no other significant statistical difference in CTPA findings among the different age groups.

Discussion

Pulmonary embolism (PE) is the blockage of a pulmonary artery due to the movement of a substance through the bloodstream. As a result, blood flow is reduced, which could result in low blood oxygen levels and potential organ damage. Multiple clots or a big PE can be extremely dangerous and even fatal. Effective classification of patients with suspected PE is thus necessary. When diagnosing PE, diagnostic computed tomography pulmonary angiography (CTPA) is the go-to procedure. Recent years have seen significant advancements in the radiologic assessment of pulmonary embolism.[7,8] When a pulmonary embolism is suspected in a patient and CTPA is contraindicated, ventilation-perfusion scanning may be considered.[3] Although ventilation-perfusion scans with normal and high-probability findings have a significant predictive value, multiple investigations conducted at prestigious academic institutions have revealed that most of these scans lack diagnostic value.[9,10] Although historically considered the gold standard for pulmonary embolism diagnosis with sensitivity and specificity surpassing 95%, invasive pulmonary angiography is hardly performed, especially in community centres.[11] A significant change in the imaging strategy for patients with suspected pulmonary embolism resulted from the invention of helical CT technology, which offered a noninvasive method of examining the pulmonary vasculature. Early research suggests that the sensitivity and specificity of CT pulmonary angiography are comparable to those of ventilation-perfusion scanning and pulmonary angiography, with values approaching 100% for proximal clots and variable reported numbers (60-94%) in the distal vasculature.[12]

Our study population included 51% of male patients and

Table 4. CTPA findings according to age groups

CTPA Findings	Age Group – Number (Percentage)			P-value (≤45/46-65/≥66)
	≤45	46-65	≥66	
Pulmonary Embolism	11 (18.6)	15 (19.0)	12 (21.4)	.497/.507/.410
Consolidation	17 (28.8)	25 (31.6)	19 (33.9)	.365/.541/.377
Lymphadenopathy	8 (13.6)	15 (19.0)	9 (16.1)	.307/.280/.553
Cavitation	0 (0.0)	5 (6.3)	2 (3.6)	.075/.099/.674
Mass	3 (5.1)	1 (1.3)	3 (5.4)	.361/.145/.326
Granulomas	4 (6.8)	6 (7.6)	10 (17.9)	.211/.216/.030
Pleural Effusion	14 (23.7)	22 (27.8)	18 (32.1)	.254/.562/.248
Pulmonary Edema	5 (8.5)	0 (0.0)	2 (3.6)	.028/.024/.674
Pulmonary Fibrosis	4 (6.8)	15 (19.0)	16 (28.6)	.004/.460/.015
Pneumothorax	1 (1.7)	0 (0.0)	1 (1.8)	.517/.350/.495
Atelectasis	18 (30.5)	23 (29.1)	18 (32.1)	.556/.435/.432
Emphysema	1 (1.7)	3 (3.8)	5 (8.9)	.182/.463/.081
Normal CTPA	17 (38)	13 (34.2)	8 (21.1)	.028/.235/.162

49% of female patients in contrast to study,[13] where 36% of the population was male in another study,[14] where the male population was 43.9%. The mean age of the studied population was 55.12, which is consistent with the findings of other studies.[13,14] Compared to our research, J. Van et al. reported COPD, heart failure, and malignancy were the most familiar comorbid conditions.[15] Of 194 patients, Pulmonary Embolism was found to be positive in 38 (19.6%) compared to a study where Pulmonary Embolism was detected in 37.8% of cases.[14] In another study conducted by Alshumrani et al. during 2012-2018 on 534 patients where 24.9% of patients were reported to be positive for Pulmonary Embolism. Similarly, in a more recent prospective trial that included 1814 patients from 12 hospitals, the diagnostic yield of CTPA for PE was shown to be 25%.[16] In another retrospective study done in a Canadian academic tertiary care centre, a 15.9% positive rate for PE detection via CTPA was reported.[17] In a meta-analysis of 23 investigations, Moore et al. discovered that CTPA-positive rates varied from 13% to 42%, with an average PE prevalence of 27%.[18] Following that, multiple international assessments noted reduced CTPA study diagnostic yield rates. Positive CTPA test results have typically varied between 8% and 10% over the past ten years in the US,[19-21] but these percentages are significantly higher (14–16%) in studies conducted outside of the country.[22,23] The causes of CTPA's poor diagnostic yield are unclear. Noncompliance with guidelines and legally protected practises chosen by some physicians, on the other hand, are likely to be the culprits.

Besides PE, CTPA reported several other findings supporting alternative diagnoses in this study. Previous research looked into the possibility of alternative diagnosis in patients with CT scans for suspected PE. The percentage of discovered alternate diagnoses ranged from 25% to 52%, consistent with current findings.[24,25] Hall and colleagues found an alternate diagnosis in 33% of 589 patients and an incidental discovery requiring follow-up in 24%, significantly outnumbering the 9% occurrence of PE in their investigation.[24] A retrospective examination of 512 consecutive patients from a major multicenter clinical management trial on PE looked at the incidence of alternate diagnoses

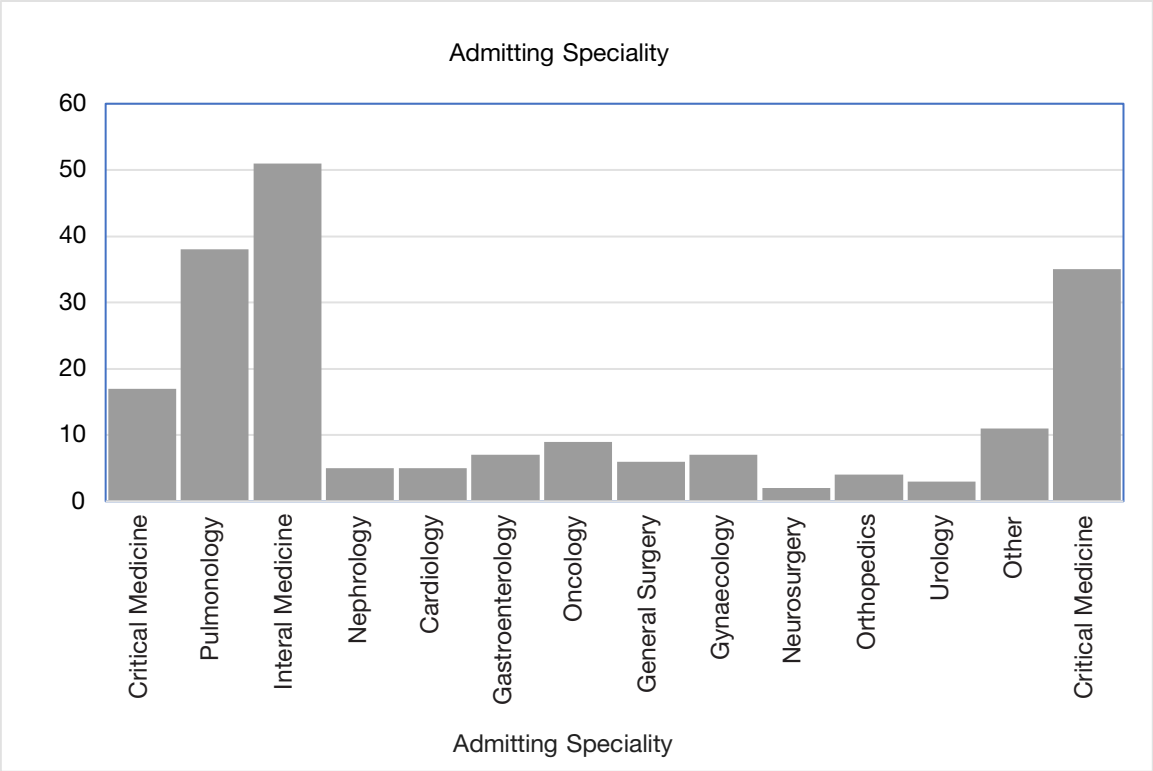

Figure 3. PE according to admitting specialty

on CTPA.[28] An alternate diagnosis was considered likely in 130 of 512 patients without PE (25%, 95% CI, 9.5%-18%). However, it was not determined whether these alternative diagnoses revealed on CTPA were already identified before CT scanning or whether these findings were clinically significant regarding therapeutic implications.

Some limitations of the current investigation should be considered. First, the study was limited to a single tertiary-care referral centre. Therefore, the findings may not be applicable in other situations. Second, there could be significant variation in radiologists' reporting. An independent radiologist did not confirm the diagnosis of CTPA in most patients in the current investigation. Although all CTPA scans were evaluated per a predefined methodology, some patients may have been misclassified as having PE, an alternate finding, or an incidental discovery. Third, the reduced sample size may have resulted in relatively slight differences in data supporting an alternate diagnosis. Fourth, we did not investigate the effect of CTPA on clinicians' trust in the findings supporting an alternative diagnosis and the resulting patient demands. Finally, obtaining a standard reference test for each recommended finding supporting an alternate diagnosis was not attainable.

Conclusion

In conclusion, while CTPA proves to be a valuable diagnostic tool for identifying pulmonary embolism, its capacity to unveil non-PE findings introduces a layer of complexity. The discovery of incidental findings may necessitate additional investigations, potentially leading to invasive procedures with associated costs and risks to the patient. Careful consideration and a balanced approach are crucial in managing incidental findings on CTPA to ensure optimal patient outcomes while minimizing unnecessary interventions.

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