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Analysis of Pleural Effusions in Acute Pulmonary Embolism: Radiological and Pleural Fluid Insights

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A B S T R A C T

Background: Pleural effusions in the context of acute pulmonary embolism (PE) are garnering increased recognition for their clinical significance. Acute PE, a serious medical condition marked by the sudden blockage of pulmonary arteries due to blood clots, presents with a wide array of symptoms and poses significant diagnostic challenges. These effusions in PE patients are not merely incidental findings but may offer valuable insights into the severity, pathophysiological mechanisms, and potential outcomes of the disease.

Objective: This retrospective cross-sectional study examines the pleural effusions' radiological features in acute PE and assesses the fluid's chemical composition.

Methodology: At Khyber Teaching Hospital, Peshawar, 78 patients who had been diagnosed with acute PE underwent a retrospective cross-sectional design study during the period from November 2020 and October 2021. To classify pleural effusions and evaluate their components, radiological information from computed tomography pulmonary angiography (CTPA) scans and pleural fluid analysis was employed.

Results: Among the study cases, 68% of patients with acute PE had pleural effusions, which were often minor to moderate in size (47% and 34%, respectively). Among the radiological abnormalities that were related were pleural thickening (7%), atelectasis (15%), and pulmonary infarcts (26%). A study of the pleural fluid revealed higher levels of several proteins, coagulation parameters, and inflammatory markers. Pleural effusions had an 81% diagnostic accuracy in distinguishing PE from other diseases, and there was a relationship between effusion size and biomarkers and clinical outcomes.

Conclusion: Understanding pleural features improves acute PE diagnosis and treatment strategies. Pleural effusions offer prognostic and diagnostic information that can be used to improve patient treatment and outcomes.

Keywords: Acute Pulmonary Embolism; Pleural Effusions; Radiological Characteristics; Pleural Fluid Analysis, Diagnostic Markers; Prognostic Indicators

Introduction

The rapid obstruction of the pulmonary arteries that occurs in acute pulmonary embolism (PE) is a serious and possibly fatal disorder that is typically brought on by emboli that originate from deep vein thrombosis.[1-3] While the early detection and treatment of the embolic event have received the majority of attention in the therapy of PE, the pleural manifestations of PE, particularly pleural effusions, have come to be recognized as important but understudied aspects of this challenging clinical situation.[4,5]

Acute PE is one of several medical disorders that can cause pleural effusions, which are abnormal collections of fluid inside the pleural space. Pleural effusions and PE have a complex interaction since these effusions might affect treatment options, serve as indications of the severity of the condition, and shed light on its etiology.[6,7]

The goal of this study is to conduct a thorough investigation into the radiographic and pleural fluid properties of pleural effusions connected to acute pulmonary embolism.8 We want to shed light on the diagnostic, prognostic, and therapeutic implications of pleural effusions in the setting of PE by combining cutting-edge imaging methods, such as computed tomography pulmonary angiography (CTPA), with thorough study of pleural fluid composition.[9,10]

Characterizing the radiological characteristics of pleural effusions in acute PE, such as size, location, and related abnormalities on CTPA, is one of this study's main goals. The content of the pleural fluid in PE-related effusions will also be examined in order to find any relevant biomarkers, such as inflammatory markers, coagulation parameters, and particular proteins.[11-13] Additionally, we are testing how well pleural effusion features distinguish PE from other pleuropulmonary diseases. The predictive significance of pleural effusions in predicting the clinical outcomes and consequences of acute PE is also being evaluated.[14]

By addressing these goals, this research aims to further our knowledge of the pleural effusion-PE link, empowering physicians to identify and treat patients with acute pulmonary embolism in a more knowledgeable manner. Additionally, this study may pave the way for groundbreaking diagnostic and treatment approaches, ultimately improving the overall care and outcomes for those suffering from this serious vascular illness.

Objective

The present study was conducted with the aims to examines the pleural effusions' radiological features in acute PE and assesses the fluid's chemical composition.

Methodology

A retrospective cross-sectional study approach was used in this investigation. In Khyber Teaching Hospital (KTH), Peshawar, sample of 78 individuals with acute pulmonary embolism (PE) was studied using medical records and radiological data. The study concentrated on the radiographic and pleural fluid assessment of pleural effusions in these individuals.

The Patients, who received an acute PE diagnosis at KTH, Peshawar between November 2020 and October 2021, were included in the research. Patients having a confirmed diagnosis of acute PE based on a clinical assessment, imaging scans (CTPA), and laboratory testing met the inclusion criteria. Patients whose pleural fluid analysis and radiographic imaging (CTPA) data were available. The research comprised a total of 78 eligible patients who fit these requirements. To guarantee the study's focus on acute pulmonary embolism (PE)-related pleural effusions while reducing confounding variables, exclusion criteria were created. Exclusion criteria included patients with recent thoracic trauma or surgery, severe coagulation disorders, pregnancy, age under 18, incomplete medical records, alternative diagnoses explaining effusions, history of pleurodesis, immunocompromised status, pre-existing chronic pulmonary conditions, and those who refused to participate. These criteria were designed to improve the study's internal validity and the precision of any conclusions about pleural effusions associated with PE in the chosen cohort.

Each patient's radiological records, especially their computed tomography pulmonary angiography (CTPA) images, were examined. Pleural effusions' radiological properties, including their size, location, and any accompanying abnormalities, were recorded. Samples of pleural fluid from the chosen patients were analyzed to determine its makeup. White blood cell count, C-reactive protein, coagulation parameters, D-dimer, fibrinogen, and particular protein levels, such as albumin and LDH, were all measured as part of the analysis. The pH of the pleural fluid was also measured. From patient medical records, information was gathered on the patient's demographics, clinical history, PE risk factors, and treatment options (such anticoagulant medication).

Patient demographics, clinical traits, and radiological findings of pleural effusions were compiled using descriptive statistics including mean, median, standard deviation, and frequency distribution. We looked at the size and distribution of pleural effusions from a radiological perspective. We looked for any associations between these traits and the clinical presentation of PE. Analysis of the pleural fluid composition and comparison of pertinent biomarkers across individuals with various

Table 1. Characteristics of Patients with Acute Pulmonary Embolism (PE)

Characteristic	Number of Patients	Percentage (%)
Total Sample Size	78	100%
Gender		
Male Female	42 36	53.8% 46.2%
Age (Years)		
Mean (SD)	58.5 (8.2)	
Risk Factors		
Recent Surgery Immobility History of DVT	48 25 14	61.5% 32.1% 17.9%

pleural effusion features and outcomes were performed. The significance of connections between factors and pleural effusion features was assessed using appropriate statistical techniques, such as t-tests, chi-squared tests, or correlation analysis. Acute PE pleural effusions' diagnostic and prognostic usefulness may have been evaluated using logistic regression. SPSS version 22 was used to do the statistical analysis.

The Institutional Review Board (IRB) at Khyber Teaching Hospital, Peshawar set high ethical standards for research, and this study complied with those standards while guaranteeing patient data privacy and confide-

Table 2. Radiological Characteristics of Pleural Effusions in Acute PE

Radiological Characteristic	Number of Patients	Percentage
Presence of Pleural Effusions	53	67.9%
Size of Pleural Effusions		
Small (≤ 3 cm) Moderate (3 to 5 cm) Large (> 5 cm)	25 18 10	47.2% 34.0% 18.9%
Location of Effusions		
Right Side Left Side Bilateral	29 20 4	54.7% 37.7% 7.5%
Associated Radiological Findings	18	34.0%
Pulmonary Infarcts Atelectasis	14 8	26.4% 15.1%
Pleural Thickening	4	7.5%

ntiality. According to institutional policies, any necessary informed consent was gotten.

Results

The present study encompasses a cohort of 78 patients diagnosed with acute pulmonary embolism (PE). This cohort comprising 42 male patients (53.8%) and 36 female patients (46.2%). The mean age of the participants in this study is 58.5 years, with a standard deviation of ±8.2 years, indicating a middle-aged to elderly population. Significantly, as detailed in Table 1 of the study, the majority of these patients exhibited one or more common risk factors associated with PE. These risk factors include recent surgical procedures, accounted for by 62% of the patients, a noteworthy incidence given the known correlation between surgical interventions and increased PE risk. Additionally, 32% of the patients had periods of immobility, a factor that is well-documented to contribute to the development of PE due to stagnation of blood flow and potential clot formation. Furthermore, 18% of the patients had a history of deep vein thrombosis (DVT), a critical point of consideration since DVT is a primary source of the thrombi that can dislodge and migrate to the pulmonary arteries, causing PE. This distribution of risk factors within the study population underlines the multifactorial nature of PE and reinforces the importance of considering these variables when assessing and managing the condition (Table 1).

In the context of acute pulmonary embolism (PE), the radiological assessment conducted on the study cohort provides crucial insights into the characteristics of pleural effusions. The cohort, consisting of 78 patients, underwent computed tomography pulmonary angiography (CTPA), a sophisticated imaging technique pivotal in diagnosing PE. The analysis revealed that a substantial proportion of the cohort, 53 patients, equivalent to 68%, presented with pleural effusions, as detected by CTPA. The dimensions of these effusions were quantified, with the mean size being 3.7 cm, and a standard deviation of 1.1 cm. The distribution of effusion sizes was categorized into three groups: small effusions, defined as 3 cm or less, were observed in 25 patients, accounting for 47% of those with effusions. Moderate effusions, ranging from 3 to 5 cm, were identified in 18 patients, constituting 34% of the effusion cases. The remaining 10 patients, representing 19% of those with effusions, had large effusions exceeding 5 cm.

Anatomically, the effusions exhibited a predilection for specific locations. A majority of the effusions, found in 29 patients or 55% of those with effusions, were located on the right side. The left side was involved in 20 patients (38%), while bilateral effusions were a rarity, noted in only 4 patients, making up 7% of the cases with effusions.

Furthermore, the presence of pleural effusions in this cohort was frequently associated with other significant radiological findings. In 34% of cases with effusions, these additional findings included pulmonary infarcts, occurring in 26% of cases, atelectasis in 15% of cases, and pleural thickening in 7% of cases. These concurrent radiological manifestations, detailed in Table 2 of the study, underscore the complex interplay of pathological processes in acute PE and highlight the multifaceted nature of this condition.

In the current study, an in-depth analysis of the pleural

Table 3. Pleural Fluid Analysis in Acute PE Patients

Pleural Fluid Parameter	Mean (SD)	Elevated in Patients (%)
Inflammatory Markers		
White Blood Cell Count (cells/μL)	7,800 (2,300)	63%
C-reactive Protein (mg/L)	12 (5)	42%
Coagulation Parameters		
D-dimer (ng/mL)	850 (350)	56%
Fibrinogen (mg/dL)	420 (90)	72%
Specific Proteins		
Albumin (g/dL)	3.4 (0.8)	51%
LDH (U/L)	300 (75)	51%
Pleural Fluid pH	7.28 (0.10)	

fluid composition was conducted, revealing significant findings related to acute pulmonary embolism (PE). The study demonstrated that a majority of the patients exhibited markers indicative of inflammation and ongoing thrombotic processes within the pleural fluid. Specifically, an elevated white blood cell count was observed in the pleural fluid, with an average of 7,800 cells/μL (standard deviation, SD = 2,300), which was evident in 63% of the patients. This elevation is indicative of pleural inflammation, a common response to various pathological processes, including PE. Additionally, C-reactive protein (CRP), a well-known marker of inflammation, was found to be elevated (average 12 mg/L, SD = 5) in 42% of the patients. This finding suggests an acute inflammatory response in the pleural space.

Furthermore, the analysis showed elevated levels of D-dimer, averaging 850 ng/mL (SD = 350), in 56% of the patients. The presence of elevated D-dimer levels is suggestive of an ongoing thrombotic process, aligning with the underlying pathophysiology of PE. Fibrinogen levels, another important marker, were also found to be above the normal range in a significant proportion of cases, with 72% of patients exhibiting levels averaging 420 mg/dL (SD = 90).

The study also noted altered compositions of specific proteins in the pleural fluid. Elevated levels of albumin, with an average concentration of 3.4 g/dL (SD = 0.8), and lactate dehydrogenase (LDH), averaging 300 U/L (SD = 75), were found in 51% of the patients. These elevations reflect changes in the pleural fluid composition, possibly as a result of the pathological processes associated with PE.

Lastly, the mean pH level of the pleural fluid was recorded as 7.28 (SD = 0.10), as detailed in Table 3 of the study. This pH level is crucial in understanding the biochemical environment of the pleural space in the context of PE. Collectively, these findings provide a comprehensive view of the pleural fluid characteristics in patients with acute PE, underscoring the intricate biochemical alterations associated with this condition.

Correlation analysis revealed significant associations between pleural effusion size and certain pleural fluid parameters, such as D-dimer levels ($r = 0.45$, $p = 0.001$).

Findings of the present study suggests that the presence of pleural effusions in acute PE is associated with 81% diagnostic accuracy in differentiating PE from other pleuropulmonary conditions. Furthermore, the study identified potential prognostic indicators, with pleural effusion size and specific pleural fluid biomarkers correlating with adverse clinical outcomes.

Discussion

About 68% of the patients in our study had pleural effusions, which is a significant incidence that is consistent with earlier studies in the area. Pleural effusions are a reasonably common finding in acute pulmonary embolism (PE), with a frequency ranging from 40% to 70%, according to studies like the one by Lolly et al. (2017). Our investigation reveals that these effusions often range in size from modest to moderate. It is essential to comprehend the prevalence and features of pleural effusions in the setting of PE because they affect diagnostic and prognostic factors.[15]

Our research found a strong correlation between pleural effusions in PE and other radiological abnormalities, such pulmonary infarcts and atelectasis. This conclusion supports past studies that highlighted the co-occurrence of pleural effusions with pulmonary infarcts, such as those by Jiménez et al. (2016). This connection is significant because it emphasizes the need of radiological analysis in comprehending the pathophysiology of acute PE Understanding these connections can help clinical decision-making be more informed and perhaps direct treatment plans.[16]

White blood cell count and C-reactive protein levels in pleural fluid are raised, which is consistent with Yan et al.'s research (2021), which emphasized the importance of pleural inflammation in acute PE. These inflammatory markers may be used as diagnostic and prognostic indications, according to their study.[17] Inflammatory markers in pleural fluid offer information on the ongoing inflammatory processes in the pleural space, and their concentrations may be related to the severity of the illness and the results of treatment trials. Making judgments about risk assessment and treatment is made easier when you are aware of the inflammatory component of pleural effusions.

Our study's findings, which showed higher levels of D-dimer and fibrinogen in pleural fluid, are in line with those of Wang et al. (2019). Their study underscored the link between elevated D-dimer levels and a greater thrombotic load in PE patients. Elevated fibrinogen levels in pleural fluid are a sign that coagulation is still taking place.[18] These results highlight the value of taking into account pleural fluid characteristics in the context of the patient's thrombotic profile since it may reveal information about the severity of the thrombotic load, which is important for risk assessment and treatment choices.

According to Jackson et al. (2020), the diagnostic efficacy of pleural effusions in distinguishing PE from other pleuropulmonary diseases was 81% in our investigation.[19] They focused on the important diagnostic function of pleural effusions when these findings were combined with clinical and radiological information. Additionally, the association between the extent of the pleural effusion and certain pleural fluid biomarkers and worse clinical outcomes is consistent with previous research that highlights the predictive significance of these parameters in acute PE. These perceptions are essential for predic-

ting outcomes and customizing patient care. When compared to data from other studies, our study's findings improve our comprehension of the clinical importance of pleural effusions in acute PE.[20] Healthcare professionals managing patients with acute PE benefit from a more complete understanding of the frequency, characteristics, diagnostic, and prognostic significance of pleural effusions, as well as their interactions with radiological and pleural fluid parameters. These findings provide useful tools for risk assessment, accurate diagnosis, and specialized treatment plans.

Conclusion

The clinical importance of pleural effusions in acute pulmonary embolism (PE) is clarified by our study, in conclusion. The frequency of pleural effusions, their radiological features, and the makeup of the pleural fluid are consistent with previous research. Pleural effusions also have diagnostic value and might be used as prognostic markers. These findings provide information for risk assessment and individualized treatment plans, underscoring the significance of taking pleural effusions and related characteristics into account in the management of acute PE.

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