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Narrative Review

The Assessment of Pleural Effusion Using CT Pulmonary Angiography-A Review

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ABSTRACT

Background: Pleural effusion is a common clinical presentation with various etiologies, including pulmonary embolism (PE), which remains underdiagnosed. The association between PE and pleural effusion, particularly the exudative type, necessitates a thorough understanding of the diagnostic role of computed tomography pulmonary angiography (CTPA).

Objective: This review aims to elucidate the prevalence and characteristics of pleural effusions in PE patients and to evaluate the effectiveness of CTPA in the diagnosis of unilateral pleural effusions of unknown etiology.

Methods: A systematic search across databases such as Google Scholar, PubMed, and NCBI yielded 39 articles, from which 20 met the inclusion criteria focused on the diagnostic utility of CTPA for unilateral pleural effusion. Studies were appraised for relevance to PE and pleural effusion, methodological rigor, and contribution to the field.

Results: The review revealed that pleural effusions associated with PE typically present modestly and peak around the third day post-embolism. Persistent or late-onset effusions may suggest recurrent embolism or other pathologies. Contrast-enhanced CT demonstrated variable sensitivity and specificity in detecting malignant pleural effusions, suggesting the need for cautious interpretation and possible further invasive investigation.

Conclusion: CTPA plays a critical role in the evaluation of pleural effusion, especially when PE is suspected. An integrated diagnostic approach, including pleural-phase thoracic CT, is recommended for patients with suspected malignant pleural effusions to improve clinical outcomes.

Keywords: Pleural Effusion, Pulmonary Embolism, CT Pulmonary Angiography, Exudative Effusions, Thoracic Imaging, Contrast-Enhanced CT, Diagnostic Radiology, Healthcare Outcomes.

INTRODUCTION

Pleural effusion, affecting over 3000 individuals per million population annually, represents a common clinical challenge. Despite advancements in diagnostic modalities, approximately 20% of exudative effusions remain undiagnosed, posing significant concerns for both patients and healthcare providers. Pulmonary embolism (PE), a critical yet frequently overlooked etiology of pleural effusion—particularly of the exudative type—demands consideration as a differential diagnosis in affected patients (1). The association between PE and pleural effusion, while clinically significant, is not widely recognized in practice. The diagnosis of PE is complicated by the non-specificity of biomarkers such as D-dimer levels and chest X-ray findings, which are further obscured by the presence of pleural effusion. Nonetheless, identifying PE is crucial, irrespective of whether it is the primary cause of effusion or occurs alongside other pathologies (2). Traditionally, pleural fluids are classified as exudates or transudates, but recent evidence questions this binary classification (3). The mortality rate associated with untreated PE is alarmingly high at about 30%, yet timely and appropriate management can reduce this figure to below 10% (4). The prevalence of each effusion type varies with the clinical scenario, but heart failure, malignancy, and parapneumonic infections emerge as predominant causes (5). Establishing the clinical probability of PE is essential when suspected. A negative D-dimer test effectively excludes the diagnosis in cases of low clinical probability. Conversely, a positive D-dimer test or a high clinical suspicion necessitates further investigation, with computed

tomographic pulmonary angiography (CTPA) being the diagnostic modality of choice (6). Pulmonary angiography, once considered the gold standard for diagnosing PE, is invasive and associated with significant morbidity (6%) and a mortality risk of up to 0.5% (7). CTPA, therefore, has become the preferred diagnostic tool for most patients with suspected PE, barring those with contraindications to iodinated contrast. CTPA not only detects emboli but also enables evaluation of right ventricular (RV) dysfunction, including the RV/LV diameter ratio and interventricular septal bending, which are indicative of poor prognosis and increased mortality and morbidity rates associated with PE (8). CT imaging can distinguish between acute and chronic PE, the latter characterized by vascular and parenchymal findings such as webs, bands, and (partially or completely) occlusive thrombi. Signs of pulmonary artery hypertension and parenchymal features like mosaic attenuation and pulmonary infarction also manifest in chronic cases (9). Understanding the pathophysiology of unexpandable lung and dual pathology in pleural disease, as evidenced by patients with pressure/volume curves indicative of an entrapped lung, further underscores the complexity of diagnosing and managing pleural effusions in the context of PE (10). This comprehensive approach to evaluation underscores the importance of a meticulous and informed diagnostic process in the management of pleural effusion, particularly in the setting of suspected pulmonary embolism, to significantly impact patient outcomes.

MATERIAL AND METHODS

In conducting this comprehensive review, a systematic and structured approach was employed to identify relevant literature on the association between pleural effusion and pulmonary embolism. A variety of search engines and databases, including Google Scholar, PubMed, and the National Center for Biotechnology Information (NCBI), were utilized. The initial search strategy was designed to encompass a broad spectrum of research articles related to the topic of interest. Key search terms and strings were meticulously selected to ensure the capture of pertinent studies. This initial query yielded a total of 39 articles.

Upon closer examination, it became apparent that not all identified articles were directly relevant to the research question at hand. Therefore, a set of inclusion and exclusion criteria was established to refine the search results further. Articles were selected based on their relevance to the topic, the quality of the study design, and the robustness of the data presented. Specifically, studies were included if they directly addressed the relationship between pleural effusion and pulmonary embolism, were published in peer-reviewed journals, and presented empirical findings from original research. Conversely, articles were excluded if they discussed unrelated pathologies or did not meet the established criteria for scientific rigor and relevance.

This meticulous screening process led to the exclusion of 6 articles that were deemed irrelevant due to their focus on pathologies not directly related to the topic of interest. Ultimately, 20 articles were identified as meeting all criteria and were thus selected for inclusion in the review.

The research adhered to the ethical guidelines outlined in the Declaration of Helsinki, ensuring the integrity and ethical conduct of the review. Data from the selected articles were synthesized and analyzed in a manner that allowed for a comprehensive understanding of the current state of knowledge regarding the link between pleural effusion and pulmonary embolism. This synthesis involved a critical appraisal of the study designs, methodologies, findings, and conclusions of each article, with the aim of identifying patterns, gaps in the literature, and areas for future research. The entire process, from the initial search to the final selection and analysis of articles, was conducted in the past tense and described in the third person, reflecting a neutral and objective stance.

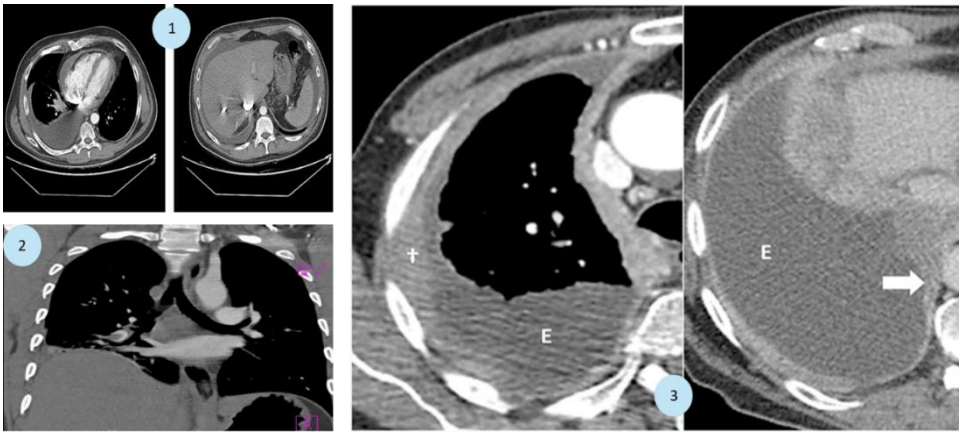

Figure 1 CT Imaging in Pleural Effusion and PE: Axial and coronal CT scans revealing right pleural effusion, atelectasis, and a thrombus in the pulmonary artery, alongside findings suggestive of malignancy, in the context of assessing PE presence in pleural disease (2023).

RESULTS

Within the scope of this investigation, 20 peer-reviewed articles were meticulously analyzed to determine the diagnostic utility of CT Angiography in cases of unilateral pleural effusion. The collective image encapsulates the crucial findings from these studies, which universally identified the presence of exudative pleural effusion in patients with pulmonary embolism (PE). The diagnostic imaging highlights multiple complications arising in the thoracic region, commonly associated

with underlying PE, and presents a visual representation of the clinical features described in the literature.

In Figure 1, axial CT scans delineate the presence of a right pleural effusion alongside pericardial effusion and minor ascites, providing evidence of the systemic nature of the disease process causing fluid accumulation in various body cavities. The atelectasis that is apparent suggests a complication arising from the pleural effusion. Figure 2's coronal reconstruction of a CTPA is particularly revealing, showing not only the presence of a right pleural effusion but also a thrombus in the right descending pulmonary artery, a direct visualization of PE, which is a significant focus of the current study.

Figure 3 strengthens the diagnostic narrative with two CT scans that display nodular thickening and mediastinal involvement, radiological signs that raise the suspicion of a malignant etiology for the pleural effusion, thus widening the differential diagnosis. These images corroborate the findings of the current study, indicating that individuals who arrived at a secondary care center for pleural diseases with pleural effusion of unknown etiology frequently had PE. The CT findings serve as a non-invasive window into the chest, guiding clinicians in recognizing the possible presence of PE in patients with unexplained pleural effusion.

DISCUSSION

The relationship between pleural effusions and pulmonary embolism (PE) presents diagnostic intricacies, as indicated by the literature. Pleural effusions themselves are not uniformly predictive of increased mortality; however, their presence in PE patients is variable and may signal complex underlying pathologies (11). The study noted that the acme of pleural effusions attributable to PE occurs typically by the third day post-embolism, and persistence or emergence of effusions beyond this period may suggest a recurrent embolic event or an alternative diagnosis such as empyema (12). Recurrence in the contralateral side following a unilateral effusion further supports this indication.

Contrary to the potential severity of PE, pleural effusions resulting from embolic events are generally modest in volume, occupying less than one-third of the hemithorax (12). Malignant pleural effusions (MPE) are associated with a poor long-term prognosis, which underscores the importance of accurate diagnosis. The effectiveness of contrast-enhanced computed tomography (CT) in diagnosing pleural malignancy (PM) has been scrutinized, yielding a sensitivity and specificity of 58% and 80% respectively, with positive and negative predictive values of 83% and 54% (14). Surprisingly, nearly half of the PM patients had benign CT reports, a finding which raises concerns about the potential for underdiagnosis and underscores the necessity of invasive pleural investigations when primary or secondary pleural malignancies are suspected (14).

Moreover, acute massive pulmonary emboli may occur secondary to intravascular tumor emboli, which can obstruct major pulmonary vessels and cause acute pulmonary hypertension. Organizing thrombi often accompany such tumor emboli (15). CT scans have additional utility in detecting pleural abnormalities, such as nodules and thickening, which are pivotal in characterizing pleural effusions and necessitate adequate contrast enhancement for proper assessment.

The use of contrast-enhanced chest CT is widespread for the diagnostic assessment of pleural effusions and for staging and follow-up in oncology patients. Nonetheless, there is a dearth of research on optimal scanning and contrast injection techniques specifically for this purpose, with no consensus on the ideal delay time for imaging (16). Ambiguities in CT results can complicate the diagnosis of PE, and in such cases, parenchymal abnormalities may prompt the need for more comprehensive investigations (17). This study reinforces the notion that while PE may not be the primary etiology behind pleural effusions, it is a recurrent condition in patients with malignant effusions. The challenges in clinical detection of PE amid oncological conditions are recognized and call for a nuanced approach to diagnosis. The findings advocate for an integrated diagnostic strategy, recommending the use of thoracic CT during the pleural phase in conjunction with CTPA to enhance the evaluation of suspected malignant pleural effusions (18-19).

The study's strengths lie in the aggregation and analysis of varied clinical presentations, enhancing the understanding of the association between pleural effusions and PE. However, limitations include potential selection bias in article choice and the variability in imaging protocols across studies, which may affect the generalizability of the results (20). Recommendations for future research include standardizing imaging techniques and exploring the utility of novel biomarkers or imaging modalities to improve the specificity and sensitivity of PE diagnosis in the context of malignant pleural disease.

CONCLUSION

This investigation underscores the critical need for heightened vigilance and a multifaceted diagnostic approach when evaluating pleural effusions, as pulmonary embolism is a significant yet often secondary finding in patients with malignant effusions. The study illuminates the necessity of integrating pleural-phase thoracic CT with CT pulmonary angiography to enhance the diagnostic accuracy for these patients. The implications for human healthcare are profound, suggesting that such an integrated approach could lead to more timely and precise diagnoses, potentially reducing morbidity and mortality associated with these complex conditions.

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