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Role Of Ultrasonography And Computed Tomography In Differentiating Transudative From Exudative Pleural Effusion

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Abstract:
Background*- Pleural effusion, mostly caused by volume overload, congestive heart failure, and pleuropulmonary infection, is a common condition in hospitalized patients. Thoracic ultrasound (TUS) helps clinicians not only to visualize pleural effusion but also to distinguish between the different types. This study aims to assess the effectiveness of USG and CT imaging findings in conjunction with diagnostic thoracocentesis to distinguish between transudative and exudative pleural effusions. As there is paucity of literature regarding the use of USG, CT attenuations values and associated findings as an aid in characterizing pleural effusion in Indian subcontinent, evaluating such a non-invasive tool would be beneficial for patients with pleural effusion and helps in further management. We evaluated the role of ultrasound and CT scan in differentiating transudative and exudative pleural effusion.*
Materials and Methods*: A prospective cross-sectional study was conducted at Department of Radiodiagnosis, AGMC & GBP Hospital, Agartala for a period of one year from August 2022 to July 2023. The study included sixty patients with pleural effusion who underwent evaluations through both USG and CT imaging, alongside diagnostic thoracocentesis. The assessments encompassed USG characteristics, CT attenuation values, and additional indicators like pleural thickening, pleural nodules, and loculation.*
Results: *Among the analyzed cases, 18 (30%) were identified as transudates, while 42 (70%) were categorized as exudates. Transudative effusions consistently exhibited anechoic properties. On the other hand, exudates displayed diverse characteristics on USG: complex septated, echogenic, complex non-septated, and in few cases anechoic. Ultrasound provided clearer visualization of loculations, whereas CT scans were superior in detecting pleural thickening and nodules.*
Conclusion: *USG proves to be a valuable non-invasive tool for bedside assessment of pleural effusion nature. TUS is essential during thoracentesis and chest tube drainage as it increases safety and decreases life threatening complications. It is crucial not only during needle or tube drainage insertion, but also to monitor the volume of the drained Pleural effusion. Furthermore, CT attenuation values play a crucial role in distinguishing the characteristics of pleural effusions. So diagnostic thoracocentesis which is associated with potential complications could be avoided in patients with radiologically confirmed transudative pleural effusion.*

Key Words:*Pleural effusion, Ultrasonography, Computed Tomography, Transudate, Exudate, Diagnostic thoracocentesis*

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I. Introduction

Pleural effusion represents a frequently encountered clinical issue that can manifest as a consequence of various diseases [1-4]. The initial step in evaluating pleural effusion involves determining whether the pleural

fluid is a transudate or an exudate. Transudate arises from imbalances in hydrostatic and oncotic forces and is linked to conditions like heart failure, kidney failure, and cirrhosis. Conversely, an exudate occurs when local factors influencing the accumulation of pleural fluid are altered, and it can be attributed to clinical conditions such as pneumonia, malignancy, chylothorax, and pulmonary embolism (PE) [1,4,5].

Various imaging modalities, including conventional radiography, ultrasonography (USG), computerized tomography (CT) scans, and magnetic resonance imaging (MRI), are employed to diagnose and assess the etiology of pleural effusion [6]. Ultrasonography is the most commonly utilized modality due to its superior accuracy in detecting pleural effusion compared to chest X-rays (93% vs. 47%) [7,8]. It exhibits heightened sensitivity for diagnosing small effusions, determining the nature of effusion [9], and distinguishing loculated pleural fluid from thickened pleura [5,7,10,11]. CT is frequently employed to assess patients with pleural abnormalities related to neoplasms, pneumonia, and empyema, offering superior spatial resolution for detecting pleural nodules and thickening, aiding in the discrimination between transudates and exudates [4].

While clinical and radiological findings can offer significant evidence regarding the cause of pleural effusion, diagnostic thoracocentesis may still be required in some cases to differentiate the nature of pleural effusion using Light's criteria [12]. However, this procedure is associated with potential complications such as pain, hematoma, pneumothorax, and splenic laceration, and it has relative contraindications including coagulation disorders, patient inability to cooperate, and skin disease at the puncture site [1,3,13]. Despite Light's criteria being highly sensitive for exudates, patients with heart failure on diuretics may also meet the criteria, leading to poor specificity [12].

Given the limited literature on the use of USG and CT attenuation values, along with associated findings, as aids in characterizing pleural effusion in the Indian subcontinent, exploring such non-invasive tools would be advantageous for patients with contraindications to invasive diagnostic methods and would contribute to improved patient management. In our study, we assessed the roles of ultrasound and CT scans in differentiating transudative and exudative pleural effusions.

II. Materials & Methods:

A cross-sectional study was conducted at the Department of Radiodiagnosis, AGMC & GBP Hospital, Agartala, over a one-year period from August 2022 to July 2023. Sixty patients with pleural effusion who underwent evaluations through both USG and CT imaging, along with diagnostic thoracocentesis, were included in the study. Pregnant women, patients with minimal pleural effusion, and those with a history of acute trauma were excluded.

Aim of the Study:

The aim was to assess the ability of USG and CT scan to differentiate transudative from exudative pleural effusion.

Observation & Results:

Among the analyzed cases, 30% were identified as transudates, while 70% were categorized as exudates. Transudative effusions consistently exhibited anechoic properties, while exudates displayed diverse characteristics on USG. CT scans were superior in detecting pleural thickening and nodules. Statistical analysis was conducted using various tests and showed excellent accuracy in identifying exudates based on CT attenuation values.

Parameter	Patients with Transudates(n=14)	Patients with exudates (n=46)
Age	48.5(20 -69)	56 (18-90)
Gender(M/F)	10/4	28/18
Anechoic	14 (100%)	1(2.17%)
Complexnon-septated	0	5(10.85%)
complexseptated	0	31(67.27%)
Echogenic	0	9(19.53%)
Effusion size	Large (2) moderate (8) small (4)	Large (16) moderate (21) small (9)
Loculations	0	33
Pleuralthickening	0	24
Pleuralnodules	0	6
	CCF-4 CKD-5 Acute pulmonary embolism-4, Cirrosis-1	Malignant- Infective- Acute pulmonary embolism-

Table1.Demographic and USG findings in exudative and transudative effusions.

Table2.CTfindingsof patients with exudative and transudative effusions.			
Parameter	Patients withTransudates(n=14)	Patientswith exudates (n=46)	Pvalue
CTattenuation(HU)	4.6(1.3–8.2)	14.6(4.5-34)	<0.01
Effusionsize(mm)	37.1(16.6-107)	75.9(17.8-211)	
Pleuralthickening	0	21	<0.01
Loculations	2	35	<0.01
Pleural nodules	1	11	0.03

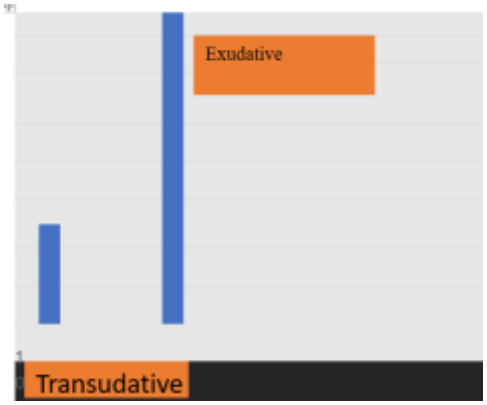

Fig: 1- Mean attenuation value of exudative and transudative effusion

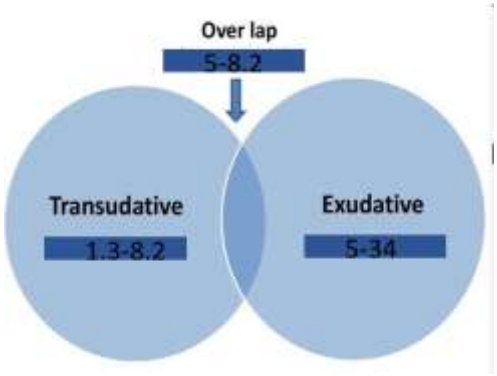

Fig: 2- Demonstration overlapping transudative and exudative pleural effusion

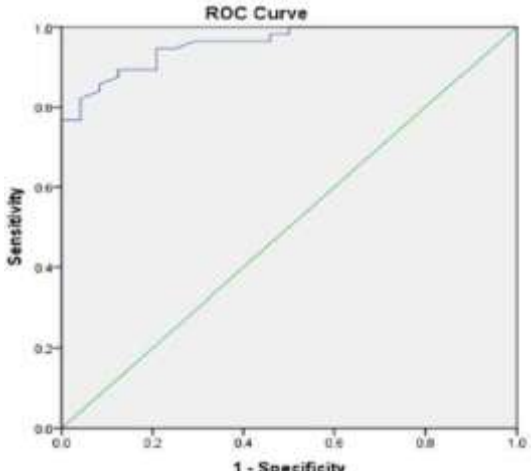

Figure 3. Graph shows receiver operating characteristic (ROC)curve plotting 1 – specificity (x axis) against sensitivity (y axis).Overall accuracy was excellent, with area under ROC curve of 0.958andstandarderrorof0.019.

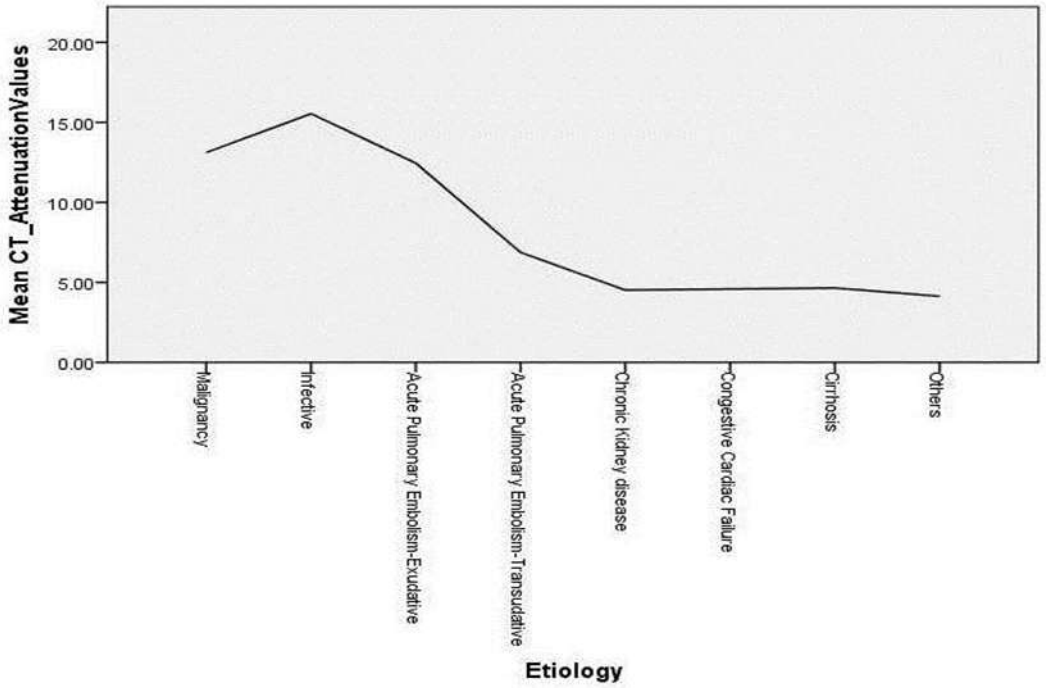

Figure 4. Graph representing mean CTattenuationvaluesacrossvariousetiologiescausingpleural effusion.

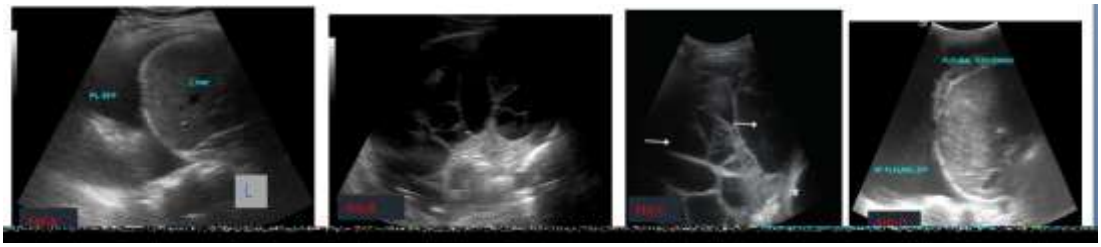

FIG:5: A,B,C,D showing different types of PE on USG

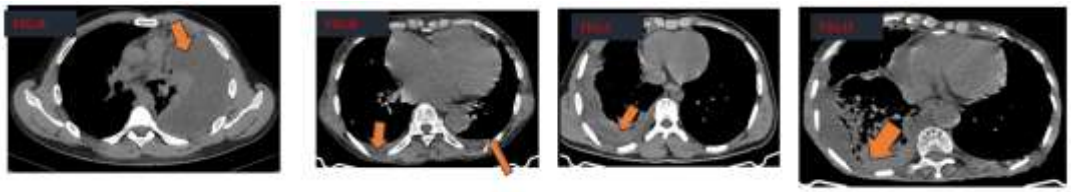

FIG: 6: A,B,C,D showing different types of PE on CT

Table 4. Comparison between USG echo-pattern andMeanCTattenuationvaluesofeffusions.	
USGecho pattern	**CTmeanattenuation values±st.dev**
Anechoic	**5.1 ±3.05**
Complexnon-septated	**11.9 ±6.79**
Complex septated	**14.0 ±4.77**
Echogenic	**14.9 ±4.38**

III. Discussion

Both USG and CT play pivotal roles in diagnosing pleural effusion. The efficacy of sonography in identifying pleural lesions is well-established [9,15]. Sonography proves valuable for localizing loculated or minimal effusions before thoracentesis [9,15,16]. As previously reported, sonography is also instrumental in determining the nature of pleural effusions [9,17]. Pleural effusion patterns can be categorized as anechoic, complex non-septated, complex septated, and homogeneously echogenic. Anechoic effusions are typically transudates, while an anechoic effusion could be either a transudate or an exudate. Pleural effusions displaying complex septated, complex non-septated, or homogeneously echogenic patterns are consistently exudates ($p<0.01$). Sonography not only enables a detailed visualization of the internal echogenicity of a pleural effusion but also clearly depicts associated pleural thickening, nodules, and parenchymal changes [5,9].

In our series, homogeneously echogenic effusions are observed in empyema, few malignant effusions, and acute pulmonary embolism, consistent with a previous study by Yang et al. [9]. The echogenic nature is likely attributed to a high content of tissue debris or blood in the pleural cavity [9,15]. Yang et al. [9] previously noted that thickened pleura and lung parenchymal changes are indicative of exudates. Pleural nodules were predominantly seen in malignant effusions, with only one case observed in a patient with cirrhosis, characterized as a benign nodule in their study. Fibrin strands and septa within a hypoechoic space serve as useful signs to distinguish pleural fluid from a solid mass. Fibrin strands are more common in protein-rich effusions, and sometimes the septa are so profuse that they present a honeycomb appearance [9,15].

In our study, fibrin strands and septa were commonly observed in all types of exudates, including empyema, PPF/CPE, and malignant pleural effusions [9]. Additionally, pleural nodules and thickening were exclusively observed in exudative effusions, consistent with previous studies.

Beyond diagnostic information, chest USG can guide percutaneous transthoracic needle aspiration/biopsy of associated pleural and lung parenchymal lesions with a high diagnostic yield [9,18]. Therefore, USG stands as a valuable diagnostic tool for determining the nature of pleural effusions, further aiding in their effective management.CT is highly sensitive and specific for detecting pleural effusions and determining their causes. Various CT parameters, including mean attenuation values, loculations, pleural thickening, and nodules, help in distinguishing between transudative and exudative effusions.

IV. Conclusion

Ultrasonographic findings are valuable in distinguishing transudate from exudate, with anechoic properties being consistent in transudates. CT mean attenuation values are useful in discerning the nature of pleural effusion, with potential for avoiding diagnostic thoracocentesis in patients with specific CT attenuation values.

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