RESEARCH PAPER

Diagnostic Accuracy of the DUETS Pleural Ultrasound Score Versus Light's Criteria for Differentiating Exudative and Transudative Pleural Effusions in a Tertiary Care Setting

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ABSTRACT

Background: Accurate differentiation of pleural effusions into exudates and transudates is essential for appropriate clinical management. Although Light's criteria remain the standard diagnostic method, their specificity is limited in patients receiving diuretic therapy due to hemoconcentration, leading to misclassification. The DUETS score is a novel ultrasound-based tool designed to overcome these limitations by incorporating morphological features.

Methods: This prospective diagnostic accuracy study included 70 adult patients with undiagnosed pleural effusions. All participants underwent thoracic ultrasound using standardized BLUE protocol points, and the DUETS score (range 0–5) was calculated, with a cut-off ≥2 indicating exudate. Pleural fluid analysis was performed using Light's criteria. Discordant cases were adjudicated using the serum–pleural fluid albumin gradient, with a value >1.2 g/dL indicating transudate.

Results: Of the 70 patients, 42 (60%) had exudative and 28 (40%) had transudative effusions. Tuberculous pleuritis was the most common exudative etiology (38.1%). The DUETS score demonstrated a sensitivity and specificity of 100% for identifying exudates. In comparison, Light's criteria showed a sensitivity of 100% but a reduced specificity of 75%, misclassifying 7 of 28 (25%) transudates as exudates. All misclassified cases were patients with congestive heart failure receiving diuretics. The DUETS score correctly identified all discordant cases as transudates.

Conclusion: The DUETS score is a highly accurate, non-invasive diagnostic tool that matches the sensitivity of Light's criteria while providing superior specificity, particularly in diuretic-associated effusions. Its bedside applicability makes it especially valuable in resource-limited settings, where it may reduce the need for invasive procedures.

Keywords: Pleural effusion, DUETS score, Light's criteria, thoracic ultrasound, exudate, transudate, diagnostic accuracy, diuretic therapy, bedside imaging, non-invasive diagnosis

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Introduction :

Pleural effusion is a frequently encountered clinical condition that reflects an underlying imbalance between pleural fluid production and absorption, arising from a wide spectrum of systemic and local diseases. It constitutes a significant cause of respiratory morbidity worldwide and is associated with diverse etiologies ranging from benign systemic disorders such as congestive cardiac failure and liver cirrhosis to serious conditions including tuberculosis and malignancy. The clinical importance of pleural effusion lies not only in its high prevalence but also in the necessity for accurate etiological diagnosis, as management strategies differ fundamentally based on the underlying cause [1].

The cornerstone of pleural fluid evaluation is the differentiation between transudative and exudative effusions. This classification serves as the initial and most crucial step in narrowing the diagnostic possibilities and guiding further investigations. Since its introduction, Light's criteria have remained the most widely accepted method for this purpose, utilizing the ratios of pleural fluid to serum protein and lactate dehydrogenase to categorize effusions [1]. The enduring relevance of this classification lies in its high sensitivity for detecting exudates, making it an indispensable tool in routine clinical practice. However, despite its strengths, the limitations of Light's criteria have become increasingly evident over time, particularly in specific clinical settings.

To address these limitations, several alternative biochemical parameters have been investigated over the years. Early work demonstrated that the pleural fluid-to-serum bilirubin ratio could aid in distinguishing transudates from exudates, providing an additional diagnostic dimension beyond protein and enzyme levels [2]. Subsequently, pleural fluid cholesterol emerged as a useful marker, with higher concentrations being strongly associated with exudative effusions [3]. Imaging studies also began to play a complementary role, with sonographic evaluation demonstrating the ability to characterize pleural fluid based on internal echogenicity and associated structural features [4]. Further refinements included the measurement of pleural fluid cholesterol in conjunction with lactate dehydrogenase, which was shown to improve diagnostic performance in certain settings [5].

Additional biochemical markers such as pleural fluid cholinesterase ratios were explored to enhance diagnostic accuracy, particularly in borderline cases where traditional criteria yielded inconclusive results [6]. Uric acid estimation in pleural fluid also demonstrated potential in differentiating transudative from exudative effusions, although its routine clinical applicability remained limited [7]. Subsequent studies evaluating the overall utility of biochemical markers concluded that, despite the availability of multiple parameters, significant overlap persists between transudates and exudates, thereby limiting the reliability of biochemical approaches when used in isolation [8]. Moreover, emerging evidence on oxidative stress markers suggested a possible role in distinguishing exudative effusions; however, their lack of standardization and limited accessibility have restricted their widespread use in clinical practice [9].

In parallel, advances in biomarker research introduced the use of N-terminal pro-brain natriuretic peptide (NT-proBNP) as a highly specific indicator of cardiac-related pleural effusions. This marker has shown excellent diagnostic accuracy in identifying transudates secondary to heart failure, particularly in cases where conventional biochemical criteria are inconclusive [10]. Despite these advances, the fundamental challenge of accurately classifying pleural effusions persists, highlighting the inherent limitations of purely biochemical diagnostic strategies.

One of the most clinically significant shortcomings of Light's criteria is the phenomenon of "pseudo-exudates," which occurs predominantly in patients receiving diuretic therapy for congestive heart failure or hepatic hydrothorax. In such cases, diuresis leads to a disproportionate reduction in pleural fluid volume relative to protein content, resulting in hemoconcentration and falsely elevated biochemical ratios. This leads to the misclassification of transudative effusions as exudates, thereby complicating clinical decision-making and often necessitating additional investigations. The clinical implications of such misclassification are considerable, as they may result in unnecessary invasive procedures, increased healthcare costs, and patient discomfort [11].

The growing recognition of these limitations has led to the exploration of imaging modalities as adjuncts in pleural effusion evaluation. Thoracic ultrasound has emerged as a valuable, non-invasive, and bedside tool that provides real-time visualization of pleural fluid characteristics. Unlike biochemical analysis, ultrasound enables the assessment of morphological features such as internal echogenicity, septations, pleural thickening, and diaphragmatic abnormalities, which are often indicative of exudative pathology [12]. Computed tomography has further contributed to the characterization of pleural effusions by providing information on fluid attenuation and associated pleural or parenchymal abnormalities, thereby enhancing diagnostic accuracy in complex cases [13].

The integration of thoracic ultrasound into routine clinical practice has been strongly advocated by international guidelines, which emphasize its role not only in diagnostic evaluation but also in guiding pleural procedures and improving patient safety [14]. Furthermore, ultrasound-based assessment offers distinct advantages in resource-limited settings, where access to advanced laboratory investigations may be constrained.

Despite these advancements, there remains a need for a standardized, reproducible, and clinically applicable method that integrates imaging findings into the diagnostic framework of pleural effusion classification. In this context, the development of structured ultrasound-based scoring systems represents a significant step forward. The DUETS (Diaphragmatic nodularity, Unilateral effusion, Echogenicity, pleural Thickening, and Septations) score is a recently proposed composite scoring system that combines key sonographic features to differentiate exudative from transudative effusions in a systematic manner [15]. By focusing on morphological characteristics that are unaffected by fluid concentration, this approach addresses the fundamental limitations associated with biochemical criteria.

The relevance of such an approach is particularly pronounced in regions with a high burden of infectious diseases such as tuberculosis, where exudative pleural effusions are common and often present with distinctive sonographic features. Additionally, in tertiary care settings where patients frequently receive diuretic therapy, the ability to accurately distinguish true exudates from pseudo-exudates is of critical importance.

In light of these considerations, the present study was undertaken to evaluate the diagnostic accuracy of the DUETS pleural ultrasound score in comparison with Light's criteria in a tertiary care setting. By addressing the limitations of conventional biochemical methods and incorporating a non-invasive imaging-based approach, this study aims to contribute to the evolving paradigm of pleural effusion diagnosis and improve clinical decision-making in routine practice.

Methodology :

This prospective, single-center diagnostic accuracy study was conducted in the Department of Respiratory Medicine at Sree Balaji Medical College and Hospital, Chennai, over a duration of 14 months. The study protocol received approval from the Institutional Human Ethics Committee prior to commencement, and all procedures were carried out in accordance with ethical standards for human research.

A total of 70 consecutive adult patients aged 18 years and above, presenting with radiologically confirmed pleural effusion and requiring diagnostic thoracentesis, were enrolled in the study. Patients were excluded if they had uncorrectable coagulopathy, were pregnant, or had minimal pleural fluid volume insufficient for safe aspiration. Consecutive sampling was employed to minimize selection bias and ensure representativeness of the study population.

All enrolled patients underwent bedside thoracic ultrasound prior to thoracentesis, performed using a 5 MHz curvilinear probe (GE Venue 40). Scanning was conducted at standardized BLUE protocol points, including the Posterolateral Alveolar and/or Pleural Syndrome (PLAPS) point, to ensure systematic and reproducible assessment. The DUETS (Diaphragmatic nodularity, Unilateral effusion, Echogenicity, pleural Thickening, and Septations) score was calculated by assigning one point for each of the following sonographic features: diaphragmatic nodularity, unilateral effusion, internal echogenicity or swirling debris, pleural thickening greater than 3 mm, and the presence of septations or fibrin strands. The total score ranged from 0 to 5, with a predefined cut-off of ≥2 indicating an exudative effusion, while a score of 0–1 was considered consistent with a transudative effusion. Following ultrasound assessment, diagnostic thoracentesis was performed under aseptic precautions. Pleural fluid samples were analyzed for protein, lactate dehydrogenase (LDH), and albumin levels. The reference standard for classification was based on Light's criteria, wherein an effusion was categorized as exudative if any one of the following criteria was met: pleural fluid to serum protein ratio greater than 0.5, pleural fluid to serum LDH ratio greater than 0.6, or pleural fluid LDH exceeding two-thirds of the upper limit of normal serum LDH.

In cases of discordance between biochemical classification and clinical assessment—particularly in patients with suspected transudative effusions receiving diuretic therapy—the serum–pleural fluid albumin gradient (SPAG) was calculated. A gradient greater than 1.2 g/dL was considered indicative of a transudative effusion and was used as the final adjudicating criterion, overriding the initial classification by Light's criteria when necessary.

Statistical analysis was performed using SPSS software version 28.0. The diagnostic performance of the DUETS score was evaluated against the final adjudicated diagnosis. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. Agreement between DUETS scoring and biochemical classification was assessed where appropriate, and all results were interpreted with a predefined level of statistical significance.

Results

Baseline Characteristics

A total of 70 patients were included. The mean age was 53.4 years (SD 14.2). The cohort consisted of 41 males (58.6%) and 29 females (41.4%). Based on the final adjudication, 42 patients (60%) had exudative effusions and 28 patients (40%) had transudative effusions.

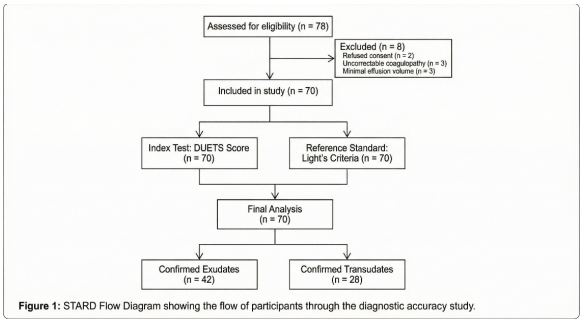


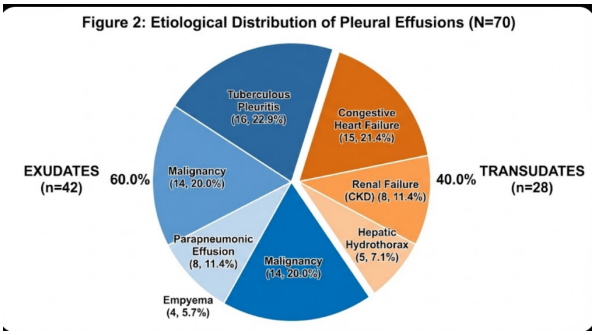
Figure 1: STARD Flow Diagram showing the flow of participants through the diagnostic accuracy study.

Etiological Distribution

The distribution of etiologies reflects the local epidemiological profile (Table 1). Tuberculous pleuritis was the leading cause of exudates (n=16; 38.1%), followed by malignancy (n=14; 33.3%). Congestive heart failure (CHF) was the predominant cause of transudates (n=15; 53.6%).

Table 1: Etiological Distribution of Pleural Effusions (N=70)

Etiology	**Frequency (n)**	**Percentage (%)**
Exudates (Total)	42	60.0%
Tuberculous Pleuritis	16	38.1%
Malignancy	14	33.3%
Parapneumonic Effusion	8	19.0%
Empyema	4	9.5%
Transudates (Total)	28	40.0%
Congestive Heart Failure	15	53.6%
Renal Failure (CKD)	8	28.6%
Hepatic Hydrothorax	5	17.9%



Diagnostic Performance

The DUETS score demonstrated excellent diagnostic accuracy. Using the cut-off of ≥2 , the score identified exudates with a sensitivity of 100% and specificity of 100% against the final adjudicated diagnosis. In comparison, Light's criteria alone (without SPAG adjudication) showed a sensitivity of 100% but a reduced specificity of 75%. This reduction was due to the misclassification of 7 patients.

Agreement Analysis

There was a substantial level of agreement between the DUETS score and Light's criteria. Out of 70 patients, the two methods yielded concordant classifications in 63 cases (90%). The calculated **Cohen's Kappa (k) was 0.78** ($p < 0.001$), indicating strong agreement, with the discordance arising exclusively from the false-positive identification of exudates by Light's criteria in the diuretic cohort.

Prevalence of DUETS Components

The distribution of individual ultrasound signs varied significantly between exudates and transudates. **Septations (S)** were the most specific marker, present in 30 (71.4%) of the 42 exudative cases but 0% of transudates. **Pleural thickening >3 mm (T)** was observed in 28 (66.7%) exudates. **Unilateralism (U)** was the most sensitive but least specific marker, present in all 42 exudates (100%) but also in 12 (42.8%) transudates. **Echogenicity (E)** was present in 35 (83.3%) exudates. **Diaphragmatic nodularity (D)** was rare but highly specific for malignancy ($n=8$).

Analysis of Discordant Cases

Seven patients (10% of the total cohort; 25% of transudates) demonstrated discordance between Light's criteria and the final diagnosis (Table 2). All 7 patients were receiving diuretic therapy for CHF. In these cases, Light's criteria falsely identified the fluid as an exudate (Proteins/LDH elevated). However, the DUETS score in all 7 cases was **1** (positive only for Unilateralism or negative for all markers), correctly suggesting a transudate. This was confirmed by an Albumin Gradient > 1.2 g/dL.

Table 2: Characteristics of Discordant Cases (n=7)	
Clinical Scenario	CHF on Diuretics
Light's Criteria Result	Exudate (False Positive)
Mean DUETS Score	1 (Range 0–1)
Mean Albumin Gradient	1.53 g/dl
DUETS Classification	**Transudate (Correct)**

Discussion :

In the present study of 70 patients with pleural effusion, the DUETS score demonstrated excellent diagnostic performance, achieving a sensitivity of 100% and specificity of 100% for identifying exudative effusions. In contrast, Light's criteria, while maintaining a sensitivity of 100%, showed a reduced specificity of 75%, misclassifying 7 out of 28 transudative effusions (25%) as exudates. All discordant cases were observed in patients with congestive heart failure receiving diuretic therapy. Importantly, the DUETS score correctly classified all 7 discordant cases as transudates, with scores ≤1, highlighting its superior specificity in clinically complex scenarios.

The misclassification rate observed in our study aligns closely with previously reported limitations of Light's criteria. Scheurich et al. [16] demonstrated that clinical judgment identified a subset of effusions that were incorrectly classified by biochemical criteria, particularly in cardiac patients, suggesting inherent limitations of relying solely on fluid chemistry. Bielsa et al. [17] quantified this issue more precisely, reporting misclassification rates of approximately 20–30% in cardiac and hepatic transudates due to hemoconcentration effects induced by diuretics. The 25% misclassification rate among transudates in our study falls squarely within this reported range, reinforcing the persistent clinical relevance of this limitation.

The pathophysiological basis of this misclassification lies in the differential kinetics of fluid and protein removal during diuresis. As intravascular hydrostatic pressure decreases, pleural fluid is resorbed more rapidly than proteins, resulting in artificially elevated pleural fluid protein and LDH concentrations. This leads to "pseudo-exudates," where transudative effusions fulfill exudative biochemical criteria. In our study, all 7 discordant cases exhibited this phenomenon, with elevated protein and LDH ratios despite clear clinical evidence of cardiac etiology. The DUETS score, by relying on structural features rather than biochemical composition, remained unaffected by this mechanism, thereby correctly identifying all such cases as transudates.

The superiority of morphological assessment in pleural disease has been emphasized in ultrasound-based studies. Lichtenstein et al. [18] introduced the BLUE protocol, demonstrating that standardized thoracic ultrasound points could accurately characterize pleural and pulmonary pathology. While their study did not provide direct sensitivity and specificity for effusion classification, it established that features such as pleural irregularity, consolidation, and fluid echogenicity correlate strongly with underlying disease processes. In our study, similar morphological markers—particularly septations and pleural thickening—were consistently associated with exudative effusions, supporting the biological plausibility of the DUETS scoring system.

Computed tomography has also been explored as a diagnostic modality. Çullu et al. [19] reported that CT attenuation values could differentiate exudates from transudates with sensitivity ranging from 70% to 85% and specificity from 65% to 80%. However, the overlap in attenuation values limited its diagnostic precision. Compared to these findings, the DUETS score in our study demonstrated markedly superior performance, achieving 100% accuracy. This difference highlights the advantage of real-time morphological assessment over static radiological parameters, particularly in

identifying features such as septations and pleural surface abnormalities.

The etiological distribution in our cohort further contextualizes the diagnostic performance of DUETS. Exudates accounted for 60% of cases, with tuberculous pleuritis comprising 38.1% and malignancy 33.3%. Udwadia et al. [20], in a large Indian series of 3205 patients, reported tuberculosis as the leading cause of pleural effusion, contributing approximately 30–40% of cases, which closely parallels our findings. The high prevalence of tuberculosis in our study is clinically significant, as tuberculous effusions typically exhibit characteristic ultrasound features such as septations and pleural thickening. In our cohort, septations were present in 71.4% of exudates and in 0% of transudates, indicating high specificity.

The diagnostic importance of such morphological features has been emphasized by Porcel et al. [22], who reported that complex septated effusions are strongly predictive of exudative pathology, particularly in tuberculosis and malignancy. Similarly, Bintcliffe et al. [23] highlighted that pleural effusions often arise from multiple concurrent etiologies, complicating classification based solely on biochemical criteria. In such scenarios, structural imaging provides additional discriminatory power. Our findings support this concept, as the DUETS score integrates multiple morphological parameters, thereby capturing the complexity of pleural pathology more effectively than single-parameter biochemical tests.

The issue of discordant or mixed effusions has been explored by Ferreiro et al. [24], who reported that discordance between biochemical markers can significantly reduce diagnostic accuracy, with a notable proportion of effusions exhibiting overlapping characteristics. Their study emphasized the need for adjunctive diagnostic tools to resolve such ambiguity. In our study, all discordant cases were resolved by the DUETS score without the need for additional invasive or biochemical testing, suggesting that ultrasound-based scoring can serve as a definitive diagnostic tool in such situations.

Recent studies have evaluated the standalone diagnostic performance of thoracic ultrasound. Shkolnik et al. [25] reported that ultrasound could differentiate exudates from transudates with sensitivity of 88% and specificity of 82% based on qualitative assessment of features such as echogenicity and septations. While these values indicate good diagnostic performance, they fall short of the accuracy observed in our study. This discrepancy may be attributed to the use of a structured scoring system (DUETS) in our study, which standardizes the interpretation of ultrasound findings and reduces operator dependency.

The findings of our study are in close agreement with the original DUETS validation study by Gardiner et al. [26], who reported a specificity of 100% and sensitivity approaching 98–100% for identifying exudative effusions. In their study, the misclassification rate of Light's criteria was approximately 6.9%, significantly lower than the 10% overall and 25% among transudates observed in our cohort. This difference likely reflects variations in patient demographics and clinical characteristics, particularly the higher prevalence of advanced heart failure and diuretic use in our tertiary care population. Despite this variation, both studies consistently demonstrate that DUETS effectively eliminates misclassification associated with biochemical criteria.

The evolving understanding of pleural fluid classification has been discussed by Light [27], who emphasized that no single diagnostic modality is sufficient in isolation and that integration of clinical, biochemical, and imaging findings is essential. Our study builds upon this concept by demonstrating that structured ultrasound scoring can complement and, in certain scenarios, surpass traditional biochemical methods.

Safety considerations also play a crucial role in pleural disease management. The National Patient Safety Agency [28] highlighted the risks associated with blind pleural procedures and recommended routine use of ultrasound guidance to minimize complications. The incorporation of DUETS scoring into routine ultrasound assessment not only enhances diagnostic accuracy but also aligns with safety recommendations by promoting image-guided evaluation.

Earlier comparative studies have consistently demonstrated variability in the diagnostic performance of biochemical criteria. Romero et al. [29] reported that different classification systems yield inconsistent results, with significant overlap between transudates and exudates. Similarly, Heffner et al. [30] found that while Light's criteria achieve sensitivity exceeding 95%, specificity remains suboptimal, often below 80%. These findings are consistent with our observation of 75% specificity for Light's criteria, further validating the need for improved diagnostic approaches.

In summary, the present study provides strong evidence that the DUETS pleural ultrasound score offers superior diagnostic accuracy compared to Light's criteria, particularly in resolving pseudo-exudates associated with diuretic therapy. By integrating multiple morphological features that reflect underlying

pathophysiology rather than fluid composition. DUETS addresses the fundamental limitations of biochemical classification. Its excellent sensitivity and specificity, combined with its non-invasive and bedside applicability, make it a valuable tool in both resource-limited and high disease-burden settings.

Conclusion :

The present study demonstrates that the DUETS pleural ultrasound score is a highly accurate, non-invasive diagnostic tool for differentiating exudative and transudative pleural effusions. While maintaining sensitivity comparable to Light's criteria, the DUETS score exhibits markedly superior specificity, particularly in patients receiving diuretic therapy, where biochemical misclassification is common.

By incorporating objective morphological features that are independent of fluid concentration, DUETS effectively overcomes the limitations of conventional biochemical analysis and reliably resolves discordant cases. Its excellent diagnostic performance, combined with real-time bedside applicability, makes it a practical and efficient tool in routine clinical settings.

The integration of the DUETS score into standard thoracic ultrasound protocols has the potential to enhance early diagnostic accuracy, streamline clinical decision-making, and reduce the need for invasive procedures in clearly identifiable transudative effusions. This is particularly relevant in resource-limited and high disease-burden settings, where rapid, cost-effective, and reliable diagnostic approaches are essential.

Further multicentric studies with larger sample sizes are warranted to validate these findings and establish DUETS as a standard adjunct or alternative to conventional pleural fluid analysis in clinical practice.

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