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Original Research Article

To Evaluate and Compare the Efficacy of Ultrasonography and Computed Tomography in Differentiating Transudate from Exudate in Patients with Pleural Effusion

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Abstract

Purpose: To evaluate efficacy of radiological method (USG and CT imaging) for differentiating transudative and exudative pleural effusion.

Materials and methods: A retrospective data base observational study, included patients who underwent USG, CT THORAX and Thoracentesis between June 2020 to June 2021, total period of 12 months. USG appearances and CT attenuation values were compared with standard method (Light's criteria) along with additional findings like presence of pleural thickening, pleural nodules and loculation were also evaluated.

Results: 25 (30.12%) were transudates and 58 (69.88%) were exudates. Transudative effusions were always anechoic. Exudative effusion may be complex septated (60.03%), echogenic (24.14%) or complex non-septated (10.34%) on USG with very few being anechoic (5.17%). Loculations and septation were better appreciated on ultrasound while pleural thickening and nodules were better seen on CT. Mean attenuation values were significantly higher in exudates (14.65 ± 6.07; mean ± SD, range: 4.5 to 34) than transudates (4.66 ± 2.29; mean ± SD, range: 1.3 to 8.2) with a P-value <0.01. Effusions can be considered transudative if the CT attenuation value is <8, with a sensitivity of 91.8% and specificity of 82.9% with a significant P value <0.01. Pleural thickening, nodules and loculations were seen more commonly in exudates than transudates with a high specificity (92.1 %, 96.3% and 100% respectively).

Conclusion: USG is a bedside non-invasive tool and very helpful in determining transudative and exudative effusions. CT attenuation values are useful in determining the etiology of pleural effusions. CT HU values are < 8 mostly indicating transudative effusions.

Keywords: Pleural Effusion,Transudates, Exudates

Introduction

Pleural effusion is a common clinical problem encountered in respiratory OPD and has many etiological diagnoses [1-4]. pleural effusion is broadly of 2 types, first is transudative and second is exudative.

Transudative effusion mainly occurs due to imbalances in hydrostatic and oncotic forces, seen in many diseases such as heart failure, kidney failure and cirrhosis.

Exudative effusion occurs as a consequence of diseases that alter local

factors that lead to the accumulation of pleural fluid, seen in many clinical conditions such as pneumonia, malignancy, chylothorax and pulmonary embolism (PE) [1,4,5].

Radiological methods used to diagnose and assess etiology of pleural effusion such as chest x-ray, ultrasonography (USG), computerized tomography (CT) scan and magnetic resonance imaging (MRI) [6].

The most commonly used Radiological modality is Ultrasonography, having higher accuracy to detect pleural effusion, much higher sensitivity in diagnosis of small amounts of effusion, nature of effusion and differentiation of the loculated pleural fluid and the thickened pleura, in comparison with chest X-rays (93% *versus* 47%) [5,7,8,9,10,11].

CT scan is also used to assess pleural abnormalities associated with neoplasm, pneumonia and empyema having better spatial resolution in detection of pleural nodules and pleural thickening, which help in the discrimination of transudates and exudates [4].

Clinical and radiological findings give us significant evidence about the etiology of pleural effusion BUT need for diagnostic thoracentesis is a must because it is still gold standard to differentiate transudate and exudate pleural effusion by using Lights criteria (100% sensitive for exudative pleural effusion) [12]. However, there are certain complications associated with the diagnostic Thoracentesis like pain, hematoma, pneumothorax and rarely splenic laceration and some relative contradictions such as coagulation disorders (haemophilia, thrombocytopenia etc), noncooperative patient and skin disease at the puncture site [1,3,14].

Materials and Methods:

Source of data

This retrospective study (between June 2020 to June 2021) was conducted in the

Department of TB and Chest, Jhalawar Medical College, of patients above 18 yrs of age irrespective of their sex, who presented with clinical and radiological signs and symptoms suggestive of pleural effusion.

Individuals with clinically or radiographically suspected pleural effusion were referred for Ultrasonography and CT thorax to the Department of Radiology at our centre and screened for the study.

Criteria of Inclusion:

Patients more than 18 years of age with pleural effusion and willing to undergo USG and CT evaluation with diagnostic Thoracentesis were included in the study.

Criteria of exclusion:

1) Patients less than 18 years of age
2) Pregnant women.
3) History of acute trauma.
4) Patients with HIV positive status
5) Allergic to anesthetic agents and Dye used for CT scan.
6) Rapidly fatal underlying disease

Data collection:

After reviewing data and history including cardinal symptoms of the patient like fever, cough of more than 2 weeks, chest pain, decreased appetite, weight loss, night sweats, neck and face swelling, decreased urine output, pedal edema and dyspnea etc.

Age, gender and weight of the patient were considered. Physical examination, necessary laboratory investigations and related data were also considered.

The Patients were evaluated radiologically with chest x-ray as well as Ultrasonography (USG) and CECT chest in all cases.

USG and CT were performed in patients suggestive of pleural effusion on chest x-ray.

Imaging findings on reports were correlated with biochemical and cytological reports and analysis was compared to each other by using Lights criteria considered the gold standard.

USG findings in pleural effusion are classified into anechoic, complex non-septated, complex septated and echogenic effusions. The parietal pleural thickness was measured and if the pleural thickness was 3 mm or greater was defined as pleural thickening. The pleural nodules were seen as hypoechoic lesions with margins located in the parietal or visceral pleura, while focal pleural thickenings were seen as echogenic areas of increased thickness in the parietal pleura that had poorly defined margins.

CT findings, in reference to effusion, depend on the shape of effusion such as convex shape indicating loculated effusion when it showed septations or in non-dependent portion of the pleural space. Otherwise, a concave-shaped effusion suggests free fluid in the dependent portion of the pleural space. Pleural nodules in the parietal or visceral pleura were also evaluated. CT scans were also effectively evaluated for the presence of pleural thickening. For Parietal pleural thickening, pleural line was visible internal in relation to the ribs and for Visceral pleural thickening pleural line was seen on the surface of the lung adjacent to the fluid and differentiated from the compressed lung [1,14].

Result:

The study population (retrospective database study) constituted 83 patients, 54 males and 29 females (age range, 18–98 years; mean age, 53.2 years), who underwent ultrasonography, CT and diagnostic thoracentesis within 72 hours.

Table 1: USG findings in exudative and transudative effusions.

Parameter	Patients with Transudates (n=25)	Patients with exudates (n=58)
Age	49.7 (22 -77)	57 (18 -98)
Gender (M/F)	15/10	39/19
Anechoic	25 (100%)	3 (5.17%)
Complex non-septated	0	6 (10.34%)
complex septated	0	35 (60.03%)
Echogenic	0	14 (24.14%)
Effusion size	massive (2) moderate (10) small (13)	massive (16) moderate (32) small (10)
Loculations	0	35 (60.34%)
Pleural thickening	0	23 (39.66%)
Pleural nodules	0	6 (10.34%)
Probable Etiology	Infective / Pul. TB 15 Congestive cardiac failure 7 chronic kidney disease 3	Malignant 12 Infective/Pul. TB 42 Others 4

As per Lights criteria, 25 of the 83 pleural effusions were transudates (30.12%) and 58 were exudates (69.88%). Transudative effusions mostly occurred bilateral (87.7%) as compared to exudative effusions which were unilateral (90.2%)

with a significant p-value of <0.01. Overall pleural effusion is mostly unilateral (67.3%) and commonly on right side (76.8%). Etiological conditions are seen in our study population (TABLE 1) included malignant (14.46%), infective (68.67%), congestive cardiac failure (8.43%), chronic kidney disease (3.61), chronic hepatic diseases (2.41%) and other causes (2.41%) e.g. hypoalbuminemia, anaemia, dengue fever. Of the infective effusion (n=57), 27 were parapneumonic effusions (47.37%), 19 complicated parapneumonic/empyema (33.33%), 5 hydropneumothorax (8.78%) and 6 pyopneumothorax (10.52%). total of 45 patients have tubercular etiology as infective agent and remaining 12 patients were non-tubercular.

Malignant effusions were seen in 12, of which 9 patients had carcinoma lung, 1 had gastric cancer, 1 malignant transformation of phylloides tumor and 1 case of mesothelioma.

Exudative effusions mostly were complex septated (n=35, 60.03%), echogenic (n=14, 24.14%) or complex non-septated (n=6, 10.34%) on ultrasound with very few being anechoic (n=3, 5.17%). In case of Transudative effusions, they always were anechoic (n=25, 100%) (TABLE 1) and smaller (n=13, 52%) to moderate (n=10, 40%) in size as compared to exudative which were mostly moderate (n=32, 55.17%) to larger (n=16, 27.59%) in size both on USG and CT. Pleural thickening, pleural nodules and loculations were seen only in exudative effusions and were not seen in any of the transudative effusions on USG (TABLES 1 and 2). Loculations are better seen on ultrasound than on CT. Pleural thickening and pleural nodules were better visualized on CT compared to USG. Pleural thickening was seen commonly in exudates than transudates with a sensitivity (63.2%), specificity (92.1%), PPV (95.1%), NPV (51.3%) with a *P* value <0.01. Pleural nodules were also more commonly seen in exudates than transudates with a sensitivity (20.1%), specificity (96.3%), PPV (92.4%), NPV (33.5%) with a *P* value 0.03. Loculations were only seen in exudates and accounting for a sensitivity (37.8%), specificity (100%), PPV (100%), NPV (40.8%) with a *P* value <0.01. These findings yielded low sensitivity but were more specific (TABLES 2 and 3).

Table 2: CT findings in exudative and transudative effusions

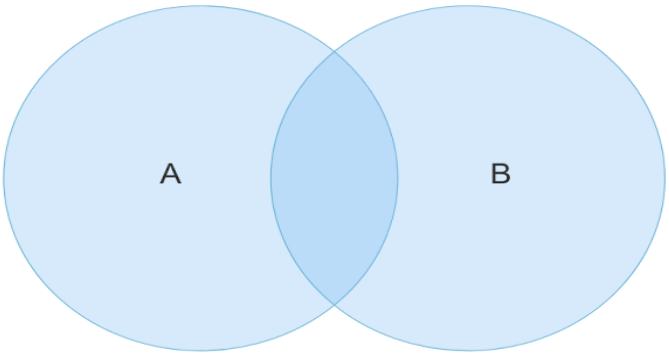
Parameter	Patients with Transudates (n=25)	Patients with exudates (n=58)	P value
CT attenuation (HU)	4.6 (1.3 – 8.2)	14.6 (4.5 - 34)	<0.01
Effusion size (mm)	38.1 (17.5 - 108)	75.3 (18.5 - 180)	-
Loculations	0	23	<0.01
Pleural thickening	2	36	<0.01
Pleural nodules	0	9	0.03

Table 3: Performance of CT parameters in differentiating exudates from transudates

CT parameters	CT attenuation values < 8 as cut off	Loculations	Pleural thickening	Pleural nodules
Sensitivity	91.8	37.8	63.2	20.1
Specificity	82.9	100	92.1	96.3
PPV	73.5	100	95.1	92.4
NPV	96.3	40.8	51.3	33.5
P-value	<0.01	<0.01	<0.01	0.03

Mean attenuation values were significantly higher in exudative (14.65 ± 6.07; mean ± SD, range: 4.6 to 34) effusions than transudates (4.66 ± 2.29; mean ± SD, range: 1.3 to 8.2) with a *P*-value <.001. There is an overlap in the range of 4.5 to 8.2 (FIGURE 1).

overlap range from 4.5 to 8.2



A	Transudative
B	Exudative

Figure 1: Demonstrates the overlap in mean attenuation values between transudative and exudative effusion

Although CT attenuation values show good sensitivity and specificity in differentiating pleural effusion, presence of loculations, pleural nodules, and thickening are more specific (TABLE 3). On comparing the echopattern versus CT attenuation values, anechoic effusions showed much lower attenuation values than the other echo-patterns of effusion supporting the lower attenuation values observed in transudative effusion (TABLE 4).

Table 4: Comparison between echo-pattern and Mean CT attenuation values of effusion

USG echo pattern	CT mean attenuation values ± st. dev
Anechoic	5.0 ± 3.08
Complex non-septated	11.5 ± 6.75
Complex septated	15.1 ± 4.79
Echogenic	14.5 ± 4.55

Discussion

For proper diagnosis and management. It is necessary to differentiate the type of effusion between transudative and exudative forms [2]. Radiographic methods such as USG and CT, both are effective in the diagnosis of pleural effusion**.**

Ultrasonography The role of Sonography in the detection of pleural lesions is well established [9,15] and is useful in localizing the site of loculated or minimal effusion before thoracentesis [9,15,16]. Already described that sonography is very useful in determining the nature of pleural effusions [9,17]. On the basis of sonography, Pleural effusions are

subclassified into four categories such as anechoic, complex non-septated, complex septated and homogeneously echogenic. Transudates are always anechoic, but an anechoic effusion is either a transudate or an exudate. Exudative Pleural effusions may present as complex septated, complex non-septated, or homogeneously echogenic patterns ($p<0.01$). It visualizes the internal echogenicity of pleural effusion and also gives information regarding associated pleural thickening, nodules and parenchymal changes [5,9]. We found similar results as described in other studies also, that transudates present as anechoic in 100% of cases while similar findings were being observed in only 3.5% of cases of exudative effusion. In our studies, the homogeneously echogenic were seen in pyothorax (empyema), few malignant effusions with hypoalbuminemia and acute pulmonary embolism, which is similar to study by yang et al. [9]. The echogenic appearance in sonography is mostly due to presence of a high content of tissue debris or blood in the pleural cavity [9,15]. As described earlier by yang et al. [9], pleural thickening and lung parenchymal changes indicate exudative type of effusion. The pleural nodules are mostly seen in malignant effusions. presence of Fibrin strands and septa within a hypoechoic space help to distinguish pleural fluid from a solid mass. The fibrin strands indicate that effusion is rich in protein, sometimes the septa may appear as they had a honeycomb appearance [9,15]. In our study, fibrin strands and septa, seen in different cases but all were the types of exudates, including empyema, PPF/CPE and malignant pleural effusions [9]. But interesting thing is that pleural nodules and thickening were observed only in exudative types of effusions similar to previous studies. Sonography not only provides diagnostic information but also is used to guide a percutaneous transthoracic needle aspiration/biopsy of the associated pleural and lung parenchymal lesions with high diagnostic yield [9,18]. Hence, USG is a very useful diagnostic and therapeutic tool for determining the nature of pleural effusions and also guides proper thoracentesis procedure which is a further aid in the management of pleural effusions.

Computed tomography: Already described earlier that a CT scan is a sensitive as well as specific radiological tool for detection of pleural effusions and very helpful tool for determining etiological diagnosis of pleural effusions [2]. There are too many studies that have evaluated the efficacy of various computed tomographic parameters in differentiating transudative from exudative effusions. Such parameters are mean attenuation values, loculations, pleural thickening, and nodules. Some variation in the results regarding the use of attenuation values between various studies [1,2,4,6,13,14,19]. In Previous studies, mean CT attenuation values of exudates are higher (8.1 - 17.1 HU) as compared to transudates (3.5 - 12.5 HU) and those studies determine it as moderately helpful in differentiating transudates from exudates [2,4,6,13,20].

According to Abramowitz et al., the mean attenuation values of exudates (7.2 ± 9.4 HU) were lower than those of transudates (10.1 ± 6.9 HU; $p=0.24$), results were not statistically significant [1]. Our study results were similar to the prior studies [2,4,6,13,20] which show that exudative effusion has significantly higher mean attenuation values (14.65 ± 6.07), compared with the transudates (4.66 ± 2.29), P-value 8, with a sensitivity around 91.8%, specificity 82.9%, PPV of 73.5% and NPV of 96.3% with having a significant P value <0.01. [21] Finally, we found that the mean attenuation values of exudates were significantly higher than those of transudates and had an overlap range in the values.

Conclusion

On the basis of our retrospective study, we conclude that ultrasonographic appearances of Thorax are much helpful to differentiate transudate from exudate and transudative effusions are always anechoic (100%) as compared to exudates, which was seen only in very few numbers of cases (5.17%). Other USG appearances such as complex non-septated, complex septated and echogenic are seen only in exudative effusions. Mean attenuation values play a crucial role in differentiating the nature of pleural effusions. As per the results of our study, in transudative effusions, HU values are less than 8 with a sensitivity of 91.8%, specificity of 82.9%, PPV of 73.5% and NPV of 96.3%. Hence, in case of pleural effusions with CT attenuation value <8, diagnostic thoracentesis could be avoided due to potential complications such as pneumothorax and hemothorax, etc. Since there is overlap in HU values (4.5 to 8.2), this case correlates with additional CT findings like pleural thickening, pleural nodules and loculations which are more specific and highly prevalent among exudative effusions.

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