Is computed tomography scan able to replace laboratory tests to differentiate transudate effusions from exudate effusions? that is a question

Yousef Ahmed[a], Sahar Farghly[b], Mohamed I. Seddic[c], Shimaa Farghaly[d]

Background Pleural effusion is considered an interesting clinical problem that is commonly faced by physicians and is caused by several diseases. The ability of computed tomography (CT) to differentiate transudate effusion from exudate effusion is still under research.

Objective The aim of this study was to assess the accuracy of the CT in diagnosing the nature of the pleural effusion.

Patients and methods In this prospective cross-sectional analytic study, laboratory biochemistry markers were used to classify pleural effusion into exudate or transudate based on Light's criteria. Chest CT without contrast had been done for all patients, and CTs were diagnosed by the radiologist. Measurement of the pleural fluid density was done and shown using the CT attenuation values [Hounsfield unit (HU)].

Results Of 79 patients with pleural effusion, 60 patients had exudate effusion and 19 patients had transudate. The mean attenuation values were significantly higher in exudate effusion (20.11±7.11 HU) versus transudate effusion (13.8 ±4.11 HU), with *P* value of 0.03. Receiver operating characteristic curve analysis showed that the cutoff for exudate effusion was optimal at greater than or equal to 15.33 versus less than 15.33 HU for transudate (area under the curve=0.57; 95% confidence interval: 0.45–0.68). This point had 85.71% sensitivity and 46.55% specificity.

Conclusion We reasoned the CT attenuation values of the pleural fluid may replace the laboratory tests in characterizing the pleural effusion, either exudate or transudate. However, there was an overlapping HU values in most effusions. So correlation of the CT results with the clinical findings is essential, and further CT studies are highly recommended to confirm and validate these findings.
Egypt J Bronchol 2019 13:244–248

Egyptian Journal of Bronchology 2019 13:244–248

Keywords: computed tomography, exudate, Hounsfield unit, pleural effusion, transudate

[a]Associate professor, Chest Diseases and Tuberculosis, [b]Lecturer of Chest Diseases and Tuberculosis, [c]Lecturer of Clinical Pathology, [d]Lecturer of Radiologye, Assiut University Hospital, Assiut, Egypt

Correspondence to Sahar F. Youssif, MD, Department of Chest Diseases and Tuberculosis, Faculty of Medicine, Assiut University, 71515 Assiut, Egypt. Tel: +20 100 297 6708;
e-mail: saherfr2009@yahoo.com

Received 6 June 2018 **Accepted** 30 September 2018

Introduction

Pleural effusion is considered an interesting clinical problem that is commonly faced by physicians and is caused by several diseases [1,2]. Pleural effusion often provides data about the underlying pathology involving the thorax. Deciding whether the pleural fluid is a transudate or an exudate is usually the most important initial step in the management of pleural effusion to reach the underlying pathological process. Pleural fluid aspiration or what is called thoracentesis is routinely applied to differentiate exudate from transudate using Light's criteria, but this procedure carries possible hazards [3–7]. Thus, noninvasive methods to diagnose the nature of the pleural fluid could be essential to guide management of pleural effusion and avoid the possible risks of thoracentesis. These methods could be also specifically helpful in situations with contraindications to the thoracentesis procedure. Ultrasonography and computed tomography (CT) can be valuable noninvasive methods that are helpful in diagnosing and predicting the type and etiology of the pleural effusion. These methods may reduce the need for a procedure such as thoracentesis [8,9]. Few reported studies were concerned with the measurement of the pleural fluid density using the CT attenuation values [Hounsfield Unit (HU)], and there was a debate on the results of these studies [10–16]. The purpose of the present study was to find out the accuracy of the CT in enabling the differentiation of the pleural exudate from transudate on the basis of the attenuation values of the pleural fluid.

Patients and methods

This prospective cross-sectional analytic study conducted upon patients admitted to the Department of Chest and Tuberculosis at Assiut University Hospital from June 2016 to June 2017. The work was carried out after approval from the local committee of ethics, and all the studied patients provided a written consent. Patients with pleural effusions had been included. The demographic data of the studied patients were gathered. Chest CT and thoracentesis were performed for all patients within 48 h of each other. Patients with unclear causes of the pleural effusions were excluded. Moreover, excluded from this study were patients who had pleural intervention (tube drainage, thoracoscopy, biopsy, etc.) between the pleural fluid analysis and chest CT. Laboratory analysis of the pleural fluid was performed in the Clinical Pathology Department at Assiut University Hospital and the pleural fluid workup and serum chemistry (protein, albumin, and lactate dehydrogenase levels) were determined by a clinical pathologist who was blinded to the clinical and radiological information. Pleural effusion was classified as exudate or transudate according to the Light's criteria [4]. Noncontrast chest CT was performed in the Radiology Department at Assiut University Hospital using 16-MDCT scanners (Light speed; Saurav Medical System, Shahpur Jat, Delhi). Standard scanning parameters were used with slice thickness 3.70, 120 kV, and automated mAs. The radiologist was blinded to the clinical and laboratory data before reviewing CT scans. The mean attenuation values (HU) of the pleural fluid with SD were estimated by determining the region of interest. Region of interest was placed in the area of the maximal fluid accumulation on the axial plane at each three contiguous slices in the same region. The average of the attenuation values at the three levels was calculated.

Statistical analysis

SPSS (version 20; IBM, Armonk, New York, USA) was used for analyzing the collected data. The nominal data were expressed in the form of frequency (percentage), and continuous data were expressed in the form of mean±SD or range. Student's t-test used to compare between continuous data whereas the nominal data were compared by the χ^2-test. Receiver operating characteristics (ROC) curve analysis was performed to investigate the efficacy of the attenuation values when diagnosing the exudate and transudate. The sensitivity, specificity, P value, and area under the curve were calculated for the attenuation values. The cutoff values were determined to predict the differentiation of exudate and transudate effusions. Statistical significance was defined as P less than 0.05.

Results

The current study included 79 patients with pleural effusion with mean age was 51.37 years, and the age range was between 21 and 79 years. Male-to-female ratio in this study was 1.07. Patients with exudate effusion had a mean age of 52.58 years with range between 22 and 79 years, versus 47.81 years, with range between 21 and 66 years, for those with transudate type. It was noticed that age of patients had no significant difference between those with transudate type and those with exudate type with P value of 0.15.

Table 1 Demographic data of the studied patients

Variables	Patients with exudate (n=60)	Patients with transudate (n=19)	P value
Age (years)	52.58±12.79 (22–79)	47.81±13.51 (21–66)	0.15
Sex (male/ female)	30 (50)/30 (50)	11 (59.9)/8 (42.1)	0.47

Data were expressed in the form of mean±SD (range) or n (%) as appropriate. P<0.05, significant.

Although there was a male predominance in patients with transudate effusion (57.9 vs. 50% in the case of patients with exudate type), sex had no significant statistical difference between both groups (P=0.47; Table 1).

According to Light's criteria, 60 (75.9%) patients had exudate pleural effusion and 19 (24.1%) had transudate type. Mean±SD of attenuation value was 18.49±6.05 HU, with range between 5 and 36.33 HU for all patients. Patients with exudate pleural effusion had significantly higher attenuation values in comparison to those with transudate effusion [20.11±7.11 (5–36.33) vs. 13.8±4.11 (7.67–22) HU, with P=0.03; Fig. 1].

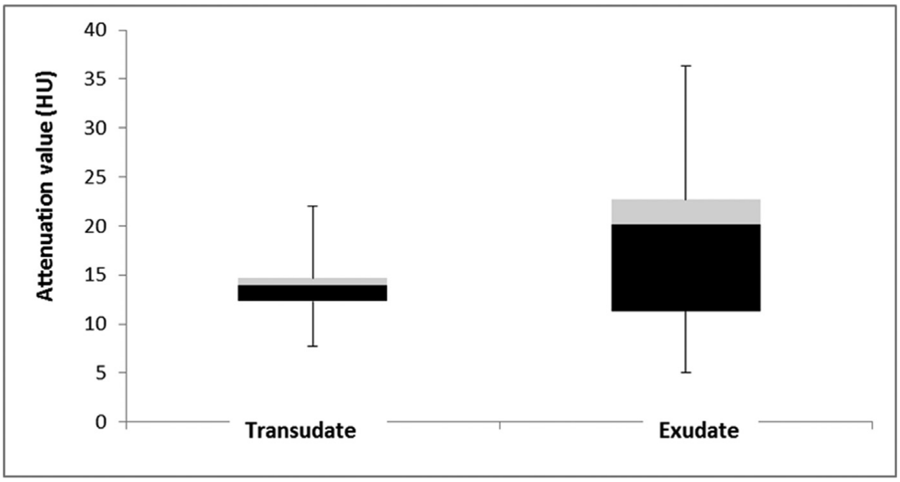
The most frequent causes of exudate effusion in the current study were pneumonia and malignant diseases, each of them recorded in 20 (25.3%) and 18 (22.8%) patients, respectively. Liver cirrhosis is the predominant cause of transudate effusion where it presented in 10 (12.6%) patients. Other etiologies and their attenuation values of effusion were presented in Table 2.

The diagnostic accuracy of attenuation value for detecting the nature of effusion is shown in Table 3 and Fig. 2. ROC curve analysis showed that the cutoff for exudate effusion was optimal at greater than or equal to 15.33 and less than 15.33 HU for transudate (area under the curve=0.57; 95% confidence interval: 0.45–0.68). This point had 85.71% sensitivity and 46.55% specificity.

Discussion

We carried out this study in the hope that we will get an answer to the question in the title of this research; thus, we planned to evaluate the ability of CT to diagnose the nature of the pleural effusion and to characterize the pleural effusion to either exudate or transudate on the basis of the attenuation values of the pleural fluid. We have relied on a logical assumption that the attenuation value of the pleural fluid in exudate effusion will be higher than those of transudate, because exudate fluid usually contains high level of

Figure 1



Box plots showing the attenuation values for transudative and exudative effusion. The boxes stretch from the 1st quartile to the 3rd quartiles. The junction between each two boxes is the mean. The vertical lines with whiskers extending below and above the boxes indicate the minimum and maximum values, respectively. HU, Hounsfield Unit.

Table 2 Causes of pleural effusion and their computed tomography-attenuation values among the studied patients

Causes	Number of cases [*n* (%)]	Attenuation values [mean ±SD (range)] (HU)
All cases	79	18.49±6.05 (5–36.33)
Patients with transudate	19 (24.1)	13.8±4.11 (7.67–22)
Liver cirrhosis	10 (12.6)	12.5±2.5 (7.6–16.67)
Congestive heart failure	7 (9)	15.61±4.3 (8.67–22)
Renal disease	2 (2.5)	13.83±0.2 (13.67–14)
Patients with exudate	60 (75.9)	20.11±7.11 (5–36.33)
Pneumonia	20 (25.3)	16.6±4.9 (9–23.67)
Malignant disease	18 (22.8)	17.67±4.03 (5–25)
Empyema	12 (15.2)	21.11±6.5 (7.6–36.33)
Tuberculosis	5 (6.3)	17.4±2.9 (13–19.67)
Pulmonary embolism	5 (6.3)	12.2±4.7 (5–18)

HU, Hounsfield Unit.

Table 3 Diagnostic indices of the computed tomography-attenuation value in determining the nature of effusion

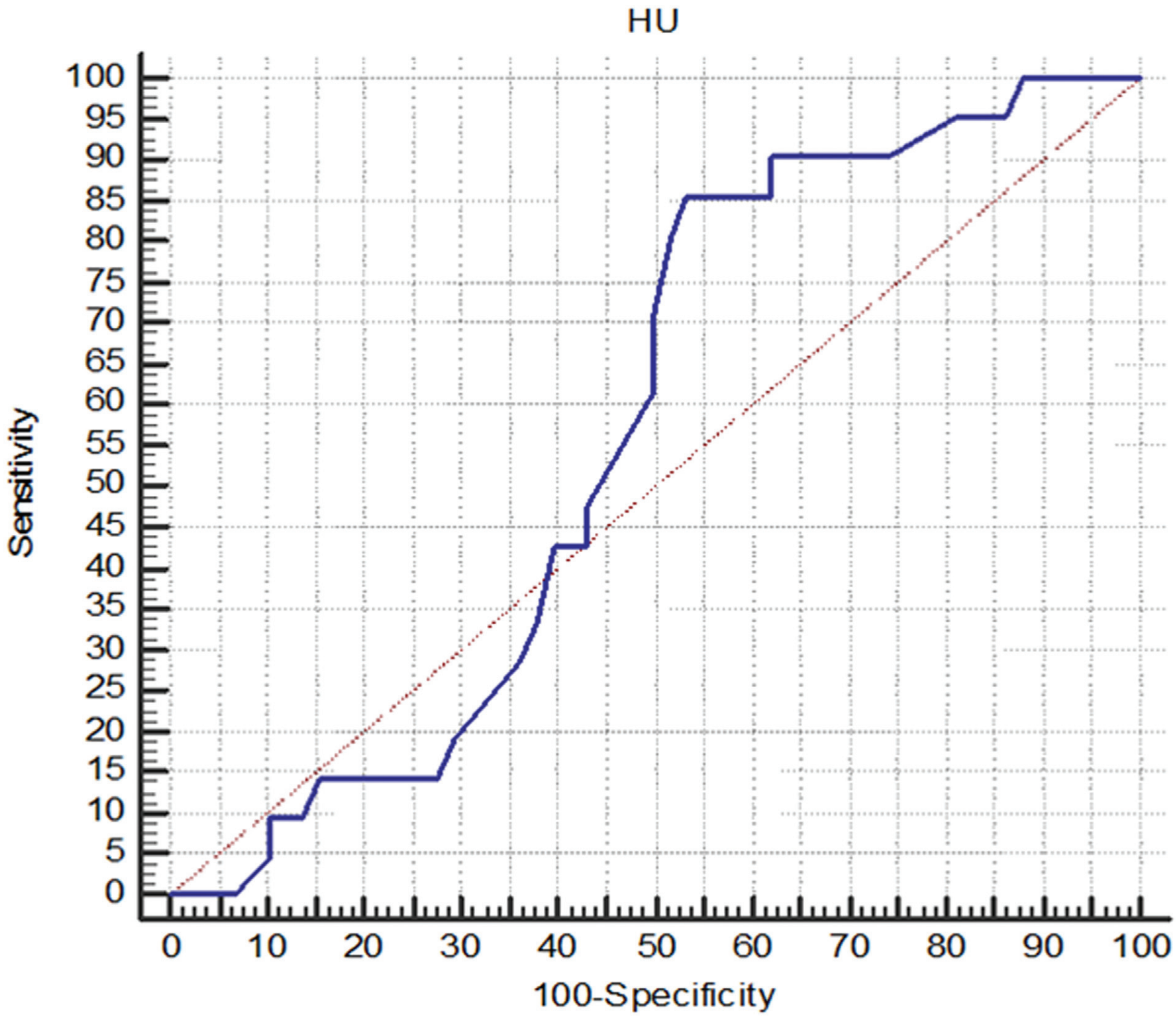
Indices	Value
Area under the curve (%)	57
Sensitivity (%)	85.71
Specificity (%)	46.55
Positive predictive value (%)	36.7
Negative predictive value (%)	90
P value	0.001

protein, which potentially can show increased attenuation on a CT scan.

A total of 79 patients were included in this study. We found that patients with exudate pleural effusion had significantly higher attenuation values (20.11±7.11 HU) in comparison with those with transudate (13.8 ±4.11 HU). Nandalur *et al.* [10] examined 145 patients with pleural effusion. They found that the mean attenuation values of the exudate fluid (17.1±4.4 HU) were significantly higher than those of transudate (12.5±6.3 HU). Similar outcome was reported by Çullu *et al.* [11] in their study. They concluded that the mean HU values of the exudate (13.6±5.5 HU) were significantly higher than those of the transudate (6±3.2 HU). Moreover, the same result was observed by Rashid *et al.* [12] in their work. They observed that the mean attenuation values of exudate were significantly higher than transudate effusion (8.1 ±5.69 vs. 3.53±4.23 HU). In contrast, different result was obtained in a work by Abramowitz and his coworkers. The mean HU values of exudate (7.2±9.4 HU) were lower than the mean HU values of the transudate (10.1±6.9 HU). However, the difference was not statistically significant. They interpreted that result by the possible contradiction between the high concentration of protein in pleural exudate, which is expected to raise the attenuation value, and the high cholesterol level, which reduces the attenuation value [13].

With regard to the diagnostic accuracy of the fluid attenuation value for detection of the nature of the effusion in our study, ROC curve analysis showed that the cutoff for exudate effusion was optimal at greater than or equal to 15.33 HU, whereas for transudate effusion was less than 15.33 HU, with sensitivity (85.71%) and specificity (46.55%). Various cutoff, sensitivity, and specificity values were registered in other studies. Although Çullu

Figure 2



Receiver operating characteristic curve shows the diagnostic indices of the computed tomography-attenuation value in determining the nature of effusion.

et al. [11] found that the cutoff value for exudate effusion was at least 8.5 with the sensitivity (85%) and specificity (86.7%), Rashid *et al.* (12) observed that the cutoff point was 4.5 HU, with sensitivity 74.46% and specificity 62.5%. Yalçin-Şafak *et al.* [14] found cutoff value for exudate effusion of at least 5 HU, and the sensitivity and specificity were 72 and 70%, respectively.

Some authors attributed the variation in the attenuation values among the studies to the number of cases included in each study in general and the number of cases for each type of pleural effusion in particular. Others said the reason may be because of using different CT scanners with different scanning parameters. Moreover, the interval between thoracentesis and CT scan may have had an effect on the results in some studies. Medicines that were taken by some patients during the study, such as diuretics, altered the pleural fluid chemistry in other studies.

Conclusion

We reasoned the CT attenuation values of the pleural fluid may replace the laboratory tests in characterizing the pleural effusion into either exudate or transudate. However, there was an overlapping HU values in most effusions. So correlation of the CT results with the clinical findings is essential, and further CT studies are highly recommended to confirm and validate these findings.

Financial support and sponsorship

Nil.

Conflicts of interest

The number of the studied patients with transudate effusion and some of those with exudate was not enough to ensure good evaluation. We did not take into account measuring the cholesterol level in the pleural fluid.

References

1 Sahn SA. The pleura. *Am Rev Respir Dis* 1988; **138**:184–234.

2 Light RW. *Pleural disease*. 3rd ed. Baltimore: Williams and Wilkins; 1995.

3 Broaddus VC, Light RW. What is the origin of pleural transudates and exudates? *Chest* 1992; **102**:658–659.

4 Light RW, Macgregor MI, Luchsinger PC, Ball WC Jr. Pleural effusions: the diagnostic separation of transudates and exudates. *Ann Intern Med* 1972; **77**:507–513.

5 Collins TR, Sahn SA. Thoracocentesis: clinical value, complications, technical problems, and patient experience. *Chest* 1987; **91**:817–822.

6 Grogan DR, Irwin RS, Channick R, Raptopoulos V, Curley FJ, Bartter T, *et al.* Complications associated with thoracentesis: a prospective, randomized study comparing three different methods. *Arch Intern Med* 1990; **150**:873–877.

7 Jones PW, Moyers JP, Rogers JT, Rodriguez RM, Lee YC, Light RW. Ultrasound-guided thoracentesis: is it a safer method? *Chest* 2003; **123**:418–423.

8 Ahmed ES, Abou Bakr SM, Eid HA, Shaarawy AT, Elsayed WT. Role of ultrasonography in the diagnosis of pleural effusion. *Egypt J Bronchol* 2017; **11**:120–127.

9 Arenas-Jiménez J, Alonso-Charterina S, Sánchez-Payá J, Fernández-Latorre F, GilSánchez S, Lloret-Llorens M. Evaluation of CT findings for diagnosis of pleural effusions. *Eur Radiol* 2000; **10**:681–690.

10 Nandalur KR, Hardie AH, Bollampally SR, Parmar JP, Hagspiel KD. Accuracy of computed tomography attenuation values in the characterization of pleural fluid: an ROC study. *Acad Radiol* 2005; **12**:987–991.

11 Çullu N, Kalemci S, Karakaş Ö, Eser İ, Yalçın F, Boyacı FN, *et al.* Efficacy of CT in diagnosis of transudates and exudates in patients with pleural effusion. *Diagn Interv Radiol* 2014; **20**:116–120.

12 Rashid RJ, Jalili J, Shohreh Sadr Arhami SS, Heris HK, Habibzadeh A, Mohtasham MA. The accuracy of chest computed tomography findings in differentiation of exudative form transudative pleural effusion. *J Clin Anal Med* 2015; **6**:341–344.

13 Abramowitz Y, Simanovsky N, Goldstein MS, Hiller N. Pleural effusion: characterization with CT attenuation values, and CT appearance. *AJR Am J Roentgenol* 2009; **192**:618–623.

14 Yalçin-Şafak K, Umarusman-Tanju N, Ayyıldız M, Yücel N, Baysal T. Efficacy of computed tomography (CT) attenuation values, and CT findings in the differentiation of pleural effusion. *Pol J Radiol* 2017; **82**:100–105.

15 Jasim AH, Fahad QA, Jabbar JA. Pleural effusion: characterization with contrast CT appearance and CT attenuation values. *J Fac Med Baghdad* 2014; **56**:30–35.

16 Thiravit P, Juengsomrasong P, Thiravit S. Computed tomography in differential diagnosis of exudative and transudative pleural effusions. *Siriraj Med J* 2017; **69**:51–56.