The Accuracy of Chest Computed Tomography Findings in Differentiation of Exudative from Transudative Pleural Effusion

Transuda ile Eksuda Plevral Sıvının Göğüs Bilgisayarlı Tomografi Bulgularıyla Ayırımının Doğrulanması

Plevral Efüzyonun BT Bulguları / CT Findings of Pleural Effusion

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Özet

Amaç: Tomografinin(CT) transuda veya eksuda ayırımında kullanımı tartışmalıdır. Bu çalışmanın amacı CT'nin plevral effüzyonun karakterini belirlemede yararlı olup olmadığını değerlendirmektir. Gereç ve Yöntem: Plevral effüzyonu olup Toraks CT ve diyagnostik torasentez yapılan 100 hasta değerlendirildi. Effüzyonlar Light kriterlerine göre eksuda ve transuda olarak sınıflandırıldı. CT'ler effüzyonun , lokulasyon ve plevral kalınlaşma gibi diğer CT özelliklerinin ortalama Hounsfield değerlerini belirlemek için 2 radyolog tarafından değerlendirildi. Bulgular: Plevral sıvı 58 hastada eksuda; 42 hastada transudaydı. Eksudatif effüzyonda transudaya göre belirgin olarak yüksek ortalama atenüasyon değerleri(8.1±5.69 vs. 3.53±4.23 HU;p<0,001), yüksek lokulasyon (%91.4 vs. %64.3;p=0,002) ve yüksek plevral kalınlaşma (%50.9 vs. %19.5; p=0,002) değerleri vardı. Eksuda,transuda ayırımında sensitivite,spesifite >4.5 HU'da atenüasyon değeri için %74.6 ve %62.5, lokülasyon için %66,25 ve %75;plevral kalınlaşmada %78.38 ve %54.10'du. Tartışma: Atenüasyon değeri ve lokulasyon diğer özelliklerle karşılaştırıldığında göreceli olarak iyi sensitivite ve spesifiteye sahipti ve effüzyonların ayırımında daha iyi olabilirdi. Ancak,torasentez ile karşılaştırıldığında, Effüzyonun natürünü değerlendirmek için CT daha güvenli bir metod değildir. Torasentezin kontrendike olduğu vakalarda daha kullanışlı olabilir.

Anahtar Kelimeler

Plevral Efüzyon; Eksuda; Transuda; Bilgisayarlı Tomoğrafi; Atenüasyon

Abstract

Aim: There is a controversy in the usefulness of computed tomography (CT) in differentiating transudate or exudates. The aim of this study is to evaluate the utility of CT in characterizing pleural effusions. Material and Method: We evaluated 100 patients with pleural effusions who underwent chest CT and diagnostic thoracentesis. Effusions were classified as exudates or transudative on the basis of Light's criteria. CTs were reviewed by two radiologists to determine the mean Hounsfield unit value of an effusion and other CT features including loculation and pleural thickening. Results: Pleural fluid was exudative in 58 patients and transudative in 42 patients. Exudative effusion significantly had higher mean attenuation values (8.1±5.69 vs. 3.53±4.23 HU; p<0.001), higher loculation (91.4% vs. 64.3%; p=0.002) and higher pleural thickening (50.9% vs. 19.5%; p=0.002) than transudative effusion. Sensitivity and specificity in differentiating exudative from transudative effusion was 74.46% and 62.5% for attenuation value of >4.5 HU, 66.25% and 75.00% for loculation, and 78.38% and 54.10% for pleural thickening. Discussion: Attenuation value and loculation had relatively good sensitivity and specificity in comparison to other features and could better differentiate between effusions. However, in comparison to thoracentesis, CT scan is not a more reliable method to evaluate the nature of the effusion and would be useful only in cases with contraindications of thoracentesis.

Keywords

Pleural Effusion; Exudates; Transudate; Computed Tomography; Attenuation

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Introduction

Pleural effusion is a common clinical problem that has many potential causes [1, 2]. In order to determine its etiology, it is necessary to evaluate the exudative or transudative characteristics of pleural effusion. Transudative effusion is a decrease in capillary hydrostatic pressure or decrease in oncotic pressure. The membrane of pleura is normal. Exudative pleural effusion has high protein content and usually is caused by an increase in the permeability of capillary due to inflammatory processes or neoplasm that affects the pleura [2-4].

Thoracentesis is usually performed for diagnosis of pleural exudates and transudates. However, it is accompanied by some minor and major complications including pain, persistent cough, hematoma, dyspnea subcutaneous fluid collection, pnemuthorax, pneumohemothorax and splenic laceration [5-7]. Thoracentesis also have some relative contradictions such coagulation disorders, using anticoagulation, low value of pleural effusion, mechanical ventilation, inability of patient to cooperate, skin disease and other infections in the puncture site. Hence, the use of an alternative technique will be specifically beneficial for patients who show contradiction to invasive diagnostic methods [6, 7].

Several imaging methods such as computerized tomography (CT) scan, sonography and magnetic resonance imaging (MRI) are being used for the diagnosis and assessment of etiology of pleural effusion. CT has been evaluated for the diagnosis of pleural exudates and transudates [8, 9]. It is shown that exudative effusions have higher attenuation, but there was an overlap in the overall accuracy of attenuation values for identifying exudates and transudates [10]. Also in a recent study by Abramowitz and colleagues [11] although exudative effusions had more CT findings than transudate effusions, but this modality could not accurately differentiate between exudates and transudates. There is a controversy in the results of these studies; in this study, we aimed to evaluate the efficacy and accuracy of CT in differentiation of exudative and transudative pleural effusions.

Material and Method

During February 2010 and February 2011, one hundred patients with pleural effusion undergoing thoracentesis and chest CT in a teaching hospital (Imam Reza hospital Tabriz, Iran) were studied. The inclusion criteria were patients with first time pleural effusion and willingness to participate in the study. Exclusion criteria were as follows: patients <15 or >89 years old, recurrent pleural effusion, any contraindication for pleural biopsy or medical thoracoscopy, or any other systemic disease that could affect CT scan. Patients were also excluded from the study if they had a pleural tube inserted when CT was performed, if they showed two or more possible causes for the pleural effusion, or if they presented a long-term evolution of the pleural effusion before CT scanning. The study protocol was approved by the institutional ethics review board and informed consent was obtained from all patients.

The present study was limited to the data from pleural effusion at the first thoracentesis. Diagnostic thoracocentesis was considered for the purpose of this study only if it was performed during 2 weeks before or after the CT examination. Light's criteria was used for differentiating transudate from exudate; exudative effusion was defined as meeting at least one of the following three criteria: 1. Pleural fluid LDH level ≥2/3 of the upper limits of the normal serum LDH value; 2. Pleural fluid LDH/serum LDH value>0.06; and 3. Pleural fluid protein/serum protein level>0.5 [12]. If the effusion did not meet any of these criteria, it was considered as a transudate.

All chest CT scans were performed on 16-MDCT scanner in Imam Reza Hospital and 64-MDCT scanner in Shahid Madani Hospital (all Siemens Medical Systems, Forchheim, Germany). Contiguous 0.6- to 2-mm-thick sections were performed. Appropriate mediastinum and lung-window images were obtained from all patients. The CT images were reviewed independently by two observers who were blinded to the final diagnosis of the pleural effusion. Interobserver disagreement was solved by consensus. All readers were experienced in interpreting CT scans of the chest.

The average of the measurements for three slices was used to assess the attenuation of pleural effusion. Maximum liquid associated with largest anterior-posterior diameter was used. A region of interest for Hounsfield unit values of the maximum amount of liquid on each slice was measured. All CT scans were also reviewed for the presence of additional pleural effusion features.

Effusion is called loculated when it has septation or collected fluid in the fissure or nondepended part of pleura and also when it has convex shape against the lung parenchyma. Concave effusion in the depended part of pleura was considered as a free pleural effusion. Thickening of partial pleura was called only when the pleural line was seen inner of ribs and was thicker than 4 millimeter (mm). Thickening of visceral pleura was called when one pleural line was observed in the adjacent lung level and the line could reliably be differentiated from the compressed lung. Loculation of pleural fluid, pleural thickness, pleural enhancement and other data from the lung and mediastinum were also studied.

Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences, version 16.0 (SPSS, Chicago, Illinois). Continuous values were expressed as mean ± standard deviation. The categorical parameters were compared by x2 tests or Fisher's exact test, and the continuous variables were compared by Student's t-tests. Receiver operating characteristic curve (ROC) was drawn to determine the accuracy of attenuation value for diagnose of exudative using the area under the ROC curve. ROC curve was also used to determine optimal threshold value for classification of transudative and exudative effusions based on Hounsfield unit. The usefulness of each feature for identifying exudates and transudates was also evaluated by calculating the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). A p value <0.05 was considered significant.

Results

A total of 100 patients underwent chest CT and thoracentesis between February 2010 and February 2011. There were 69 male and 31 female patients with a mean age of 62.5 (15 – 89) years. Pleural fluid was exudative in 58 patients and transuda-

tive in 42 patients.

Among 100 patients, pleural effusion was bilateral in 64 cases; right-sided effusion in 19 cases and left-sided in 15 cases. The evaluation of effusion side in 2 patients was not possible. They were free in 80 patients and loculated in 20.

Attenuation:

Among 100 patients, we failed to measure attenuation values of 21 patients due to lack of reliable information. Of remaining 79 patients including 47 exudates and 32 transudates, the mean attenuation of exudates was significantly higher than transudative effusion (8.1±5.69 HU vs. 3.53±4.23 HU; p<0.001). The maximum attenuation value of exudative and transudative effusion was 29 and 11 HU, respectively; and the minimum attenuation value of exudative and transudative effusions was -5 and -6, respectively. Eight patients had a negative HU value including 5 cases of transudative effusions and 3 cases of exudative effusion.

ROC curve was used to evaluate the accuracy of attenuation values in the identification of exudates among 79 patients with available attenuation values (figure 1). Area under curve was 0.747 with 95% confidence interval 0.639-0.855. ROC curve showed a significant accuracy in differentiating exudates from transudates (p<0.001). With a cut-off point of 4.5 HU according to the ROC curve, we observed a sensitivity and specificity of 74.46% and 62.5% respectively. Positive and negative likelihood ratio (PPV and NPV) were 74.47% and 62.50%, respectively.

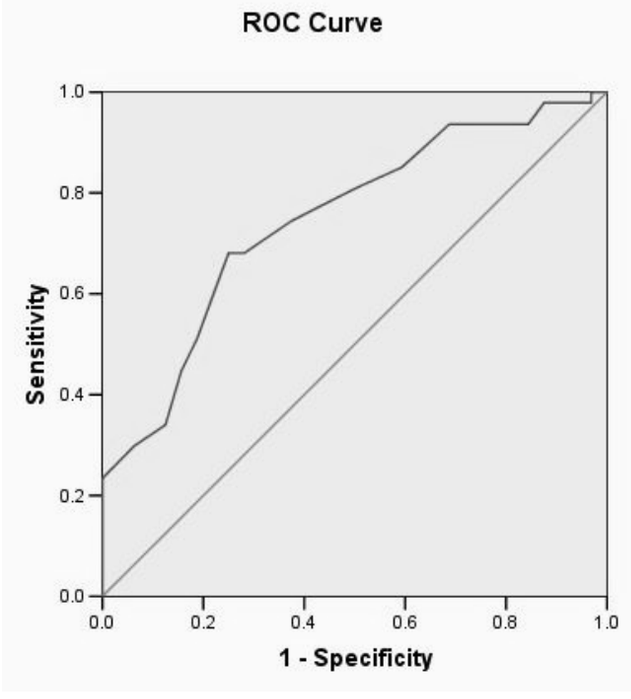


Figure 1. Graph shows receiver operating characteristic (ROC) curve. Area under ROC curve was 0.747 with standard error of 0.055 and p<0.001.

Loculation

Loculation was observed in 53 (91.4%) of exudative and 27 (64.3%) of transudative effusion (p=0.002). The calculated sensitivity, specificity, PPV and NPV for loculation in differentiating between exudative and transudative effusions were 66.25%, 75.00%, 91.38% and 35.71%, respectively.

Pleural thickening

Among 100 patients, pleural thickening was seen in 37 patients including 29 (50.9%) of exudative and 8 (19.5%) of transudative effusions (p=0.002). In 2 patients pleural thickening evaluation was not possible (one from each group). Pleural thickening has sensitivity, specificity, PPV and NPV of 78.38%, 54.10%, 50.88% and 80.49% for diagnosing exudative from transudative effusions.

Pleural enhancement

CT scans were with contrast only in 18 patients and without contrast in 82. Pleural enhancement though was evaluated in the 18 patients with contrast CT; which was seen in 5 patients all with exudative effusions, while no enhancement was seen in 5 patients with exudate and 8 patients with transudative effusions. Due to lower rate of CT with contrast, we were not able to evaluate pleural enhancement sensitivity and specificity.

Associated findings in lung and mediastinum

Mediastinal and lung abnormalities (emphysema, pulmonary embolism, heart failure and others) were reported in 74 patients. These reported abnormalities in CT were significantly higher in exudative effusions (54 cases, 93.1%) than transudative effusions (20 cases, 47.6%; p<0.001). The calculated sensitivity and specificity for differentiating exudative from transudative effusions was 72.97% and 84.62%, respectively. PPV and NPV was 93.10% and 52.38%, respectively.

Discussion

Differentiating exudative from transudative pleural effusions is the first step in defining proper treatment of the disease. Although thoracentesis is a routine method for evaluation of pleural effusion, it is aggressive and could have some complications. Computed tomography is one of modalities that could be able differentiate these two. In this study we evaluated CT in patients with pleural effusion and observed significant differences in CT findings between exudative and transudative effusions.

We observed higher attenuation in exudative effusions than transudative effusions. We found a good correlation between high attenuation values and being exudative effusion in our study. Attenuation value had relatively good sensitivity and specificity (74.46% and 62.5%, respectively) for a threshold value of 4.5 HU. In the study of Nandalur et al. [10] examining 145 patients, they also observed higher attenuation values for exudative than transudative effusions (17.1 HU vs. 12.5 HU). However, there values were higher than our findings (8.1 and 3.53 HU, respectively). They observed specificity of 71% and sensitivity of 83% for an optimal threshold value of 13.4 HU for differentiating transudates from exudates.

Unlike these findings in our study and Nandalur et al. [10] in the study of Abramowitz et al. [11] evaluating 100 patients, exudative effusion had non-significantly lower attenuation value than transudative effusion. Their calculated values in comparison to our findings were lower in exudative and higher in transudative effusions. They also reported low sensitivity and specificity for an optimal threshold value of 8.5 HU.

Although almost the same methodology was used in these three studies but we could not definitively found the reason for different Hounsfield unit values in these studies; One possibility is

that the interval between thoracentesis and CT scan was different in these 3 studies; this can cause treatment effect on biochemical markers and the pleural effusion Hounsfield unit value. Another possibility could be using three different scanners and protocols in these studies.

We also evaluated several pleural effusion CT features and observed significantly higher rates of loculation and pleural thickening in exudative effusions than transudative effusions. The sensitivity and specificity for loculation was 62.25% and 75.00% and for pleural thickening was 78.38% and 54.10%. Few other studies have evaluated these features. Abramowitz et al. [11] also reported higher rate of loculation with the sensitivity and specificity of 58% and 64% and higher pleural thickening with sensitivity and specificity of 59% and 64%.; however, the difference between exudative and transudative effusion were not significant in their study.

Arenas-Jimenez et al. [9] in their study evaluating 211 patients, found 24 loculation that all of them had exudative effusion and reported the highest specificity (100%), but the lowest sensitivity (12.9%). Likewise, they observed pleural thickening only in exudative effusions with sensitivity of 42% and specificity 100%. Waite and colleagues [13] observed the same finding for pleural thickening in differentiating between exudative and transudative effusions. Aquino et al.8 among 86 patients with pleural effusion, also observed pleural thickening only in one patient with transudative and 36 patients with exudative effusions with sensitivity of 61% and specificity of 96%. Unlike these studies, Wolek et al. [14] reported lower specificity and higher sensitivity (50% and 100% respectively) of pleural thickening. As most of these studies were performed during last two decades as Abramowitz et al. [11] has mentioned, and so elevation of the quality of the CT scans during these years could be a cause for this increased sensitivity and specificity.

However, the positive and negative predictive values for CT parameters were low in our study study. This low predictive value is a limitation for using the CT scan as a diagnostic tool for differentiating exudative from transudative pleural effusion.

This study faced with some limitations: most of our CT scans were without contrast and so we could not evaluate other features like nodularity. The lack of some findings like attenuation values in some patients could be effective in the results.

Conclusion

Among these findings in our study, attenuation value and loculation had relatively good sensitivity and specificity and could be used for differentiating exudative from transudative pleural effusions in comparison to other features. However, due to low predictive values and sensitivity and specificity, in comparison to thoracentesis, CT scan is not a more reliable method to evaluate the nature of the effusion and would be useful only in cases with contraindications of thoracentesis.

Competing interests

The authors declare that they have no competing interests.

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