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Thoracic CT Scan Image in Transudate and Exudate Pleural Effusion Cases at Haji Adam Malik General Hospital Medan in January - September 2024

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ABSTRACT

Introduction: Pleural effusion is the most common pleural disease, typically diagnosed through thoracentesis. However, thoracentesis carries risks of complications. Chest CT scans offer a non-invasive alternative to assess pleural effusion and distinguish between exudate and transudate types.

Methods: This retrospective cross-sectional study was conducted on patients with pleural effusion at Haji Adam Malik General Hospital, Medan. A total of 80 patients were included. Statistical analysis was performed to evaluate the correlation between demographic, clinical, and thoracic CT findings with the type of pleural effusion. The Mann-Whitney test determined the efficacy of attenuation values in differentiating exudate and transudate.

Results: Of the 80 patients, 57 (71.3%) had exudative pleural effusion and 23 (28.7%) transudative. The sample comprised 43 males (53.8%) and 37 females (46.3%), with a mean age of 48.44 ± 18.532 years (range: 2–84 years). Significant correlations were found between the etiology of pleural effusion and pleural nodules with effusion type ($p = 0.000$ and $p = 0.023$, respectively). No significant correlations were observed between age, gender, or other CT findings with effusion type ($p > 0.05$). Attenuation values on CT scans effectively distinguished exudative from transudative effusion ($p = 0.000$). A cutoff attenuation value of 17.5 Hounsfield Units (HU) demonstrated an AUC of 0.887, with 84.2% sensitivity and 82.6% specificity.

Conclusions: Thoracic CT scans are effective for differentiating exudative and transudative pleural effusion. Significant differences were identified in etiology, pleural nodules, and attenuation values, supporting the use of CT imaging as a non-invasive diagnostic method

Keywords

Pleural Effusion, Exudate, Transudate, Thoracic CT Scan

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INTRODUCTION

Pleural effusion is a manifestation that occurs due to the accumulation of fluid in the pleural cavity, namely the space between the parietal pleura and the visceral pleura. Under normal conditions, healthy humans have a minuscule pleural fluid that lubricates the space and facilitates normal lung movement during breathing. This fluid balance is controlled by oncotic and hydrostatic pressure and lymphatic drainage, if there is a disturbance in one of these systems, pleural fluid will accumulate.[1]

Pleural effusion is generally grouped into transudate and exudate. Transudate pleural effusion occurs when systemic factors that impact pleural fluid's (hydrostatic and oncotic pressure) formation and absorption are affected so that pleural fluid accumulation is detected in the pleural cavity, for example in heart failure

(HF) patients. Pleural effusion is referred to as exudate when the pleural or lung surface shows increased vascular permeability, for example due to malignant pleural growth.[2]

When a patient is suspected of having pleural effusion, a plain chest radiological examination should be performed for a definitive diagnosis. On a plain chest radiograph, an abnormal image will be found in the posteroanterior (PA) position with a fluid volume of 200 mL and in the lateral position with a fluid volume of at least 50 mL. If a plain chest radiograph is unable to establish a diagnosis, a computed tomography (CT) scan and ultrasonography (USG) can be performed. CT scan examination is able to detect pleural effusion that is not visible on a plain chest radiograph and is able to determine pleural fluid from pleural thickening, so it can help in determining the etiology of the pleural effusion experienced by the patient.[3]

Clinically, transudate and exudate pleural effusion can be distinguished by Light's criteria. The pleural effusion's nature is based on the diagnosis through thoracentesis, but complications from thoracentesis can be avoided by conducting a CT scan as an evaluation. CT scan images such as extrapleural fat tissue thickness, pleural nodules, pleural density, pleural thickening, and loculation can be assessed to distinguish between transudates and exudates. In previous studies, differences in Hounsfield Unit (HU) attenuation values were found in CT scan results of patients for pleural effusion evaluation.[4] Research on the use of CT scans to diagnose transudate and exudate pleural effusions is still very limited, especially domestically. To our knowledge, there has only been 1 reported study in Indonesia regarding this subject, therefore this study was aimed to acquire and analyze the data of CT scan image of the thorax in patients with transudate and exudate pleural effusion at Haji Adam Malik General Hospital Medan.

METHOD

This study is a descriptive analytical study with a retrospective cross-sectional study design conducted in Haji Adam Malik General Hospital Medan during August – October of 2024 and was conducted after obtaining approval from the Research Ethics Committee of the Universitas Sumatera Utara. This study's population included patients with pleural effusion who suit the criteria of inclusion and exclusion.

Patients with a pleural effusion diagnosis who had a thoracic CT scan and thoracentesis resulting from the CT scan were the study's inclusion criteria. Incomplete medical records were excluded. The data normality test of distribution was calculated using the Kolmogorov-Smirnov test, while the categorical variables' comparison between groups was accomplished using the Pearson Chi-Square test. The variables' continuity between groups was calculated utilizing the Mann-Whitney U test. The attenuation value's efficacy was determined using Receiver operating curve (ROC) analysis to differentiate exudate and transudate effusions. The attenuation value was based on the calculation of specificity, sensitivity, P-value, and area under the curve (AUC). The differentiation of transudate and exudate effusions was based on the cutoff value with statistical significance stated as $P < 0.05$. The data will be processed using the SPSS (Statistical Product and Service Solution) program, then the results will be analyzed descriptively-analytically.

RESULTS

A total of 80 samples that met the inclusion and exclusion criteria were acquired. Of the 80 samples, 57 (71.3%) exudate patients and 23 transudate patients (28.7%) were found (Table 1).

Table 1. Distribution of Pleural Effusion

	Frequency (n)	Percentage (%)
Exudate	57	71,3
Transudate	23	28,7
Total	80	100

A sample of 37 females (46.3%) and 43 males (53.8%) was obtained. It was also found that the age group with the most pleural effusion was in the adult group (19-59 years) at 60% and the least was found in the infant and toddler group (<5 years) at 1.3% with an average age of 48.44 ± 18.532 (2-84) years (Table 2).

Table 2. Demographic Distribution of Pleural Effusion

	Frequency (n)	Percentage (%)
Gender		
Female	37	46,3
Male	43	53,8
Age		
Infant and toddler	1	1,3
Teenager	5	6,3
Adult	48	60
Elderly	26	32,5

The normality test in the present study was conducted using the Kolmogorov-Smirnov method due to the samples number was more than 50 samples and the results obtained were a p-value <0.05 which explained that the data was not normally distributed, so the non-parametric Mann-Whitney U test was used. In the Mann-Whitney U Test, p-value = 0.000 was obtained which showed a significant difference between the two groups (Hypothesis 0 was rejected), where the exudate pleural effusion group had a mean of 23.25 ± 6.913 HU, significantly higher than the transudate pleural effusion with a mean of around 14.39 ± 6.423 HU.

Chi-square correlation test was also carried out to find out the categorical variables' correlation from demographic characteristics and CT scans to the type of pleural effusion in 80 samples, the results of which can be seen in Table 3. Exudate pleural effusion consisted of 25 women and 32 men which consisted of 1 infant and toddler, 4 adolescents, 36 adults and 16 elderly; while transudate consisted of 12 women and 11 men which consisted of 1 adolescent, 12 adults and 10 elderly. In this study, from the demographic aspect however, no significant correlation was found between pleural effusion type and gender (p = 0.5) and age (p = 0.548). Based on etiology, the most cases in exudate patients were due to tumors and malignancies with a total of 34 samples, while in transudate the most common cause was HF with a total of 7 samples, a positive correlation was also found between the etiology of patients with the type of pleural effusion (p = 0.000).

Table 3. Demographic Characteristics in Pleural Effusion Patients

	Exudate (n=57)	Transudate (n=23)	p
Gender			
Female	25	12	0,5[a]
Male	32	11	
Age			
Infant and toddler	1	0	
Teenager	4	1	0,548[a]
Adult	36	12	
Elderly	16	10	
Etiology			
Ascites	0	2	
CVI	1	0	
Hepatitis B	0	1	
HF	1	7	
Lung Infection	2	0	0,000[a]
Tumour and Malignancy	34	5	
Pneumonia	11	2	
COPD	2	1	
Nephrotic Syndrome	0	2	
TB	6	3	

P[a] : with Chi-square correlation test
CVI: Chronic Venous Insufficiency
HF: Heart Failure
COPD: Chronic Obstructive Pulmonary Disease

In terms of CT scan findings, there were found 18 cases with pleural thickening, 11 cases with pleural nodules, 7 cases with loculation and effusion volume: 28 small, 22 medium, 7 large in the exudative patients; while in transudate patients there were 6 cases with pleural thickening, 0 cases with pleural nodules, 0 cases

with loculation and effusion volume: 14 small, 7 medium, 2 large. The type of pleural effusion was found to have no significant correlation with the presence or absence of pleural thickening (p = 0.628), loculation (p = 0.079) or effusion volume (p = 0.632), but had a significant correlation with the presence or absence of pleural nodules (p = 0.023).

Table 4. CT Scan Findings in Pleural Effusion Patients

	Eksudat (n=57)	Transudat (n=23)	p
Pleural Thickening			
Present	18	6	0,628[a]
Absent	39	17	
Pleural Nodule			
Present	11	0	0,023[a]
Absent	46	23	
Loculation			
Present	7	0	0,079[a]
Absent	50	23	
Effusion Volume			
Small	28	14	0,632[a]
Medium	22	7	
Large	7	2	
Atenuation (HU)	23,25 ± 6,913	14,39 ± 6,423	0,000[b]

P[a] : with Chi-square correlation test
P[b] : with Mann-Whitney U Test
HU: Hounsfield Unit

Next, a diagnostic test was carried out by analyzing the ROC and AUC curves on the attenuation value variables (Figure 1), which correlated significantly in determining the type of pleural effusion. In this study, a good level of diagnostic performance of the test was detected based on the obtained AUC value of 0.887. Then the cutoff value of the attenuation value is determined through the intersection plot of the Sensitivity

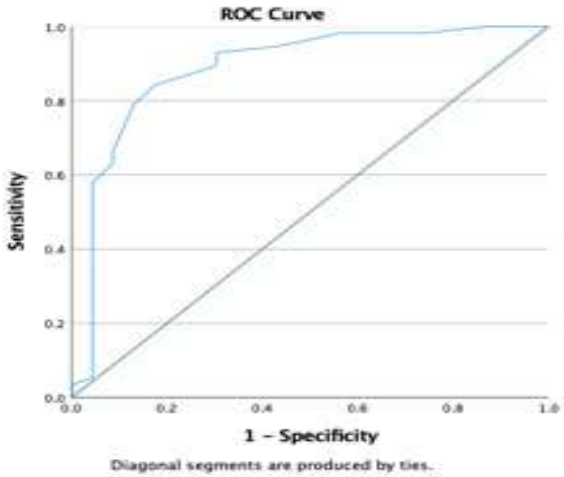

Figure 1. ROC Curve of CT Scan Attenuation Value with Pleural Effusion Type

From the plot of the intersection of the Sensitivity value and the Specificity value of the CT scan attenuation value, the cutoff value of the CT scan attenuation value in determining exudate and transudate type pleural effusion was obtained. From the results of the plot, the cutoff value of attenuation was 17.5 HU with a Sensitivity of 84.2% and a Specificity of 82.6% (Table 5).

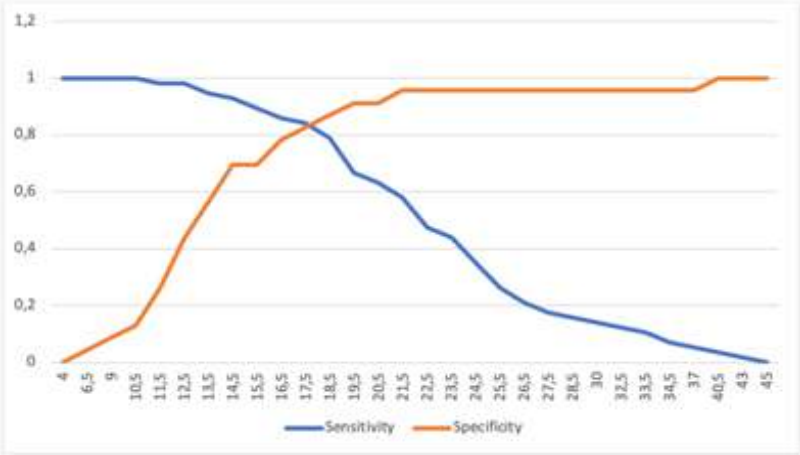

Figure 2. Intersection of Sensitivity and Specificity Values of CT Scan Attenuation Values

Table 5. ROC Curve Analysis Results of CT Scan Attenuation Values with Pleural Effusion Type

CT Scan Atenuation Cut Off Value	AUC	Sensitivity	Specificity
17,5	0,887	84,2%	82,6%

DISCUSSION

Out of 80 samples, 57 (71.3%) exudate patients and 23 transudate patients (28.7%) were found, with 37 females (46.3%) and 43 males (53.8%) and an average age of 48.44 ± 18.532 (2-84) years. In the studies of Gümüş et al. more male patients than female patients with the following values: 231 males (61%) and 149 females (39%), 52 males (65%) and 28 females (35%).[4,5] Both studies also found higher mean age results compared to this study, namely 69.9 ± 15.2 (20-107) years in the study by Gümüş et al. and 53.2 (18-98) years in the study by Bandaru & Rachegowda.[4,5] Maili et al. in Indonesia revealed through their study that the patients were dominated by > 18 years (97.5%) age with an average age of 50 (4-78) years.[6]

The normality test in this study was performed using the Kolmogorov-Smirnov method due to the sample number that exceeded 50 samples and the obtained results of p-value <0.05 which demonstrated that the data was not normally distributed, so the non-parametric Mann-Whitney U test was employed. In the Mann-Whitney U Test, a p-value = 0.000 was obtained which indicated a significant difference between the two groups (Hypothesis 0 was rejected), where the exudate pleural effusion group had a mean of 23.25 ± 6.913 HU, significantly higher than the transudate pleural effusion with a mean of around 14.39 ± 6.423 HU. These results are in line with research from Bandaru & Rachegowda which obtained a mean value of exudate pleural effusion which was also higher than transudate, which was 14.65 ± 6.07 HU compared to 4.66 ± 2.29 HU with a p-value <0.01.[6] Similar results were also found in research by Yalçin-Şafak et al. which also obtained a mean result of exudate pleural effusion of 8.82 ± 7.04 HU which was significantly higher than transudate pleural effusion with the value of 2.91 ± 8.53 and a p-value <0.001.[8] From these results, it can be inferred that the attenuation value (HU) can be used to differentiate the transudate and exudate pleural effusions.

In the present study, no significant correlation was found between gender and age with the type of pleural effusion in the sample as well, where the p-value obtained was p = 0.5 and p = 0.548 through the Chi-square correlation test. This result is in line with the study by Çullu et al. which stated that there was no significance between gender and age with the type of pleural effusion with p = 0.198 and p = 0.368.[4] A positive correlation was found between the etiology of pleural effusion and the type of pleural effusion, where the type of pleural effusion most commonly found in exudate pleural effusion was caused by tumors and malignancies (34 people), while for transudate pleural effusion, the most common cause was HF (7 people) with p = 0.000. This is different from the findings of Maili et al. who found that the most diagnoses for both transudate and exudate pleural effusions were pulmonary carcinoma, but in line with the findings of Nandalur et al. who found that the most exudate patients were diagnosed with malignant disease, as many as 39 patients, while transudate patients were diagnosed with HF, as many as 29 patients.[6-9]

A correlation test was also performed between CT scan images findings and the type of pleural effusion. There was no positive correlation between pleural thickening (p = 0.628), loculation (p = 0.079) and effusion volume p = 0.632 with the type of pleural effusion, while pleural nodules were found to have a positive correlation (p = 0.023). In the previous study by Abramowitz et al., there was also no positive correlation between pleural thickening and pleural effusion type with p> 0.1, but The previous study by Bandaru & Rachegowda, a positive correlation was discovered between pleural thickening and pleural effusion type (p <0.01).[5-10]

Based on the study by Çullu et al, different results were obtained from this study where a positive correlation was discovered between loculation and pleural effusion type (p = 0.059) while in the study by Yalçin-Şafak et al., found similar results, namely no significant correlation (p = 0.899).[4-8] Other thoracic CT scan images that did not find a positive correlation with pleural effusion type were that the volume of pleural effusion found was more often small in both exudates (28 of 57 patients) and transudates (14 of 23) with p = 0.632. Research conducted by Bandaru & Rachegowda agrees with the results of this study, where a positive correlation was found between nodules and pleural effusion type, namely p = 0.03, but research by Çullu et al. obtained different results, namely no correlation with the results obtained p = 0.532.[5-8]

Furthermore, a diagnostic test was carried out with ROC and AUC curve analysis on the attenuation value variable, which correlated significantly in determining pleural effusion type. The AUC value ranges from 0.5 (equivalent to chance) to 1 (perfect discrimination). In this study, an AUC value of 0.887 was obtained, indicating a good level of diagnostic performance of the test, where the interpretation of the AUC value is based on its clinical ability, namely: AUC> 0.9 indicates very good, 0.9> AUC> 0.8 indicates good, 0.8> AUC> 0.7 indicates moderate, 0.7> AUC> 0.6 indicates poor and 0.6> AUC> 0.5 indicates failure.[11] Then the cutoff value of the attenuation value was determined through the plot of the intersection of the Sensitivity value and the Specificity value of the CT scan attenuation value.

The previous study conducted by Zhang et al. the cut-off value of thoracic CT scan attenuation was 10.81 HU (AUC 0.85; Sensitivity 88.89%; Specificity 68.90%).[12] The previous study by Maili et al. the cut-off value of thoracic CT scan attenuation was 12.3 HU (AUC 0.948-0.990; Sensitivity 95%; Specificity 95%).[7] The previous study by Aggarwal et al. the cut-off value of thoracic CT scan attenuation was 7.5 HU (AUC 0.79; Sensitivity 98.6%; Specificity 59.6%).[13] In this study, the cutoff value of thoracic CT scan attenuation was 17.5 HU (Sensitivity 84.2%, Specificity 82.6%) with an AUC value of 0.887, which means that the attenuation value of thoracic CT scan has very good clinical ability in differentiating exudate and transudate pleural effusion.

However, this study was conducted retrospectively so there are many factors that may affect the results of the study such as the time interval between pleural fluid analysis and CT scan examinations that are not uniform, not all patients with pleural effusion underwent CT scans or pleural fluid analysis, not all patients underwent examinations with contrast and there was no data on the use of contrast used. The number of samples in this study was also limited because of the large amount of incomplete data. Another drawback of this study is that the attenuation value of the thoracic CT scan was not included in the patient's medical record.

CONCLUSION

Of the 80 samples, 57 (71.3%) exudate patients and 23 transudate patients (28.7%) were found with 37 females (46.3%) and 43 males (53.8%) and an average age of 48.44 ± 18.532 (2-84) years. The Mann-Whitney test revealed the attenuation value as good at differentiating the type of pleural effusion (p = 0.000). A correlation was discovered between the etiology of pleural effusion and pleural nodules with the type of exudate and transudate pleural effusion (p = 0.000 and p = 0.023). There was no correlation between age, gender and the other thoracic CT scan images with the type of pleural effusion (p> 0.05). The cutoff attenuation for the thoracic CT scan was 17.5 HU (AUC 0.887; Sensitivity 84.2%; Specificity 82.6%).

DECLARATIONS

Ethics approval and consent to participate. Permission for this study was obtained from the Ethics Committee of Universitas Sumatera Utara and H. Adam Malik General Hospital.

CONSENT FOR PUBLICATION

This study was approved by Ethical Committee of Universitas Sumatera Utara, Medan, Indonesia, on. The sampels provided the consent to participated in the study.

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None

COMPETING INTERESTS

The authors declare that there is no conflict of interest in this report.

AUTHORS' CONTRIBUTIONS

All authors significantly contribute to the work reported execution, acquisition of data, analysis, and interpretation, or in all these areas. Contribute to drafting, revising, or critically reviewing the article. Approved the final version to be published, agreed on the journal to be submitted, and agreed to be accountable for all aspects of the work.

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