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Analyzing the CT Features of Primary Spontaneous Pneumothorax and Its Application Value

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Abstract: *Objective:* To explore the performance characteristics of CT examination in primary spontaneous pneumothorax (PSP) and the effect of pleurodesis on patients with PSP. *Methods:* Sixty-four patients with PSP, who received medical care in the Affiliated Hospital of Hebei University from January 2017 to December 2021, were selected as the research subjects, of which 40 were male and 24 were female patients. All 64 patients were examined by X-ray and CT; the density, enhancement, and morphology of the pneumothorax were observed and analyzed, and the classification of pneumothorax was done. *Results:* The clinical analysis of 64 patients with PSP showed that the number of cases with unilateral pneumothorax was 42, accounting for 65.63%, whereas the number of cases with bilateral pneumothorax was 22, accounting for 34.37%. Among the cases of unilateral pneumothorax, the number of cases with left pneumothorax was 26, accounting for 61.90%, whereas the proportion of cases with right pneumothorax was 38.10%. When examined by CT, the diagnostic coincidence rate of 64 patients with PSP was 73.44%; using X-ray examination, the diagnostic coincidence rate of 64 patients with PSP was 92.19%. *Conclusion:* The detection accuracy of CT is higher than that of X-ray examination, which may improve the treatment effect in PSP, ensure the accuracy of findings, and facilitate follow-up treatment as well as the effect of postoperative analysis.

Keywords: Primary spontaneous pneumothorax; CT; X-ray

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1. Introduction

Primary spontaneous pneumothorax (PSP) can be examined by computed tomography (CT) or X-ray. The cost of CT examination is higher than that of X-ray. According to several reports, the diagnostic accuracy of CT is higher than that of X-ray. Primary spontaneous pneumothorax is usually caused by the rupture of subpleural blebs or pulmonary bullae. These patients generally do not have any underlying lung disease. It often affects young, thin, and tall men. Studies have found that smoking is closely related to primary spontaneous pneumothorax [1-3]. The risk of pneumothorax increases with smoking. Other risk factors include cocaine use, family history of pneumothorax, and surrounding environment [4-6]. Secondary spontaneous pneumothorax (SSP) often occurs in patients with underlying lung diseases, such as chronic obstructive pulmonary disease, cystic fibrosis, lung cancer (primary or metastatic), pulmonary tuberculosis, pneumoconiosis, and intrathoracic endometriosis [7,8]. Among them, chronic obstructive pulmonary disease is the most common, accounting for about 70% of the cases. The clinical symptoms of primary spontaneous pneumothorax are typical, most of which occur at rest. Its symptoms include sudden chest pain with or without dyspnea. Different from the symptoms of primary spontaneous pneumothorax, patients with secondary spontaneous pneumothorax usually have more serious symptoms, especially in elderly patients with chronic obstructive pulmonary disease; even if the lung compression is low, there is obvious dyspnea

[9,10]. Secondary spontaneous pneumothorax often has high mortality and recurrence rate, especially in elderly patients. Regardless of the cause, spontaneous pneumothorax is still a serious condition affecting global health. At present, there are many treatment methods for spontaneous pneumothorax, such as conservative oxygen therapy, thoracic puncture and aspiration, closed thoracic drainage, bullae resection and repair, pleural fixation, and other methods [12-16]. The treatment plan differs depending on the volume of the pneumothorax, which is one of the important bases for deciding whether to carry out closed drainage or surgery. In this study, CT and X-ray examinations are taken as examples to analyze their application effects.

2. Data and methods

2.1. General information

Sixty-four patients with PSP, who received medical care from the Affiliated Hospital of Hebei University from January 2017 to December 2021, were selected as the research subjects. Among the patients, 40 were male, with an average age of 35.69 ± 3.69, while 24 were female, with an average age of 36.98 ± 4.12. The clinical data of the enrolled patients were complete and in line with the symptoms of primary spontaneous pneumothorax. The patients were self-aware and met the requirements of the ethics committee; the study excluded cases with incomplete clinical data and patients with allergies, disorders of consciousness, and communication barriers; the patients and their families had given consent to participate in the study.

2.2. Methods

Sixty-four patients were examined by X-ray and CT.

(1) X-ray examination
An X-ray machine (XG501A, Shanghai Medical Instrument Factory) was used to examine the patients with primary spontaneous pneumothorax.

(2) CT examination
The SOMATOM Definition Flash CT was used. The average effective dose required for thoracic CT scanning was 8 mSv to 40 mSv. The scanning parameters were set as follows: 5 mm spacing, 35 cm field of view, and 5 mm scanning layer thickness.

2.3. Observation indicators

X-ray and CT examinations were performed by specially trained personnel. The classification of pneumothorax was based on the films, in which those with a ratio of 1:4 were categorized under small pneumothorax, 1:4 to 1:2 were categorized under moderate pneumothorax, and those less than 1:3 were categorized under massive pneumothorax; the lesion density, enhancement, and morphology of the pneumothorax on the X-ray and CT films were observed.

2.4. Statistical analysis

SPSS 25.0 was used for data analysis. The count and measurement data were expressed in n/% and $\bar{x} \pm s$, respectively. $\chi 2$ and t tests were performed, and the difference was considered statistically significant with $p < 0.05$.

3. Results

3.1. Clinical data analysis

The clinical analysis of 64 patients with PSP showed that the number of cases with unilateral pneumothorax was 42, accounting for 65.63%, whereas the number of cases with bilateral pneumothorax was 22, accounting for 34.37%. Among the cases with unilateral pneumothorax, the number of cases with left pneumothorax was 26, accounting for 61.90%, whereas the number of cases with right pneumothorax was 38.10%.

3.2. CT and X-ray features of primary spontaneous pneumothorax

In clinical diagnostic analysis, the diagnostic coincidence rate of 64 patients with primary spontaneous pneumothorax was 73.44% when examined by CT, of which the number of cases with small pneumothorax, moderate pneumothorax, and massive pneumothorax was 12, 24, and 28, respectively; using x-ray examination, the diagnostic coincidence rate of 64 patients with primary spontaneous pneumothorax was 92.19%, of which the number of cases with small pneumothorax, moderate pneumothorax, and massive pneumothorax was 16, 26, and 22, respectively (**Table 1**). The most common form of primary spontaneous pneumothorax involves the alveoli, with small penetrating shadows under the pleura, and some lesions having high density and irregular shape.

Table 1. CT and x-ray manifestations of 64 patients with primary spontaneous pneumothorax (n/%)

Group	Clinical diagnosis	Diagnostic coincidence rate	Small pneumothorax	Moderate pneumothorax	Massive pneumothorax
CT examination	64	47 (73.44)	12	24	28
X-ray examination	64	59 (92.19)	16	26	22
χ^2		6.8927			
p		0.0087			

4. Discussion

Primary spontaneous pneumothorax is a common clinical thoracic surgery condition that usually affects adolescent males. Studies have shown that PSP can be cured with conservative treatment, but the risk of recurrence is high. Hence, surgical treatment is recommended in clinical practice. With the rapid development of video-assisted thoracoscopic surgery, its efficacy and safety in the treatment of patients with PSP have been affirmed. At present, simple bullectomy and bullectomy combined with pleural fixation are the main thoracoscopic surgical methods in the treatment of patients with PSP. In view of the potential risk of bleeding and tissue damage from pleural fixation, employing pleural fixation to reduce postoperative recurrence rate remains a controversy [4]. However, numerous studies have reported that pleural fixation has been used in the treatment of patients with PSP, resulting in good prognosis [5].

CT is widely used in the qualitative and quantitative diagnoses of pneumothorax because at high-density resolution, there is no tissue overlap. In a study [15], CT was used to scan a lung model, in which the overall shape of the lung model was described using the axial images of each layer, and the functional lung area of the measured layer was calculated based on the area of the computer. The area of each layer was obtained, and the sum of the areas of all layers was calculated and multiplied by a fixed layer thickness to obtain the lung volume measured by CT. The actual volume of the lung model was measured by injecting a required amount of water into the lung model in the experiment. The injected amount of water reflected the actual lung volume. The results of the correlation analysis between CT measurement and actual lung volume revealed a high correlation between them. Hence, this method is considered a reliable method for measuring lung compression in patients with pneumothorax. In another study [16], several researchers approximated the degree of lung compression in pneumothorax to a fixed cross-section and used the ratio of chest area to gas area on the same plane. The arterial trunk plane was selected. When the degree of compression is weak, the median plane can be selected. In the study, the affected chest cavity and pneumothorax were obtained separately, and the total area of the affected chest cavity and the gas area were obtained.

Spontaneous pneumothorax is caused by a lung or pleural lesion, in which the lung pleura ruptures, causing gas to enter and accumulate in the pleural cavity through the ruptured lung pleura. Human lungs

are like elastic air bags, which can expand and contract. There are two layers of pleura covering the lungs: the visceral layer and the parietal layer. They form a closed chamber called the pleural cavity. When pneumothorax occurs, the pressure in the chest cavity rises, impairing the lungs' ability to expand, pressurizing the hilar, and even displacing the trachea and heart, thus eventually causing respiratory and circulatory failure.

4.1. Causes of spontaneous pneumothorax

The first is congenital developmental defects. This kind of pneumothorax is commonly seen in young adults aged 15 to 35, and most of them are male patients.

The second is lung diseases, such as pulmonary tuberculosis, chronic bronchitis with emphysema, bronchial asthma, bronchiectasis, pneumoconiosis, extensive pulmonary fibrosis, and lung cancer, which may cause pleural cavity cracks and eventually lead to pneumothorax. There are three types of spontaneous pneumothorax. The first is closed pneumothorax, which is characterized by small tear, rapid closure, and rapid lung recruitment. The second is open pneumothorax, in which air can enter and leave freely, and the pressure in the pleural cavity is equal to the atmospheric pressure. The third is tension pneumothorax, where a valve-like effect is created at the rupture. When inhaling, air enters the pleural cavity, but when exhaling, the valve closes, thus trapping the air. Hence, the intrathoracic pressure is higher than the atmospheric pressure.

4.2. Approaches to diagnosing spontaneous pneumothorax

Patients with spontaneous pneumothorax often present with shortness of breath, dry cough, and varying degrees of chest pain. Elderly patients may also have cyanosis, sweating, respiratory failure, and other symptoms. Patients with infection may have fever and an increase in leukocyte count. If blood vessels are damaged, hemothorax or even shock may occur. The following approaches can be used to identify whether the patient has spontaneous pneumothorax or not.

First, patients who develop spontaneous pneumothorax tend to experience sudden sharp or stinging chest pain. Coughing or deep inhalation may aggravate the pain. This can be explained by the pulling and tearing of the adhered pleura.

Second, patients with spontaneous pneumothorax tend to have dry cough, which is caused by the reflex stimulation of the pleura. With concurrent infection and bronchopleural fistula will worsen the cough and cause expectorated purulent sputum.

Third, if tension pneumothorax is not treated in time, shock may occur. In addition to dyspnea, patients may present with cyanosis, sweating, restlessness, unconsciousness, cold limbs, weakened pulse, decreased blood pressure, and other signs and symptoms.

Fourth, if cyanosis worsened after oxygen administration, or symptoms cannot be relieved by bronchodilator or hormonal therapy, shock or coma develops, and breath sounds are reduced on the affected side, spontaneous pneumothorax should be considered. Especially in elderly patients with respiratory diseases, if they are not treated in time, spontaneous pneumothorax may occur, but the symptoms may be occult. If there is a delay in diagnosis or treatment, their lives may be in danger. In addition, the primary condition may mask the signs and symptoms of spontaneous pneumothorax, resulting in delayed diagnosis. In order to identify potential risk factors, X-ray and CT examinations should be performed in time, the degree of lung compression should be evaluated, and tracheal deviation should be examined for.

4.3. Precautions for elderly patients with pneumothorax

In order to prevent the occurrence of spontaneous pneumothorax, elderly patients with lung diseases should take some precautions. First, it is necessary to control the underlying lung disease and strengthen the

treatment of chronic lung diseases, in order to prevent the occurrence of spontaneous pneumothorax from the root. Second, they should avoid breath holding activities, exertion, intense physical activity, and severe coughing, all which could induce spontaneous pneumothorax. Third, pneumothorax in elderly patients is often complicated with heart disease. Their clinical manifestations are similar to other cardiopulmonary emergencies, and the risk is high. These patients should consult their doctors as soon as symptoms appear to avoid delaying treatment.

5. Conclusion

In conclusion, the detection accuracy of CT is higher than that of X-ray examination, which may improve the treatment effect in primary spontaneous pneumothorax, ensure the accuracy of findings, and facilitate follow-up treatment as well as postoperative effect analysis.

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