

Application of Multi-slice Spiral CT Low-dose Chest Scanning in Pneumoconiosis Examination

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Abstract: *Objective:* To analyze the effect of multi-slice spiral CT low-dose chest scanning in the diagnosis of pneumoconiosis patients. *Methods:* From May 2024 to April 2025, 72 patients with pneumoconiosis were selected for data analysis in our hospital. Multi-slice spiral CT low-dose chest scans and conventional-dose chest scans were performed, respectively. The gold standard was high-kilovoltage X-ray photography. *Results:* Compared with the conventional dose, the low-dose image noise was significantly higher, and the SNR was significantly lower, $p < 0.05$; comparing the image quality of the two groups, $p > 0.05$. *Conclusion:* The application of multi-slice spiral CT low-dose chest scanning in the diagnosis of pneumoconiosis patients has ideal results.

Keywords: Multi-slice spiral CT low-dose chest scan; Pneumoconiosis; Diagnostic value

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1. Introduction

Long-term inhalation of production mineral dust during occupational activities can lead to a serious occupational disease - pneumoconiosis. Patients have diffuse fibrosis of lung tissue. The occurrence of the disease poses a serious threat to the patient's health. Due to the protracted course and high disability rate of patients with pneumoconiosis, early and accurate diagnosis is very important, which can help delay the progression of the disease and improve the prognosis of patients. At present, high-kilovoltage X-ray photography is clinically recommended for the diagnosis of pneumoconiosis. It has significant application advantages, such as easy operation and low cost ^[1]. However, it has certain limitations in clinical application, such as tissue overlap, low-density resolution, etc., and it cannot accurately identify early microscopic lesions in patients. The application advantage of multi-slice spiral CT chest scan in clinical research is tomographic imaging, which can effectively eliminate tissue overlap and interference, clearly display the details of patients' lung nodules, fibrosis, and other lesions, and significantly improve the detection rate of early pneumoconiosis ^[2]. Clinical practice has confirmed that conventional dose CT scans have higher radiation doses. If patients require long-term follow-up and repeated examinations, the health risks will increase, and long-term clinical application is limited ^[3]. With the continuous development of clinical imaging technology, multi-slice spiral CT low-dose chest scanning technology is gradually improved, which can ensure diagnostic accuracy and significantly reduce the radiation dose, which is consistent with the clinical needs of long-term diagnosis and treatment and repeated follow-up of patients with pneumoconiosis ^[4].

This study selected 72 patients to analyze the effect of multi-slice spiral CT low-dose chest scanning in the diagnosis of pneumoconiosis patients.

2. Materials and methods

2.1. Information

From May 2024 to April 2025, 72 patients with pneumoconiosis were selected for data analysis in our hospital, 60/12 men and women, aged 41–91 (68.25 ± 7.89) years old.

2.1.1. Inclusion criteria

Consistent with disease diagnostic criteria; long-term occupational dust exposure history, accompanied by hemoptysis, cough and sputum, dyspnea, etc., without obvious inducement; complete clinical data.

2.1.2. Exclusion criteria

Pregnancy and lactation; reduced heart, brain, and kidney function; associated with lung cancer, tuberculosis, idiopathic pulmonary fibrosis, sarcoidosis, etc.; associated with endocrine diseases, autoimmune diseases, and mental and psychological disorders.

2.2. Method

Multi-slice spiral CT low-dose chest scans and conventional-dose chest scans were performed, respectively, and the gold standard was high-kilovoltage X-ray photography.

2.2.1. High-kilovolt X-ray photography inspection

Completed using a high-frequency X-ray photography system. The voltage, exposure time, power, and current are 125 kV, 0.1 s and less, 20 kV and above, and 160 mA. Select a small focus (< 1.0 mm). The target distance and exposure are 1.8m and 3–10 mA. Fully inhale and hold the exposure.

2.2.2. Multi-slice spiral CT low-dose chest scan and conventional dose chest scan

Use multi-slice spiral CT; the slice distance, tube voltage, slice thickness, matrix, pitch, and tube current are 5 mm, 120 kV, 5 mm, 512×512 , 1.0, 30 mA. Before the examination, inform the patient how to hold his breath correctly. Once he has mastered it, he will perform a CT scan for the patient. He will scan the patient's lungs from the bottom of the lungs to the lung apex while lying on his back, and carefully observe the patient's lung lesion shape, size, location, edge, imaging manifestations, etc. The low dose is 30 mA, and the conventional dose is 150 mA.

2.3. Observation indicators

Compare the image noise, SNR, and image quality of the conventional dose and the low dose. If small nodules and shadows are clearly visible in the lung field and there are no artifacts, the judgment is excellent; if small nodules and shadows are clearly visible in the lung field and there are some artifacts, the judgment is good; in other cases, the judgment is poor.

2.4. Statistical analysis

SPSS 28.0 software was used for data analysis. Counting and measurement data were expressed in the form of rate (%) and $(\bar{x} \pm s)$ χ^2 and t tests were carried out, respectively. $p < 0.05$ was statistically significant.

3. Results

Compared with the conventional dose, the low-dose image noise was significantly higher, and the SNR was significantly lower, $p < 0.05$; comparing the image quality of the two groups, $p > 0.05$. See **Table 1** and **2**.

Table 1. Comparison of image noise and SNR between conventional dose and low dose

Group	Image noise	SNR
Conventional dose (n = 72)	8.02 ± 0.48	7.61 ± 0.92
Low dose (n = 72)	14.71 ± 0.92	7.23 ± 0.18
t	54.7047	3.4396
p	< 0.05	< 0.05

Table 2. Comparison of image quality between conventional dose and low dose (%)

Group	Excellent	good	Poor
Conventional dose (n = 72)	64 (88.89)	8 (11.11)	0
Low dose (n = 72)	59 (81.94)	9 (12.50)	4 (5.56)
χ^2		4.2621	
p		> 0.05	

4. Discussion

Analyzing the core pathological changes of pneumoconiosis, patients will develop diffuse fibrosis in the lung tissue after long-term inhalation of productive mineral dust. It is necessary to carry out early and accurate diagnosis and regular follow-up for patients to monitor the progression of the disease, which will help delay the deterioration of the patient's lung function and improve the patient's quality of life. In patient diagnosis, high-kilovoltage X-ray photography is the gold standard, but it has some shortcomings. Therefore, this study proposes the application of multi-slice spiral CT. Its technical advantages are tomographic imaging, high spatial resolution, multi-plane reconstruction, etc. However, the radiation dose of conventional-dose chest CT scans is high, and long-term application is not recommended. It is recommended to use multi-slice spiral CT for low-dose chest scanning. By optimizing parameters, such as reducing tube current, it can not only control the radiation dose, but also retain core diagnostic information, which can effectively meet the basic requirements for diagnosis of pneumoconiosis patients and provide an empirical basis for clinical promotion and application^[5].

The data of this study show that the image noise of multi-slice spiral CT low-dose chest scans (14.71 ± 0.92) is significantly higher than that of the conventional dose, and the signal-to-noise ratio of multi-slice spiral CT low-dose chest scans (7.23 ± 0.18) is significantly lower than that of the conventional dose, $p < 0.05$. The reasons for the results are related to the physical principles and parameter setting logic of multi-slice spiral CT imaging. In clinical measurement of CT image quality, the core quantitative indicators are image noise and signal-to-noise ratio. The former comes from the number of photons, electronic noise, scanning parameters, and other factors, while the latter reflects the ratio of effective signal to noise, which can determine the ability to display the details of the lesion^[6]. The tube current of CT scanning parameters is a key parameter that can regulate the radiation dose and image noise. It is positively related to the number of photons and negatively related to the radiation dose and image noise. Therefore, the higher the tube current, the more photons the detector receives, the lower the image noise, the higher the signal-to-noise ratio, and the clearer the image. In this study, the low-dose scanning tube current was set to 30 mA, while the conventional dose was 150 mA. In comparison, the low-dose tube current was only 1/5 of the conventional dose, so it not only significantly reduced the radiation dose but

also significantly reduced the photon flux. Therefore, the low-dose scanning results showed an increase in image noise and a decrease in signal-to-noise ratio. At the same time, parameters such as layer thickness, layer spacing, and pitch will also affect noise and signal-to-noise ratio. In this study, two or more groups of parameters were unified, and interference from other parameters was eliminated^[7]. It was confirmed that the difference in tube current will lead to statistical differences in noise and signal-to-noise ratio between the two groups, and was determined as the only variable.

Starting from the analysis of the image quality evaluation results, the excellent, good, and poor rates of conventional dose scans were 88.89%, 11.11%, and 0%, respectively. The excellent, good, and poor rates of low-dose scans were 81.94%, 12.50%, and 5.56%, respectively. The image quality of the two groups was compared; the p value was > 0.05 . The results confirmed that when using multi-slice spiral CT low-dose chest scanning in the diagnosis of pneumoconiosis patients, although the noise increases and the signal-to-noise ratio decreases, the image quality can be maintained to meet the diagnosis of pneumoconiosis. This result is the core value of low-dose CT. Typical imaging features of pneumoconiosis in clinical research include diffuse small nodules, irregular small shadows, large shadows, pleural thickening, emphysema, etc. The key basis for early diagnosis and staging is small nodules and small shadows. In lung tissue, such lesions have a high-density contrast and can still be clearly identified even if there is a certain amount of noise interference. Multi-slice spiral CT low-dose chest scans were applied to patients. Although the noise was increased, the characteristics of the core lung lesions were not masked. Key diagnostic information such as the shape, size, and distribution of small nodules and shadows in the lung fields could still be effectively displayed. Slight artifacts appeared in some patients, so a small number of image quality was rated as poor, accounting for a small proportion of 5.56%, which did not affect the overall diagnostic performance of the patients. At the same time, by optimizing the detector technology and image reconstruction algorithm of multi-slice spiral CT, the noise defects of low-dose scanning can also be compensated^[8]. Iterative reconstruction algorithms and other technologies can be used to reduce noise and improve image clarity, ensuring that low-dose scanning can be used for clinical diagnosis.

Compared with high-kilovolt X-ray photography, the clinical application of multi-slice spiral CT low-dose scanning has the advantage of tomographic imaging, which can eliminate the overlapping interference of chest tissue and prevent the ribs, clavicle, heart, mediastinum and other structures from blocking lung lesions, especially the lung apex, subpleura, paraspinal, paracardial margin, etc., which are areas easily missed by X-ray photography, and the ability to display small lesions is enhanced. Clinical studies of pneumoconiosis have found that early lesions are mainly micronodules with a diameter of less than 3 mm and mild interstitial fibrosis. High-kilovoltage X-ray photography is used for patients. The disadvantage is that the density resolution is low and the tissues overlap. Such small lesions cannot be clearly displayed, making it easy to miss or misdiagnose. The patient misses the best opportunity during clinical intervention. Applying a multi-slice spiral CT low-dose chest scan to the patient can clearly identify the shape, density, and distribution of the patient's micro-nodules, accurately judge the scope and degree of fibrosis, and provide a reliable basis for the diagnosis of early pneumoconiosis. The application of multi-slice spiral CT low-dose chest scanning in the staging of patients with pneumoconiosis can clearly distinguish key staging indicators such as the density of small shadows, the formation of large shadows, the extent of emphysema and bullae, and the degree of pleural thickening and adhesion. Its diagnostic accuracy is not significantly different from that of conventional-dose CT, so that it can replace conventional-dose CT in the staging evaluation of pneumoconiosis.

From the perspective of clinical application safety, compared with multi-slice spiral CT conventional-dose chest scans, the radiation dose of multi-slice spiral CT low-dose chest scans is significantly lower. In this study, the low-dose tube current was 30 mA, and the radiation dose was about 1/5 of the conventional dose. The patient's radiation exposure risk was significantly reduced. For patients with pneumoconiosis, most of them are workers who have been exposed to dust for a long time. They are older and have poor lung function. Some patients have complications such as chronic bronchitis, emphysema, and lung infection, and have poor ability to withstand radiation damage. Therefore, it is recommended to use low-dose scanning, which can effectively avoid the radiation hazards of conventional dose CT. Patients can have regular follow-up multi-slice spiral CT low-dose chest scans 1–2 times a year to monitor the progress of the patient's lesions

dynamically. At the same time, applying low-dose scanning to patients does not increase the scanning time or operational complexity. The patient can lie on his back and hold his breath to complete the scan. It is not difficult to cooperate. It can also be performed on elderly and weak people, so the feasibility of clinical promotion is very high.

Analyzing the limitations of clinical application, the noise of low-dose chest scans of multi-slice spiral CT increases. Therefore, its ability to display low-density contrast lesions such as ground-glass opacity and slight interstitial changes in the lungs is slightly inferior to conventional-dose CT, which may affect the judgment of subtle lesions in very early pneumoconiosis. In addition, this study selected 72 patients for a single-center study. There are individual differences among different patients, which may affect the generalizability of the results of this study. In future research, the sample size can be expanded, multi-center studies can be carried out, multi-slice spiral CT low-dose chest scanning parameters can be further optimized, and artificial intelligence image post-processing technology can be combined to reduce noise, improve detail display capabilities, and expand the application scope of multi-slice spiral CT low-dose chest scanning in early screening of pneumoconiosis, accurate staging, and efficacy evaluation.

At present, high-kilovoltage X-ray photography is still regarded as the gold standard for the diagnosis of pneumoconiosis in clinical practice, and multi-slice spiral CT low-dose scanning can be used as an auxiliary diagnostic tool. In clinical practice, a joint diagnostic method can be applied to patients with pneumoconiosis, using a high-kilovoltage X-ray primary screening + multi-slice spiral CT low-dose chest scan accurate assessment model. This model complies with national diagnostic standards, improves the accuracy of early diagnosis and staging, controls radiation dose, and ensures patient safety. After a patient is diagnosed with pneumoconiosis, multi-slice spiral CT low-dose chest scan is the first choice for long-term follow-up. The progress of the patient's lung lesions can be regularly monitored, and the treatment plan can be adjusted in a timely manner to delay the deterioration of lung function and significantly reduce the patient's disability and mortality rates.

In summary, the application of multi-slice spiral CT low-dose chest scanning in the diagnosis of pneumoconiosis patients has ideal effects, and the image quality is equivalent to that of conventional doses, and is worthy of clinical promotion and use.

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Disclosure statement

The author declares no conflict of interest.

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