Image quality of 320-row wide volume CT scans with the diffuse lung diseases: comparison with 64-row helical CT scans

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Purpose

Introduction

Recently, 320 detector-row CT with 0.5 mm collimation appears in the MDCT market, and it has the wide scan range of 16 cm in one gantry rotation with the scan time of 0.35 second. To obtain the wider scan range, wide volume CT scan can be available. Wide volume scan is the contiguous step-and-shoot scan protocol, and only three gantry rotations are enough to scan the whole lung by using wide volume scan. Initially, coneXact algorithm was developed for the image reconstruction to overcome cone beam artifacts. The new reconstructed algorithm of volumeXact algorithm expanded the reconstructed area of CT images which could not be obtained by coneXact.

Purpose

The purpose of this study is to evaluate the image quality of 320-detector row wide volume (WV) CT scans in comparison with 64-detector row helical scans on axial image and coronal multiplanar reformation (MPR), especially for the diffuse lung disease.

Methods and Materials

Patients

35 patients with diffuse lung diseases were included in this study. The patients consisted of 21 males and 14 females (mean age, 66.1 years ± 11.2). Clinical diagnoses consisted of interstitial pneumonia (n=27), suspect of interstitial pneumonia (n=2), combined pulmonary fibrosis and emphysema (n=2), airway disease in rheumatoid arthritis (n=1), sarcoidosis (n=1), bird breeder's disease (n=1) and suspect of asbestosis (n=1).

CT image aquisition

Whole chest CT scans without contrast medium administration were performed with 320-detector row CT scanner (Aquilion One; Toshiba Medical Systems). The scan protocol was two patterns; 64-detector row helical scans and 320-detector row WV scans.

64-row helical scans were performed with 120kVp, 430mA, 0.35sec/rotation, 0.5mm collimation and a helical pitch of 0.828. 320-row WV scans were performed with same condition; 120kVp, 430mA, 0.35s/rotation and 0.5mm collimation.

CT image reconstruction
All CT images with 64-row helical scans or 320-row WV scans were reconstructed with a slice thickness of 1 mm and 32 cm field of view. In 320-detector row WV scans, both coneXact and volumeXact+ were used for the image reconstruction. Both a high spatial frequency algorithm (FC 51) and a low spatial frequency algorithm (FC 13) were used for all the image reconstruction. Then, six patterns of image data were obtained:

1. high spatial frequency algorithm with 64-row helical scans,
2. low spatial frequency algorithm with 64-row helical scans,
3. high spatial frequency algorithm and coneXact with 320-row WV scans,
4. low spatial frequency algorithm and coneXact with 320-row WV scans,
5. high spatial frequency algorithm and volumeXact+ with 320-row WV scans,
6. low spatial frequency algorithm and volumeXact+ with 320-row WV scans.

**CT image analysis for MPR images**

Above all six patterns of image data sets were used. All CT images were transferred to a workstation, and MPR images with 0.625 mm thickness were independently evaluated by three chest radiologists on lung and mediastinal window setting.

The dislocation and the heterogeneity of normal structures were evaluated by using a 3-point scale (1: severe dislocation / severe heterogeneity, 2: mid dislocation / severe heterogeneity, 3: no dislocation / no heterogeneity).

The final scores of each case were determined by the median scores of three independent observers.

They also evaluated the location of both dislocation and heterogeneity (upper, middle or lower lung fields).

**CT image analysis for axial images**

For the evaluation of image quality of diffuse lung disease, two patterns of image data sets of lung window settings were used;

1. high spatial frequency algorithm with 64-detector row helical scans
2. high spatial frequency algorithm and volumeXact+ with 320- detector row WV scans.
The lung fields were divided into six parts (right or left lung, upper, middle or lower lung fields), and three observers evaluated the visibility of the following CT findings by using a 5-point scale (1: non-diagnostic, 2: poor, 3: satisfactory, 4: good, 5: excellent);

1. normal peripheral vessels
2. ground glass opacity
3. consolidation
4. nodules
5. septal thickening
6. intralobular reticulation
7. bronchiectasis
8. honeycombing
9. cardiac artifact
10. overall image quality

The final scores of CT findings were determined by the median scores of three independent observers.

**Results**

**Results of the MPR images**

The results of mean scores of both dislocation and heterogeneity shows that WV scan with coneXact is inferior to WV scan with volumeXact$^+$ or helical scan (Figure1 on page 7). There were no significant difference between WV scan with volumeXact$^+$ and helical scan on lung window setting. Though there was also no significant difference of dislocation between WV scan with volumeXact$^+$ and helical scan on mediastinal window setting, helical scan is inferior to WV scan with volumeXact$^+$ for heterogeneity on mediastinal window setting.

Heterogeneity is prominent in mediastinal window setting rather than in lung window setting on both WV scan with coneXact and helical scan ($p<0.01$) (Figure1 on page 7).
The dislocation and the heterogeneity were observed especially in the upper and lower lung field on WV scan with coneXact (Figure 2 on page 7, Figure 3 on page 8).

WV scan with volumeXact\(^+\) and helical scan scarcely showed the dislocation and the heterogeneity on lung window setting (Figure 2 on page 7).

The heterogeneity was more often seen on mediastinal window setting of helical scan rather than on that of WV scan with volumeXact\(^+\) especially in middle and lower lung field (Figure 3 on page 8).

**Results of the axial images**

There was no significant difference between WV scan with volumeXact\(^+\) and helical scan in each lung field for both overall image qualities and the visibility of peripheral vessels (Figure 4 on page 8). The mean scores of cardiac artifact were 3.7 - 5.0 in WV scan with volumeXact\(^+\) and 3.5 - 4.9 in helical scan, and there was no significant difference between WV scan with volumeXact\(^+\) and helical scan except left middle lung field \((p<0.01)\) (Figure 4 on page 8).

Though there was significant difference between WV scan with volumeXact\(^+\) and helical scan on septal thickening in right middle lung field \((p<0.01)\), any other significant difference could not be detected for the seven abnormal pulmonary CT findings (Figure 5 on page 9).

**Example cases**

Figure 6 on page 10

MPR image of coneXact on lung window setting shows the dislocation of inner tracheal wall (arrow) and the abruption of pulmonary vessel (arrowhead) in the upper lung field, which is improved in MPR image of volumeXact\(^+\) or that of helical scan.

Figure 7 on page 11

MPR images of the mediastinal window setting show the heterogeneity by coneXact algorithm or helical scan (arrow). The dislocation of mediastinal structure also can be seen on MPR image with coneXact (arrowhead). However, any heterogeneity or any dislocation cannot be observed on MPR image with volumeXact\(^+\).
Figure 8 on page 12

Axial thin-slice image with helical scan shows cardiac motion artifact in the middle field of left lung (arrowhead). In addition, the bronchus and the vessels near the left cardiac border are obscure. Cardiac motion artifact cannot be seen on axial image with volumeXact⁺.

Images for this section:

Table 1 The Mean Scores of MPR image qualities on pulmonary and mediastinal window setting

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Fig. 1: The Mean Scores of MPR image qualities on pulmonary and mediastinal window setting
**Fig. 2:** The number of the dislocation and the heterogeneity on MPR images in lung window setting

**Fig. 3:** The number of the dislocation and the heterogeneity on MPR images in mediastinal window setting
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**Fig. 4:** Mean scores of axial image qualities for visibility of peripheral vessels, cardiac artifact and overall image quality.
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*Note: parenthesis is the number of each abnormal CT finding

**Fig. 5:** Mean scores of axial image qualities for seven abnormal CT findings
Fig. 6: MPR (lung window setting)
Fig. 7: MPR (mediastinal window setting)
**Fig. 8:** Axial image (lung window setting)
Conclusion

1. On axial thin-slice image, overall image quality of WV scans with volumeXact is almost comparable to that of helical scans on lung window setting.

2. On MPR image, WV scan with coneXact is inferior to WV scan with volumeXact or helical scan for both the homogeneity and the dislocation.

3. On MPR image of mediastinal window setting, the homogeneity of the density on helical scans is inferior to that on WV scans with volumeXact.

So, we can choose either WV scan with volumeXact or helical scan for the evaluation of the lung disease. However, we may had better to use WV scan with volumeXact if the evaluation of mediastinum is also needed.

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