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Application of low-dose revolution CT combined with iterative reconstruction technique in coronary angiography.

Xiujie Duan, Daliang Liu, Yucun Fu, Qing Wang*

Shandong University, Qilu Hospital, Ji'nan, Shandong, PR China

Abstract

Objective: To explore the diagnostic value of combined use of revolution CT with different weights of ASIR-V iterative reconstruction in coronary artery imaging at low tube voltage (100 kVp).
Methods: Fifty patients who were underwent coronary CT angiography by Revolution CT from January 20 to January 2017 were enrolled in this study. With administration of regular FBP and 20%, 40%, 60%, 80%, and 100% of Adaptive Statistical Iterative Reconstruction (ASIR) technique, the subjective and objective indicators of the images in each group were evaluated.
Results: The radiation doses of the subjects were (1.72 ± 0 MSv). The subjective and objective scores of reconstructed images in each group at different ASIR-V weights (20%, 40%, 60%, 80% and 100%) were better than those in FBP group (P<0.05). The difference of objective scores of ASIR-V reconstructed images at different weights (20%, 40%, 60%, 80% and 100%) was statistically significant (P<0.05).
Conclusion: The low dose revolution CT combined with iterative reconstruction technique in coronary angiography at low tube voltage (100 kVp) can help reduce the dose of radiation and ensure the diagnostic value of the images. In the course of use, 60% or 80% ASIR-V reconstruction is recommended for best image quality.

Keywords: Low tube voltage, Iterative reconstruction, Coronary angiography, ASIR-V, Radiation dose.

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Introduction

Coronary angiography is a common method and an effective means clinically used to check the presence or absence of coronary artery disease [1]. In recent years, with the extensive use of CT in clinical practice, Coronary CT Angiography (CCTA) has become more and more popular, and increasingly highlighted such advantages as noninvasive, simple, and relatively high negative predictive value. However, people also note that CCTA check requires higher radiation doses [2,3]. Therefore, in order to reduce the radiation dose of the subjects and to ensure the health of the subjects, it is necessary to explore a test plan for reducing the radiation dose of the subjects under the premise of ensuring the image quality that meet the diagnostic requirement.

The iterative reconstruction algorithm is a new reconstruction algorithm, which can effectively reduce the noise of the image, greatly increase the quality of the image, and obtain the high-resolution reconstructed image at low tube voltage (100 kVp) [4,5]. To investigate the diagnostic effect of combined use of Revolution CT with different weights of ASIR-V iterative reconstruction in coronary angiography at low voltage (100 kVp), this study was performed with revolutionary CT scanner for real-time ASIR-V reconstruction to investigate the application value of different weights of the ASIR-V iterative reconstruction in the patients treated with coronary CT angiography, thus finding the best weight of the SIR-V reconstruction parameters.

Materials and Methods

General information

A total of 28 men and 22 women aged 34-78 y old, with an average age of (66.3 ± 2.5 y) were enrolled in the study of 50 cases of coronary CT angiography using the Revolution CT from January, 2016 to January 2017; their heart rates were between 52 and 62 times/min, with a mean heart rate of (55.5 ± 3.5 times/min); and their BIMs were 32-36 kg/m^2, with a mean BIM of (35.8 ± 2.1 kg/m^2). Participants were given informed consent, while patients with allergy to iodine contrast agents, renal insufficiency (CCr 80~50 ml/min; SCr 136.2~176.8umol/L; GFR<70 ml/min) and previous coronary artery surgery were excluded.

Methods

Scanning method: The revolution CT used is produced by the GE Company (United States). The revolution CT was adjusted to the prospective ECG-gated trigger scan mode, the low tube voltage was 100 kV, and the current was automatically 600-720 mA; the noise figure was set to 12, the iodine contrast agent was 370 mgI/mI, and the scanning range was from 10 mm under the carina to 10 mm under the apex; 50 ml of iodine contrast agent was injected to each subject's ulnar vein, the injection rate remained at 5 ml/s, and then coronary CT angiography was performed; the contrast agent to be tracked was excitated at 200 HU, the scan started after 2 s delay [6].

Image reconstruction: At low-tube voltage (100 kVp), 50 patients were underwent traditional FBP algorithm and 20%, 40%, 60%, 80%, 100% of different weights of ASIR-V iterative reconstruction technology for image reconstruction and evaluation.

Image evaluation

Subjective evaluation: The images were evaluated by two radiologists who had 2 y or above work experience according to the four point scoring method after reading the images. Evaluation criteria: (1) Poor image quality, dislocation of superior coronary artery in the reconstructed image, artifacts in the vassal wall, and no diagnostic value; then 1 point was given; (2) poor image quality, insufficient wall sharpness, coronary motion or other artifacts that have impact on the image quality; however, if the image can be used for clinical diagnosis, 2 points were given; (3) integrity of continuous coronary artery can be observed from the images; there were only local blur edges and slight artifacts; then 3 points were given; (4) good image quality, clear continuity and integrity of coronary artery, sharp and clear edges, no artifacts; then 4 points were given. Objective Evaluation: The noise was measured and the Signal-to-Noise Ratio (SNR) and Contrast-to-Noise Ratio (CNR) were calculated according to the Formulas 1 and 2. The image noise (SD) was the horizontal noise of left main, i.e., the root of aorta ascendens; The ROI selected the measured area of ascending artery, the measured area of the left ventricular cavity and the measured area of the left ventricle wall, which were respectively (2.5 ± 0.5 mm), (2.5 ± 0.5 mm), and (2.0 ± 0.5 mm), and the average value of the 3 times measurement was taken as the measured data [7].

(1) $SNR=CT_{\text{Aortic root}}/SD$; (2) $CNR=(CT_{\text{Left ventricular cavity}}-CT_{\text{Left ventricular wall}})/SD$.

In addition, the value of Dose-Length Product (DLP) must be recorded in detail to calculate the Effective Dose (ED), and the method of calculation is: ED=DLP × K, where K=0.014 mSv/(mCy•cm), The unit is mSv [8].

Statistical method

The data were processed with SPSS 21.0. Age, BMI, CT value of measured segment of coronary artery, radiation dose and image noise, SNR and CNR were expressed by mean ± Standard Deviation (SD). Comparison between groups used two-sample t-test, comparison of subjective scores for image quality among groups used the rank sum test and Friedman M-test with a number of samples, and pairwise comparison used the q-test. P<0.05 indicated that the difference was statistically significant.

Results

Comparison of effective dose in each group

Because the voltage, current and iodine contrast agent concentration and dose used in each group were the same, the Effective Dose (ED) of each group was the same, and all ED was (1.72 ± 0.55 mSv). The differences among groups were not statistically significant (P>0.05).

Comparison of subjective scores of images among groups

In different methods and different weights of ASIR-V reconstruction, for comparison of the subjective scores of the image quality among groups, except that there was no significant difference between the 60% and 80% ASIR-V reconstructed groups (P>0.05), for pairwise comparison among the rest groups and comparison between FBP group and all ASIR-V groups, the differences were statistically significant (P<0.05), as shown in Table 1. Coronary artery CTA axial images are shown in Figure 1.

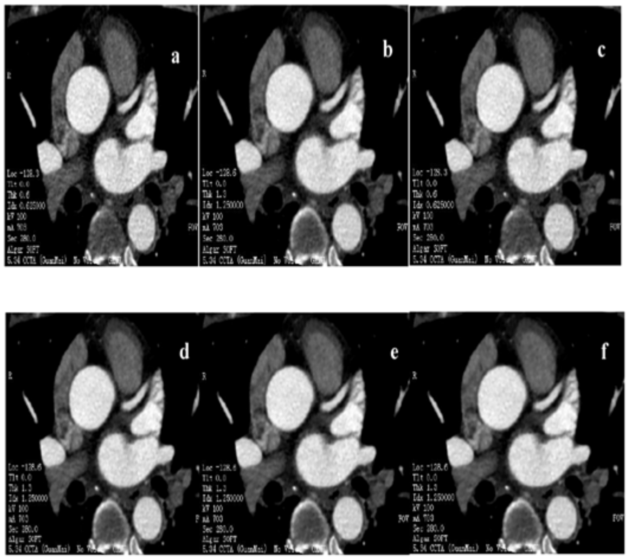

Figure 1. Coronary CTA axial images (window width 900 HU, window position 280 HU). a. FBP reconstructed image; b. 20% ASIR-V reconstructed image; c. 40% ASIR-V reconstructed image; d. 60% ASIR-V reconstructed image; e. 80% ASIR-V reconstructed image; f. 100% ASIR-V reconstructed image.

Comparison of objective scores of images among group

According to the objective scoring results of images among groups, the results showed that the differences of SD, SNR and CNR between FBP group and all ASIR-V groups were statistically significant (P<0.05), while the percentage of ASIR-V weight was larger, SD was smaller (P<0.05), and

CNR and SNR were increasing. The differences between groups were statistically significant (P<0.05, Table 2 and Figure 2).

Table 1. Subjective score results of reconstructed images in each group (n).

Score	FBP group	20%	40%	60%	80%	100%
		ASiR-V reconstructed group	ASiR-V reconstructed group	ASiR-V reconstructed group	ASiR-V reconstructed group	ASiR-V reconstructed group
1	2	0	0	0	0	0
2	43	40	34	18	16	26
3	5	10	16	24	25	22
4	0	0	0	8	9	2

Table 2. Objective scoring results of images among groups ($\bar{x} \pm s$).

Parameter	FBP group	20%	40%	60%	80%	100%
		ASiR-V reconstructed group	ASiR-V reconstructed group	ASiR-V reconstructed group	ASiR-V reconstructed group	ASiR-V reconstructed group
SD	27.6 ± 4.1	23.7 ± 3.5	20.9 ± 1.4	18.7 ± 1.0	17.1 ± 1.4	15.6 ± 3.1
CNR	14.9 ± 3.2	17.3 ± 2.0	19.4 ± 2.1	22.0 ± 2.6	24.1 ± 2.4	26.4 ± 2.4
SNR	17.1 ± 3.3	21.3 ± 2.4	23.2 ± 1.3	25.6 ± 1.9	27.7 ± 2.3	30.5 ± 2.8
F value	10.941	5.63	6	9.71	26.333	31.941
P	0.01	0.042	0.037	0.013	0.001	0.001

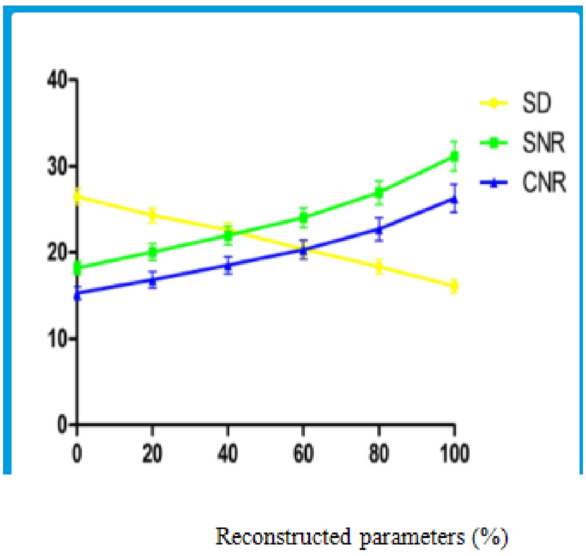

Figure 2. Curves of SD, SNR, and CNR of reconstructed images among groups with different percentages of ASIR-V weights.

Discussion

Coronary CT angiography is a common method and an effective means of clinical examination of coronary artery disease. With the application of this method more and more extensive, the radiation dose received by the subject has become a common concern [9]. Studies show that [10-12], if the conventional FBP algorithm is used to reconstruct the image at the low tube voltage under 100 kV, though the radiation is reduced, the image quality is also decreased, and the noise is large, which is not conducive to clinical diagnosis [13]. Therefore, the authors propose to reconstruct the image by combining the iterative reconstruction technique ASIR-V algorithm under the condition of low tube voltage, which can reduce the noise and improve the image quality while reducing the radiation dose [14,15]. The results of this study show that the radiation dose received by the subject is low, but it can be seen from the results in Table 1 that the subjective score of the reconstructed image quality in the FBP group under the same radiation dose, namely, at low tube voltage, was worse than that in each ASIR-V group. Then combined with the study results in Table 2, the objective score of reconstructed images in each ASIR-V group was better than that of FBP group, and with increasing percentage of ASIR-V weights, noise continually decreased, and SNR and CNR increased. This suggests that the effect of reconstructed images using the iterative reconstruction techniques was better than that using conventional FBP for coronary CT angiography under low tube voltage conditions. Meanwhile, when the ASIR-V weights was 60% and 80%, the subjective score of the reconstructed image was the best, and there was no significant difference between the two groups. Therefore, when the iterative reconstruction technique was used at low dose, the quality of reconstructed images was best under 60% or 80% of ASIR-V weights. In other words, low-dose combined iterative reconstruction techniques can be used to reduce the radiation dose of the subject while maintaining the diagnostic value in the coronary CT angiography [16,17].

In summary, combined with the iterative reconstruction technique, the Revolution CT can not only reduce the radiation dose, but also improve the quality of reconstructed images and ensure its clinical diagnostic value for CT angiography at low tube voltage (100 kVp).

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*Correspondence to

Qing Wang

Shandong University

Qilu Hospital

PR China