

## Application of 64-slice Spiral CT in coronary artery imaging

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### Abstract

**Objective:** To study the use of 64-slice spiral CT in coronary artery imaging and to explore the value and limitation of non-invasive examination in clinical application. A total of 100 patients with clinical diagnosis or suspected coronary heart disease were included in this study.

**Methods:** All patients underwent 64-slice spiral CT coronary angiography and selective coronary angiography. The coronary artery was divided into 16 segments with not more than 2 weeks before and after treatment. The visual diameter method was used to judge the degree of coronary artery stenosis. Coronary angiography was used as the "golden standard" for the diagnosis of coronary heart disease (CHD). The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic coincidence rate of 64-slice spiral CT moderate and severe coronary artery stenosis were calculated.

**Results:** The results showed that 1547 (96.7%) of the 1600 coronary segments could be simultaneously displayed and evaluated. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic coincidence rate of 64-slice spiral CT were 91%, 97%, 84%, 98% and 97%, respectively.

**Conclusion:** It could be concluded that the 64-slice spiral CT had good diagnostic value for moderate and severe coronary stenosis, and could basically meet the diagnostic needs of coronary heart disease, helping to avoid invasive coronary angiography in patients with normal coronary artery or without interventional therapy.

**Keywords:** 64-slice spiral CT, coronary angiography, coronary artery disease. (JPMA 70: 2 [Special Issue]; 2020)

### Introduction

Coronary heart disease (CHD) refers to the manifestations of coronary atherosclerosis (which narrows or obstructs the vascular lumen) or functional changes of coronary artery and spasm. These could lead to myocardial ischaemia, hypoxia or necrosis. It is a common disease that seriously endangers human health.<sup>1</sup> The incidence of coronary heart disease (CHD) in China is rising and has become the leading cause of death.<sup>2</sup> The invasive coronary angiography (CAG) used in the past is a clinical method to describe coronary artery norms.<sup>3</sup> It has been developed as a "golden standard" for determining whether coronary artery disease occurs. CAG plays a leading role in the diagnosis of coronary heart disease.<sup>4</sup> However, its high trauma, high cost and possible complications limit its wide range of application. It has been reported that only about 30% of the patients receiving selective coronary angiography need interventional therapy, and the remaining patients have no definite abnormal changes.<sup>5</sup> Lesions and degrees are used for disease diagnosis. Therefore, the search for a less invasive examination method that can directly display the coronary artery has attracted more and more attention

in the medical professionals. Compared with selective coronary angiography, MSCTA (64-slice spiral CT scanning technology) has the advantages of low cost, low risk and high speed, which can be used for the preliminary diagnosis of coronary stenosis.<sup>6</sup> Cardiac and coronary artery imaging has always been a technical challenge. The key is that the rapid and continuous movement of the heart brings great difficulties to imaging.<sup>7</sup> The 64-slice spiral CT scanning technology has the advantages of fast scanning speed, high image resolution and the ability to combine with ECG-gated corresponding technology.<sup>8</sup> The application of these technologies greatly improves the volume coverage imaging, real-time imaging and spatial resolution. The advantage of 64-slice CT is that it is non-invasive, can be repeated in a short time, and has a high negative predictive value. However, it does not get rid of the influences of calcification and metal shadow. It still requires the heart rate of patients required when examining the patient.<sup>9-19</sup>

Thus, the focus of this study was on the application of 64-slice spiral CT in coronary artery imaging and to explore the value and limitation of non-invasive examination in clinical application.

### Patients and Methods

In this study, a total of 100 patients with coronary heart disease and suspected coronary heart disease were

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collected from the department of cardiology of The First People's Hospital of Yongkang from May 2017 to August 2019. According to the calculation equation of sample size,  $N$  is the sample size,  $Z$  is the statistic,  $Z = 1.96$  when the confidence is 95%,  $Z = 1.64$  when the confidence is 90%;  $E$  is the error value;  $P$  is the probability value. In this study,  $Z = 1.67$ ,  $E = 5\%$ ,  $P = 10\%$ , so the sample size is 100. All patients underwent 64-slice spiral CT coronary angiography and selective coronary angiography by catheterization. The time before and after coronary angiography was less than 2 weeks. Both were operated and interpreted by consultation with two senior radiologists without knowledge of CAG (coronary angiography) results. All patients or their families signed informed consent, and this study was approved by the Ethics Committee of The First People's Hospital of Yongkang.

**Inclusion criteria:** All the participants with no history of severe allergic reaction to iodine contrast media, no thyroid disease, no acute heart failure, no severe arrhythmias, no severe renal insufficiency, no severe premature contraction, and no moderate to severe atrioventricular block and all patients who could hold their breath for 20 seconds were included. The basic rhythm was sinus rhythm and arrhythmia. The informed consent for participating in the clinical study was signed prior to the scan, and the clinical value of the study was explained to get the cooperation of the patients.

**Exclusion criteria:** Women of childbearing age, and patients with history of iodine allergy, with serum creatinine  $> 130\mu\text{mol/L}$ , and fasting blood sugar  $> 13\text{mmol/L}$  were excluded. Patients with severe cardiopulmonary insufficiency after pacemaker placement or artificial valve replacement, and those with severe left ventricular dysfunction, atrial flutter and atrial fibrillation were also excluded.

Before scanning, the basic information of the patients, such as gender, age, height, weight, current medical history and related medical history, was recorded in detail. The informed consent of the clinical study was signed by the patients. The tension of the patients was eliminated, and they were informed of the adverse reactions such as bitterness of mouth and fever after the injection of the contrast agent during the examination process, so as to avoid the exercise artifacts caused by tension of the patients. Heart rate was measured before scanning. Patients with heart rate  $> 70$  minute received Betaloc 12.5-25mg sublingual administration 30-60 minutes before coronary spiral CT, and rested quietly for half an hour. Their heart rate was controlled at  $58\pm 12$  at  $\text{min}^{-1}$  ( $50-70 \text{ min}^{-1}$ ) during the 64-slice spiral CT scanning.

The patients were repeatedly trained to hold their breath to ensure that the chest and abdomen remained stationary during the scanning exposure image acquisition.

Light speed VCT 64-slice spiral CT (GE USA) was used for scanning. The 64-slice spiral CT detectors had 64 rows, each row was 0.625mm, and one acquisition completed 40mm range acquisition. Scanning type: Cardiac Helical, 32ms; Layer thickness was 0.625mm. Scanning layer interval was 1.25mm with 120kV, 500mA, matrix  $512 * 512$ , scanning delay time  $25\pm 2\text{s}$  (23-27s). Before the examination, it was necessary to explain and talk with the patients to relax them. At the same time, breath-holding training was carried out to ensure that the patients' chest and abdomen were still during the exposure period. The patients were in the supine position, and the electrodes were placed correctly to confirm that the ECG signal had been received. Scanning was carried out when holding your breath after deep inhalation.

Firstly, a prospective ECG-gated sequence was used to perform coronary artery plain scan, covering the whole heart from the bottom of the heart (marked by tracheal eminence) to the subdiaphragm. Coronary artery calcification and soft plaque were observed, and the exact location of coronary artery enhancement scan was made. Then, 65-80 mL of iohexol injection (350 mgI/mL), a non-ionic contrast agent, was injected into the right distal forearm vein or elbow vein through a two-barrel high-pressure syringe at a flow rate of 3.5-5.0mL/s. The subjects were asked to hold their breath once after normal inhalation. The cross-sectional images of the coronary artery enhancement scanning were previewed. The left anterior descending branch, the middle and distal segments of the right coronary artery were selected. A 10%-100% cross-sectional image of the cardiac cycle was previewed at 5% Preview series function intervals. The CT images of each coronary artery in each phase window were observed. The left and right coronary arteries were compared and selected to show the clearest. The reconstructed images with the best image quality and the smallest motion artifacts were screened out. The R-R interval of the image was used to reconstruct the 0.75mm thin-layer image, and the thickness of the reconstructed layer was 5-10mm. The imaging methods and principles were the same as those of CT angiography. Volume rendering VR, maximum intensity projection MIP, sliding thin-slab STS-MIP, multiplanar reformation MPR, shaded surface display SSD and CT virtual endoscope CTVE were mainly used. Vertical sections were made for the limited stenosis segment of the blood management department. The normal lumen area of the stenosis segment as well as

its proximal and distal end were measured. The following formulas were used to calculate the degree of stenosis:  $[(\varphi \text{ normal proximal part of } \phi + \varphi \text{ normal distal part of } \phi) / 2 - \varphi \text{ stenosis}] / [(\varphi \text{ normal proximal part of } \phi + \varphi \text{ normal distal part of } \phi) / 2]$ . For a wide range of lumen stenosis, it was necessary to combine surface reconstruction image with comprehensive evaluation. Finally, the positional relationship between coronary artery stenosis and the heart was observed from different angles by VRT image reconstruction. CAG was performed with Siemens AXIOM Artis angiograph and digital imaging system (AXIOM Artis; Siemens Medical Systems, Erlangen, Germany) and Judkins coronary angiography. A 6F multifunctional coronary angiographic catheter was inserted routinely through radial artery puncture, followed by left and right coronary angiography. The contrast agent was iohexol injection (350mgI/mL), and the dose injection rate was 4-8mL/time. Five standard projection positions of the left coronary artery were taken: posterior anterior + head position, left anterior oblique + foot position, right anterior oblique + foot position, right anterior oblique + head position, and left anterior oblique + head position. Two standard projection positions were taken for the right coronary artery: left anterior oblique position, and posterior anterior + head position. If necessary, the projection position should be increased according to the specific situation.

The degree of coronary artery stenosis was classified into four grades according to the reduction of lumen area. Class I lesions: lumen area reduced by 1%-25%; Class II lesions: lumen area reduced by 26%-50%; Class III lesions: lumen area reduced by 51%-75%; Class IV lesions: lumen area reduced by 76%-100%. The stenosis degree of one or more main coronary arteries (left main coronary artery, anterior descending coronary artery, circumflex coronary artery, right coronary artery) were reduced to grade III, and would be diagnosed as coronary heart disease.

According to the American Heart Association (AHA) score, all coronary arteries were divided into 16 segments. The coronary arteries were divided into 5 grades and scored based on the image quality. The score of grades 1-5 was 5-1. 5 points: There was no artifacts. The trunk and branches were clearly displayed. 4 points: A certain segment of the main blood vessel was a little blurred. 3 points: Half or more of the main vessels were blurred, but continuous. 2 points: All the main vessels and branches were blurred. 1 point: Blood vessels were indistinguishable. Only segments with image quality grading of 1-2 were included in the study. Then, the stenosis of coronary artery and the degree of stenosis

were further evaluated. In addition, when reading the film, a comprehensive evaluation was made based on the cross-sectional images and reconstructed images such as MPR, CPR, VR and MIP. At least two planes showed coronary artery stenosis, the existence of stenosis was confirmed.

SCA images were reviewed by two veteran cardiologists to evaluate the inner diameter (>2 mm) of coronary artery vessels. When selective CAG was used to display coronary artery stenosis or 64-slice spiral CT was used to display coronary artery stenosis, the visual diameter method was commonly used. The relative normal diameter of the proximal end of the stenosis was taken as the reference value to quantitatively evaluate the degree of stenosis.

**Specific calculation formula:** the degree of stenosis of the lumen = the diameter of the normal blood vessel near the heart of the stenosis site — the diameter of the stenosis site / the diameter of the normal blood vessel near the heart of the stenosis \* 100%. The percentage of diameter stenosis  $\geq 50\%$  was diagnosed as coronary heart disease.

SPSS 16.0 statistical software was used to analyze the data. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic coincidence rate of CT coronary angiography showing moderate and severe coronary stenosis ( $\geq 50\%$ ) were calculated using routine coronary angiography as the "gold standard". Normality test and homogeneity test of variance for each group of data showed that the data accorded with normal distribution and homogeneity of variance. Stepwise multiple regression analysis was employed to explore gender, age and body mass index.

## Results

### Case characteristics

In this study, 100 patients were collected, including 75 (75%) males and 25 (25%) females, as shown in Figure-1. The age ranged from 46 to 68. There were 45 (45%) patients with a history of smoking, of which 22 (22%) had hyperlipidaemia, 71 (71%) had hypertension, 29 (29%) had familial cardiovascular disease, 23 (23%) had diabetes, 3 (3%) had myocardial infarction, 64 (64%) had typical angina pectoris, 19% (19%) had the history of atypical chest pain, 13% (13%) had asymptomatic myocardial ischaemia, 4% (4%) had stent surgery and 5% (5%) had bypass surgery.

### Coronary artery display

According to the American Heart Association (AHA)

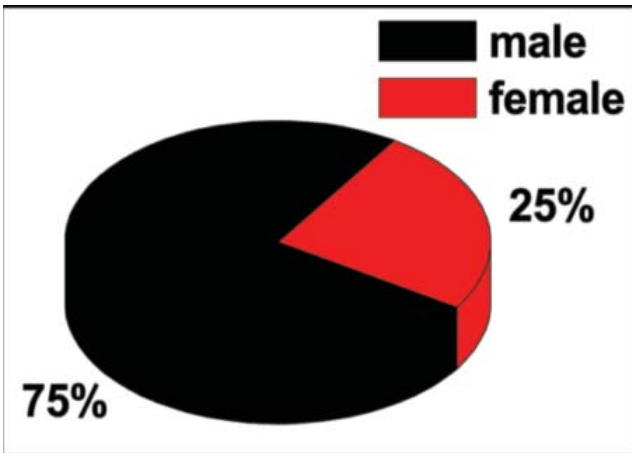


Figure-1: The proportion of male and female patients.

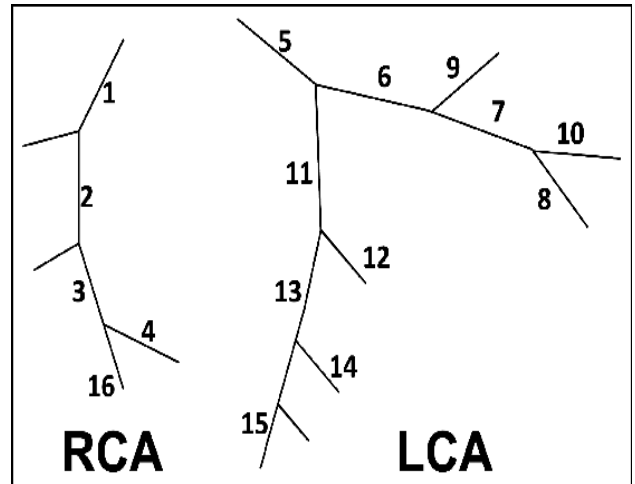


Figure-2: American Heart Association (AHA) coronary segmentation 1. Proximal segment of right coronary artery 2. Middle segment of right coronary artery 3. Distal right coronary 4. Posterior descending right coronary 5. Left main trunk 6. Proximal segment 7. Middle segment 8. Distal segment of anterior descending branch 9. The proximal segment of the first diagonal branch 10. The second diagonal branch 11. The left circumflex branch 12. First blunt marginal branch 13. Distal left circumflex branch 14. Second blunt marginal branch 15. Distal left circumflex branch 16. Posterolateral right coronary branch.

scoring method, all coronary arteries were divided into 16 segments, as shown in Figure-2. A total of 1547 (96.7%) of the 1600 segments could be displayed and evaluated simultaneously on CAG and MSCT. The main factors affecting the 64-slice spiral CT assessment were motion artifacts and coronary artery calcification. The total

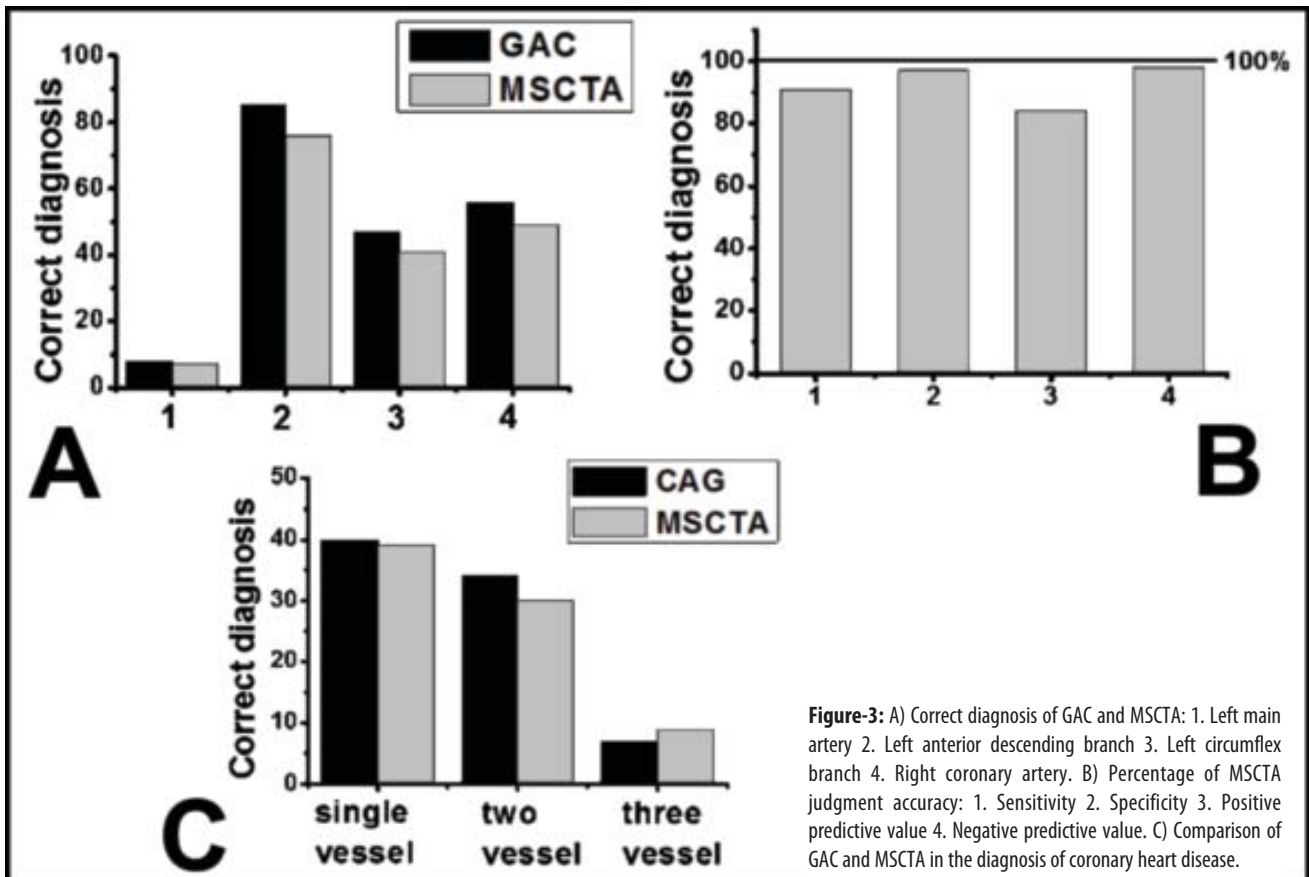


Figure-3: A) Correct diagnosis of GAC and MSCTA: 1. Left main artery 2. Left anterior descending branch 3. Left circumflex branch 4. Right coronary artery. B) Percentage of MSCTA judgment accuracy: 1. Sensitivity 2. Specificity 3. Positive predictive value 4. Negative predictive value. C) Comparison of GAC and MSCTA in the diagnosis of coronary heart disease.

number of assessable segments of proximal coronary artery 1, 2, 5, 6, 7, 11 and 13 was 670, accounting for 99% of the assessable segments and 877 segments of distal coronary artery, accounting for 95% of the assessable segments. On the three-dimensional reconstruction images reconstructed by the best phase window of 64-slice spiral CT, the display length of left main coronary artery was 13-35mm, the display length of left anterior descending branch was 90-188mm, the display length of left circumflex branch was 73-119mm and that of right coronary artery was 65-196mm.

### Coronary artery stenosis and coronary heart disease

In coronary angiography, 173 segments were correctly diagnosed with 64-slice spiral CT, 7 segments of left aorta, 76 segments of left anterior descending artery, 41 segments of left circumflex artery and 49 segments of right coronary artery. The 22 segments were underestimated as mild stenosis, with 1 segment of left main artery, 8 segments of left anterior descending artery, 6 segments of left circumflex artery and 7 segments of right coronary artery. The diagnosis was compared with Figure-3A. Overall, 64-slice spiral CT showed that the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic coincidence rate of moderate and severe coronary artery stenosis were 91%, 97%, 84%, 98% and 97%, respectively. The diagnostic accuracy of left main artery, anterior descending artery, circumflex artery and right coronary artery was similar, while the sensitivity and positive predictive value of the distal vessels were decreased, as shown in Figure-3B. The CAG found 81 (81%) patients with coronary heart disease (40 cases with single vessel disease, 34 cases with two vessel disease and 7 cases with three vessel disease). The MSCTA diagnosed 78 (78%) patients with coronary heart disease (39 cases with single vessel disease, 30 cases with two vessel disease and 9 cases with three vessel disease), as illustrated in Figure-3C.

### Discussion

Coronary heart disease is one of the common and frequently occurring diseases that seriously affect human health. More than half of coronary events occur in asymptomatic population.<sup>19</sup> Therefore, early diagnosis of coronary heart disease is of great significance. Coronary artery is the only source of blood supply to the heart. The occurrence of coronary heart disease is closely related to the anatomy of coronary artery. Accurate reflection of coronary artery condition through imaging examination is the prerequisite for effective early diagnosis and safe treatment of coronary heart disease. Selective coronary

angiography is the "gold standard" for the diagnosis of coronary heart disease. It is of great significance to determine the presence, location and severity of coronary artery disease, but it has a high cost and a certain injury rate and death rate.<sup>20</sup> Because of this clinical application is limited, it is not suitable as a screening method for coronary heart disease. Coronary angiography was an invasive procedure with potentially serious complications such as arrhythmia, myocardial infarction, coronary artery perforation, etc. In addition, coronary angiography had some limitations as it could only show the internal condition of coronary lumen, and the information provided by coronary atheromatous plaque was not enough.<sup>21</sup>

With the development of minimally invasive diagnostic technology, 64 slice spiral CT has been gradually applied. For example, 64 slice spiral CT is superior to conventional ultrasound in the diagnosis of HCC and focal nodular hyperplasia, especially in the diagnosis of small lesions less than 1 cm in diameter.<sup>22</sup> 64 slice spiral CT was also used to image the cross-sectional area of pulmonary small vessels.<sup>23</sup> 64 slice spiral CT scan has been used to analyse and calculate perfusion parameters, to image the cross-sectional area of pulmonary small vessels, to diagnose ovarian tumours, to evaluate the relationship between sub pulmonary nodules (SSNs) and peripheral blood vessels, bronchi inflation, and to associate its imaging characteristics with benign and malignant pathological diagnosis.<sup>24,25</sup>

At present, 64 slice spiral CT coronary artery imaging has become the most important imaging method of coronary heart disease screening.<sup>26</sup> With the further improvement of spatial and temporal resolution, the role of 64 slice spiral CT in clinical cardiology has been redefined. The 64-slice spiral CT had a multi detector system that allowed the thickness of the slice to be selected. In the process of rescanning, it could acquire image data of more than four layers at the same time. It could significantly reduce the volume scanning time with a high spatial resolution and time resolution. Moreover, it was a better non-invasive examination method for coronary artery imaging.<sup>27</sup> The 64-slice spiral CT could show the main trunk, 2-3 branches of the coronary artery, as well as the patency of the lumen. The sensitivity of calcification in different degree of coronary artery was higher. Small non calcified plaques could be found, and the location, shape and length of plaques, and the relationship between plaques and coronary branches could be determined, which can serve as an important theoretical basis for the development of follow-up treatment plans.

In this study, a total of 100 patients with clinical diagnosis

or suspected coronary heart disease were examined by 64 slice spiral CT coronary angiography and selective coronary angiography. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic coincidence rate of 64-slice spiral CT in detecting moderate or severe coronary artery stenosis was calculated. The results showed that the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of 64-slice spiral CT were 91%, 97%, 84%, 98% and 97%, respectively. Similarly, other research teams also carried out 64 slice spiral CT enhanced scanning to evaluate the sensitivity and accuracy of the diagnosis of small hepatocellular carcinoma, and achieved good results.<sup>28</sup> Therefore, 64-slice spiral CT had a good diagnostic value for moderate and severe coronary artery stenosis, which could basically meet the diagnostic needs of coronary heart disease, and could be used as a primary screening method for high-risk population of coronary heart disease. With more advanced CT machines, such as 256-slice spiral CT, being put into clinical research, the data collection of coronary arteries is no longer dependent on heart rate control, which simplifies the examination process. In future research, a more in-depth exploration on diagnosis of coronary heart disease will be made to replace the current selective coronary angiography.

The 64-slice spiral CT had excellent diagnostic value for moderate and severe coronary stenosis in coronary artery imaging. It could basically meet the diagnostic needs of coronary heart disease, and could be used as a screening method for high-risk population of coronary heart disease.<sup>29,30</sup> Besides that, it could detect blood vessels of different thicknesses from different angles and levels.<sup>31</sup> It could also effectively detect the changes of haemorrhagic vessel diameter stenosis. At the same time, it could accurately evaluate the cardiac performance and pathological condition of blood vessel wall. In addition, it had a high negative predictive value and specificity for moderate and severe coronary stenosis, helping to avoid normal or no need of interventional therapy for coronary artery diseases. The Invasive CAG could basically meet the requirements of screening interventional therapy for patients with coronary heart disease.

## Conclusion

The 64-slice spiral CT showed the main, 2-3 branches of coronary artery and the patency of the lumen. It had a good diagnostic value for moderate and severe coronary stenosis, and could basically meet the diagnosis needs of coronary heart disease. It could also be used as a primary screening method for high-risk population of coronary heart disease.

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**Conflict of Interest:** None.

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