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Original Article

The value of coronary CTA in the diagnosis of coronary artery disease

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Abstract: Objective: To investigate the diagnostic value of coronary computed tomography angiography (CTA) in the detection of coronary artery disease. Methods: From January 2017 to December 2019, 150 patients with suspected coronary artery disease admitted to the Affiliated People's Hospital of Ningbo University were recruited as the research cohort for this study. All the patients underwent a coronary CTA and a coronary angiography. The results of the patients' coronary CTAs and coronary angiographies were compared. Analyses were performed on the practical implications of coronary CTA in the detection of coronary artery disease and the detection and coincidence rates of coronary CTA for determining the severity of coronary stenosis. Results: There were no statistical differences in the detection of positive results of coronary artery diseases or the identification of coronary stenosis between the coronary CTAs and the coronary angiographies. The sensitivity of coronary CTA in the examination of coronary artery diseases was 81.8%. The specificity was 87.5%, the negative predictive value was 63.6%, and the positive predictive value was 94.7%. In contrast to the coronary angiography, the coincidence rates of coronary CTA for determining the location of coronary lesions were 89.1% for LAD lesions, 80.0% for LCX lesions, and 100% for RCA lesions. Conclusions: Coronary CTA has a significant value in the detection of coronary artery diseases, as it can accurately examine the severity of coronary stenoses and locate the sites of the stenotic lesions. It is worthy of clinical use.

Keywords: Coronary artery disease, coronary computed tomography angiography, coronary angiography, diagnosis

Introduction

Ischemic heart disease remains the leading cause of mortality worldwide [1]. It is characterized by a rapid and transient myocardial oxygen imbalance resulting from coronary stenosis [2, 3]. In patients with suspected coronary artery disease, a careful assessment of the diagnosis is very important, and a considerable number of treatment decisions are based on this knowledge. Invasive coronary angiography is the gold standard for the diagnosis of coronary artery disease [4, 5]. It was reported that coronary angiography can accurately and intuitively reflect the severity of coronary stenosis [6, 7]. However, the invasive nature of coronary angiography is risky and results in significant trauma. And many scholars consider that coronary angiography is ideally reserved for patients likely to require revascularization [8]. For patients suspected of having coronary artery disease with a low risk of significant coronary stenosis, the guidelines recommend that non-invasive ischemia examinations be used as gatekeeper to invasive coronary angiography [9]. Many previous studies found that non-invasive ischemia examinations have a low accuracy rate in identifying patients with coronary artery disease [10, 11]. In recent years, with the improved technology of multislice computed tomography, coronary computed tomography angiography (CTA) has provided clinicians with a new and promising tool for the non-invasive assessment of coronary artery disease [12, 13]. Currently, coronary CTA plays an important role in the early detection of coronary artery disease. It is reported that coronary CTA is of modest value in quantifying the severity of coronary stenosis and in locating the "criminal" coronary artery branch [14]. However, studies comparing the results of coronary CTA and coronary angiography are rare, and the results of such studies are controversial. In this context, the current study aimed to compare these two methods to help clinicians determine which method is most appropriate for diagnosing coronary artery disease for patients with suspected ischemic heart disease today.

Materials and methods

Subjects

A total of 150 patients with suspected coronary artery disease admitted to the Affiliated People's Hospital of Ningbo University from January 2017 to December 2019 were recruited as the study cohort. The inclusion criteria were as follows: (1) According to the diagnostic criteria of coronary artery disease [15], patients who were suspected of having coronary artery disease, (2) Patients whose cardiac function ranged from class I to class II, (3) Patients with no history of acute myocardial infarction, (4) Patients who voluntarily underwent coronary CTA and coronary angiography, and complied with this study, and (5) Patients with complete clinical data. The exclusion criteria were as follows: (1) Patients who were allergic to iodine, (2) Patients also suffering from severe liver or renal dysfunction, (3) Patients also suffering from arrhythmia, congestive heart failure, sick sinus syndrome, cognitive disorders, or a malignancy. This study was approved by the Research Ethics Committee of our hospital. An informed consent was collected from every patient included in this study. All the patients underwent a coronary CTA and a coronary angiography.

Coronary CTA

The coronary CTA was conducted using 64-slice CT systems (GE Company, USA). Before each examination, the patients' heart rates were regulated using oral metoprolol and kept at about 60 beats/min. First, a low-dose non-contrast enhanced scan was conducted to determine and quantify the coronary artery calcium. The contrast agent was injected into the antecubital vein at a flow rate of 5 ml/s, depending on the each patient's body habitus, and followed by saline. The coronary CTA was conducted with 180 mA of tube current and 100 kV of peak tube voltage, depending on each patient's weight. The gantry rotation time was 350 ms. Synchronized to ECG, the data were retrospectively reconstructed covering 70%-80% of the R-R interval. The reconstruction parameters for field of view, convolution kernel, and slice thickness were adjusted according to the instructions reported by previous researchers [16] and were in line with standard clinical practice. The images were transferred to an external designated workstation to reestablish the 3D model of the coronary artery.

Coronary angiography

The coronary angiographies were performed according to the methods reported by previous researchers [17]. Local anesthesia was administered with 2 mL of 2% lidocaine. A radial artery puncture or a femoral artery puncture was made, and Judkins catheters were used. The coronary angiography was conducted with a selective catheterization of the right and left coronary districts through the injection of contrast material. The images were obtained in different projections. It was usually two for the right coronary artery and four for the left coronary artery.

Observed indexes

The coronary CTA and coronary angiography results were evaluated by two experienced physicians who were not aware of the basic information of the patients included in this study. The coronary artery was assessed by visually contrasting it with the surrounding normal blood vessels, and more than 50% stenosis of any coronary artery was considered as a positive result. The coronary CTA and coronary angiography findings were compared, and an analysis was conducted to confirm the validity of coronary CTA in the detection of coronary artery disease and the accuracy of examining coronary stenosis with different severity levels and localizing the coronary lesions.

Statistical analysis

All the data in this study were analyzed using SPSS software version 22.0. The measurement data were expressed as the mean ± SD, and the comparisons between two groups were done using t tests. The count data were presented as a percentage or as the number of cases. The comparisons between two groups were conducted using chi-square tests. With the findings of coronary angiography selected as a reference, ROC curves were used to assess the diagnostic efficiency of coronary artery diseases using coronary CTA. $P<0.05$ indicated that the differences were significant.

Table 1. The basic patient information

Parameters	Values
Number of cases	150
Suspicious stable angina pectoris	122 (81.3%)
Suspicious unstable angina	28 (18.7%)
Sex (cases)	
Male	93 (62.0%)
Female	57 (38.0%)
Average age (years)	65.4±3.8
BMI (kg/m^2)	22.1±0.7
History of smoking (cases)	25 (16.7%)
Course of disease (years)	2.3±0.5
Diabetes mellitus (cases)	60 (40.0%)
Hyperlipemia (cases)	35 (23.3%)
Hypertension (cases)	72 (48.0%)

Note: BMI: Body mass index.

Results

Basic patient information

The patients' basic information is summarized in **Table 1**. There were 150 patients, including 93 males and 57 females. The average age was 65.4±3.8 years. There were 60 patients with diabetes mellitus, 35 patients with hyperlipemia, and 72 patients with hypertension. The course of the disease was 2.3±0.5 years. Their average BMI was 22.1±0.7 kg/m^2. There were 25 patients with a smoking history. The coronary CTA and coronary angiography images are shown in **Figure 1**.

Detection of the positive rate of coronary CTA

Among the 150 patients with suspected angina pectoris, the coronary angiography results showed that the positive rate was 73.3% (110/150), and the negative rate was 26.7% (40/150). The coronary CTA results revealed that there were 95 (63.3%) patients with coronary artery disease and 55 (36.7%) patients without coronary artery disease. There were no statistically significant differences in the detection of the positive rate of coronary artery disease between coronary angiography and coronary CTA, as seen in **Table 2**.

Results of ROC curve analysis

The sensitivity of coronary CTA in the detection of coronary artery disease was 81.8% (90/110), and the specificity was 87.5% (35/40). The negative predictive value was 63.6% (35/55), and the positive predictive value was 94.7% (90/95), as seen in **Table 3**. The results of the ROC curve analysis showed that the area under the curve was 0.785, and significant differences were found (P=0.017), as seen in **Figure 2**.

The coronary stenosis profiles in patients with coronary artery disease using coronary CTA and coronary angiography

Among the 90 patients with coronary artery disease identified through the coronary CTA and the coronary angiography, the coronary CTA results showed that there were 26 patients with coronary stenosis less than 70% and 64 patients with coronary stenosis more than 70%. The coronary angiography results showed that there were 30 patients with coronary stenosis less than 70% and 60 patients with coronary stenosis more than 70%. No significant differences were found, as shown in **Table 4**.

Detection of the coronary lesion locations using coronary CTA

The coronary angiography results showed that 46 coronary lesions were localized in the LAD, 25 coronary lesions were localized in the LCX, and 36 coronary lesions were localized in the RCA. The coronary CTA results revealed that 41 coronary lesions were localized in the LAD, 20 coronary lesions were localized in the LCX, and 36 coronary lesions were localized in the RCA. The coincidence rates were 89.1% (41/46) for the LAD lesions, 80.0% (20/25) for the LCX lesions, and 100% (36/36) for the RCA lesions, as seen in **Table 5**.

Discussion

As one of the most severe illnesses, coronary artery disease seriously threatens the physical and psychological health of patients. It has become the main cause of mortality in developed and developing countries [18]. At present, a variety of medical imaging examinations including coronary angiography, coronary computed tomography angiography (CTA), and intravascular ultrasound are used to detect coronary artery disease early [19]. Coronary angiography is thought to be the most accurate examination for assessing and diagnosing coronary artery disease. In this study, the coronary

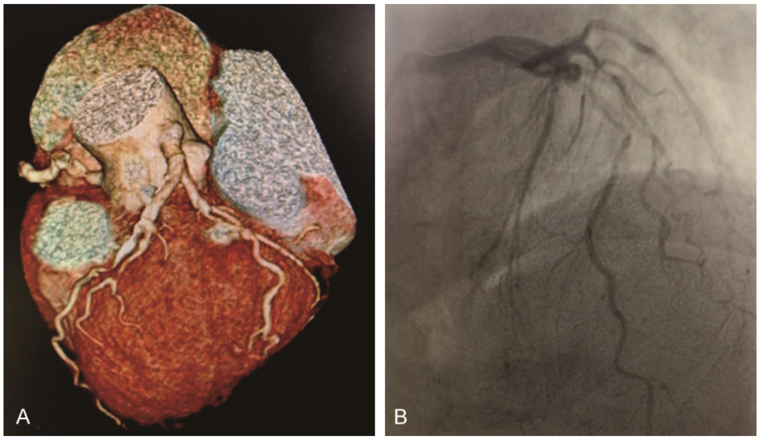

Figure 1. Detection of coronary artery diseases using coronary CTA and coronary angiography. A: Coronary CTA images; B: Coronary angiography images.

Table 2. Comparison of the positive and negative rates of coronary artery disease between coronary angiography and coronary CTA

Groups	Positive rate [n (%)]	Negative rate [n (%)]
Coronary angiography	110 (73.3)	40 (26.7)
Coronary CTA	95 (63.3)	55 (36.7)
χ^2 value	3.466	
P value	0.063	

Table 3. Detection using coronary CTA and coronary angiography for suspected angina pectoris

Coronary CTA	Coronary angiography		Total
	Positive	Negative	
Positive	90	5	95
Negative	20	35	55
Total	110	40	150

angiography examination was selected as the reference. However, in clinical practice, it has been found that coronary angiography can lead to cardiovascular complications and local arterial puncture site complications [7, 20]. Because of this, patients usually hesitate to agree to this method. Coronary CTA is a non-invasive examination for detecting coronary artery disease, so it is very popular among patients with suspected coronary artery disease. To further confirm the efficacy of coronary CTA, this study conducted a comparison of the results between coronary CTA and coronary angiography. In this study, no complications occurred in the patients who underwent coronary CTA and coronary angiography.

It has been reported that irregular heart rhythms or rapid heart rates are relative contraindications for coronary CTA [13, 21]. In this study, each patient's heart rate was controlled to a rate of 60 to obtain the optimized image quality through premedication with oral metoprolol. Compared with coronary angiography, coronary CTA can reflect pulmonary veins or right heart structures by adjusting the scanning time. Moreover, the image data during the process of coronary CTA are often obtained in spiral mode. The continuous acquisition of image data permits a retrospective reconstruction at any point along the R-R interval. In this study, the coronary artery reconstructions were performed at 70%-80% of the R-R interval, corresponding to mild to late diastole, which was in line with the results reported in previous studies [22].

This study also showed that, among the 150 patients with suspected coronary artery disease, 110 had positive results using coronary angiography, for a positive rate of 73.3% (110/150), while 63.3% (95/150) were identified using coronary CTA. Although fewer patients were found to have coronary artery disease using coronary CTA compared with coronary angiography, there were no significant differences. The ROC curves showed that the value of AUC was 0.785, which suggests that coronary CTA is of great value in detecting coronary artery disease. It also showed that the sensitivity of coronary CTA in the detection of coronary artery disease was 81.8%, and the specificity was 87.5%, which indicated that if the coronary artery images were normal on the coronary CTA, it was unnecessary to further administer a coronary angiography. All of these results imply that the non-invasive coronary artery examination by coronary CTA could be utilized for the preliminary screening of patients with suspected coronary artery disease,

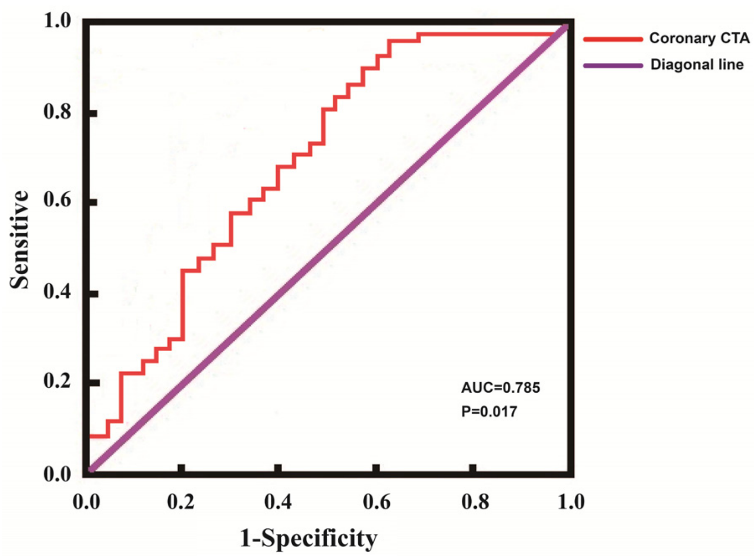

Figure 2. ROC curves for coronary CTA in the detection of coronary artery disease.

Table 4. Detection using coronary stenosis in patients with coronary artery disease between coronary CTA and coronary angiography

Methods	Coronary stenosis (n, %)	
	>70%	<70%
Coronary angiography	30 (33.3)	60 (66.7)
Coronary CTA	26 (28.9)	64 (71.1)
χ^2 value	0.415	
P value	0.520	

Table 5. Detection of the location of coronary lesions between coronary CTA and coronary angiography (Cases)

Location of lesions	Coronary CTA	Coronary angiography	Coincidence rate
LAD	41	46	89.1%
LCX	25	20	80.0%
RCA	36	36	100%

so invasive injuries induced by coronary angiography can be significantly reduced.

The qualitative assessment of coronary stenosis benefits the treatment plan. Leber et al. reported that the absolute quantification of coronary stenosis on a segment using coronary CTA showed a moderate correlation with coronary angiography [23]. Another study revealed that there is a systemic bias for coronary CTA, which usually overestimates the degree of coronary stenosis by about 5-10%, especially for coronary lesions related to calcified plaques [24]. It was reported that there is a higher false positive rate of coronary CTA associated with increased calcium scores [25]. And the image resolution of coronary CTA is generally sufficient to allow the categorization of stenosis severity into broader categories. In this study, the coronary stenosis severity categorization was divided into less than 70% and more than 70%. The results of this study showed that coronary CTA identified 33.3% of the cases with less than 70% coronary stenosis and 66.7% of the cases with more than 70% coronary stenosis. It also showed that no significant differences were found in the detection of coronary stenosis severity between coronary CTA and coronary angiography. This might be due to the spatial resolution and the coronary artery calcification. These results are similar to those reported by Castellano et al. [26]. Moreover, this study also revealed that compared with coronary angiography, the coincidence rates of coronary CTA were 89.1% for LAD lesions, 80.0% for LCX lesions, and 100% for RCA lesions, which indicates that coronary CTA can accurately localize the stenotic lesions of the coronary artery. As we can see, coronary CTA seems to be the best option for the detection of coronary artery disease in patients suspected of having it. It may be helpful to avoid unnecessary coronary angiography, reduce the related risks, and optimize the medical resources.

In summary, coronary CTA is of practical application in the early diagnosis of coronary artery disease. It is easy to operate and non-invasive. In addition, coronary CTA can accurately locate the sites of coronary stenosis and identify the stenotic severity. Therefore, it is worthy of extensive use as a screening test for suspected coronary artery disease. However, there are some limitations to this study: The sample size was relatively small. No follow up was done. The study did not assess the prognostic role of coronary CTA in patients with coronary artery disease, nor did it report the results of the safety analysis. In the future, a multi-center study with a larger sample size would be required for further validation.

Disclosure of conflict of interest

None.

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