

Decreased Diagnostic Accuracy of Multislice Coronary Computed Tomographic Angiography in Women with Atypical Angina Symptoms

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Abstract

Background: Multislice computed tomography (MSCT) coronary angiography (CAG) is a noninvasive technique with a reported high diagnostic accuracy for coronary artery disease (CAD). Women, more frequently than men, are known to develop atypical angina symptoms. The purpose of this study was to investigate whether the diagnostic accuracy of MSCT in women with atypical presentation differs from that in men.

Methods: We enrolled 396 in-hospital patients (141 women and 255 men) with suspected or proven CAD who successively underwent both MSCT and invasive CAG. CAD was defined as any coronary stenosis of $\geq 50\%$ on conventional invasive CAG, which was used as the reference standard. The patients were divided into typical and atypical groups based on their symptoms of angina pectoris. The diagnostic accuracy of MSCT, including its sensitivity, specificity, negative predictive value, and positive predictive value (PPV), was calculated to determine the usefulness of MSCT in assessing stenoses. The diagnostic performance of MSCT was also assessed by constructing receiver operating characteristic (ROC) curves.

Results: The PPV (91% vs. 97%, $\chi^2 = 5.705$, $P < 0.05$) and diagnostic accuracy (87% vs. 93%, $\chi^2 = 5.093$, $P < 0.05$) of MSCT in detecting CAD were lower in women than in men. Atypical presentation was an independent influencing factor on the diagnostic accuracy of MSCT in women (odds ratio = 4.94, 95% confidence intervals: 1.16–20.92, Walds = 4.69, $P < 0.05$). Compared with those in the atypical group, women with typical angina pectoris had higher PPV (98% vs. 74%, $\chi^2 = 17.283$, $P < 0.001$), diagnostic accuracy (93% vs. 72%, $\chi^2 = 9.571$, $P < 0.001$), and area under the ROC curve (0.91 vs. 0.64, $Z = 2.690$, $P < 0.01$) in MSCT diagnosis.

Conclusions: Although MSCT is a reliable diagnostic modality for the exclusion of significant coronary artery stenoses in all patients, gender and atypical symptoms might have some influence on its diagnostic accuracy.

Key words: Angina Pectoris; Coronary Artery Disease; Multidetector Computed Tomography; Women

INTRODUCTION

Cardiovascular disease is the leading cause of mortality throughout the world, accounting for 17.3 million deaths/year.^[1] A large number of studies have proven that the epidemiology, clinical manifestations, and clinical prognosis of coronary artery disease (CAD) have sex-related differences.^[1-6] In the past 30 years, the mortality of male patients with CAD has declined gradually, but an increase had been observed in women.^[1] Unfortunately, accurate diagnosis of CAD might be more challenging in women than in men because women more frequently present with atypical symptoms.

Thus, women are at increased risk of delayed or incorrect diagnosis. According to a report from the American Heart Association (AHA) in 2015, the mortality rate of female patients with cardiovascular disease (50.6%) has exceeded that

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of men (49.4%).^[1] Conventional coronary angiography (CAG) is the gold standard diagnostic modality for CAD, but it is invasive and associated with several potential complications. Moreover, nearly half of the women who underwent invasive CAG were found to have nonobstructive CAD.^[7]

Multislice computed tomography (MSCT) CAG is highly accurate for the exclusion of significant coronary artery stenoses (>50% luminal narrowing), with high negative predictive values (NPVs), as compared with conventional CAG.^[8] At present, the accuracy of MSCT diagnosis in women is still not clear. Data are mainly based on the male population, with only about 20% of the included patients being female.^[8] Many of the studies that have been conducted have small sample sizes and conflicting results.^[9–12] In addition, whether atypical presentation influences the diagnostic accuracy of MSCT in women remains unknown. Moreover, the clinical utilization of MSCT in the diagnosis of CAD remains unreasonable.^[13] This study aimed to investigate the effect of sex and atypical symptoms on the diagnostic accuracy of the current 64-slice MSCT CAG technique using conventional CAG as the reference standard.

METHODS

Study group

Totally, 1246 in-patients who had performed CAG from January 2007 to February 2011 in the Peking University People's Hospital were included in the study. Demographic information, medical history, and clinical data were obtained from the patients' medical records. The exclusion criteria were nonsinus rhythm (145 patients), intolerance to iodine contrast (11 patients), renal dysfunction (serum creatinine levels ≥ 15 mg/L, 87 patients), pregnancy (0 patients), history of percutaneous coronary intervention or coronary artery bypass surgery (46 patients), uninterpretable images due to poor quality (72 patients), and other complications not suitable for MSCT (489 patients). Finally, a database of 396 patients with suspected or proven CAD on admission, who successively underwent both MSCT and invasive CAG, was reviewed. The median interval time between CAG and MSCT was 4 (0–8) weeks. CAD was diagnosed based on invasive CAG results, indicating stenoses of $\geq 50\%$ in any coronary artery.

The patients were divided into typical and atypical groups based on their symptoms of angina pectoris. Typical angina symptoms were defined as the sensation of chest pain or discomfort that may feel like tightness, heaviness, or burning in the central chest. The discomfort might move or radiate to the shoulder, arms, jaw, neck, and back. Angina is typically precipitated by exertion or emotional stress, lasting only a few minutes and relieved by rest and nitroglycerin. Atypical angina lacks the described characteristics. This retrospective study was approved by the Ethics Committee of Peking University People's Hospital.

Multislice computed tomography

All the patients underwent coronary MSCT imaging using the General Electric LightSpeed volume computed

tomography (GE Healthcare, Milwaukee, WI, USA). Patients with a heart rate of >65 beats/min received additional β blockers (25 or 50 mg of metoprolol) 1 h before the CT examination. Then, the patients were injected with 60–80 ml of iodinated contrast medium in the antecubital vein at a high flow rate (5 ml/s), followed by saline flushing and coronary CT angiographic examinations. The collimation was 64 mm \times 0.625 mm; gantry rotation time was 350 ms, tube current was 600–750 mA, and voltage was 120 kV. Automated bolus-tracking in the aortic root was used for timing of the scan. All the images were acquired during a single inspiratory breath hold of about 10 s, with simultaneous electrocardiographic recording. Images were reconstructed in the cardiac phase showing least motion artifacts.

Multislice computed tomography data analysis

All images were interpreted in consensus by two experienced radiologists, who were unaware of the clinical presentations of the patients. The coronary arteries were divided into 13 separate segments according to the modified AHA classification.^[14] CAD was defined as coronary artery stenoses of $\geq 50\%$. Coronary artery plaque was defined as an area of ≥ 1 mm², and a clearly recognizable structure associated with the coronary artery wall in at least two independent image planes. Plaques with a CT density greater than that of the contrast-enhanced coronary lumen were defined as calcified plaques.

Conventional invasive coronary angiography

For patients with suspected or proven CAD who needed to undergo a second evaluation of coronary arteries, conventional invasive CAG was performed according to the standard protocols. CAD was defined as the presence of stenosis with a diameter of $\geq 50\%$. CAGs were visually assessed in consensus by two experienced observers who were unaware of the results of the MSCT CAG.

Statistical analyses

Continuous variables were expressed as mean \pm standard deviation (SD) and compared between the two groups using the *t*-test for independent samples. When not normally distributed, continuous data were expressed as median (interquartile range) and compared between the two groups using the nonparametric Mann-Whitney *U*-test. Categorical variables were expressed as absolute numbers (percentages) and compared between the two groups using the Chi-square test. The diagnostic performance of MSCT was assessed in comparison with that of CAG, which was used as the reference standard. Diagnostic accuracy was evaluated on a segmental, vessel, and patient basis. Sensitivity, specificity, positive predictive value (PPV), and NPV were calculated. The Youden index was calculated as (sensitivity + specificity - 1) to summarize both sensitivity and specificity in a single number between 0 and 1. The higher the Youden index, the better the diagnostic accuracy of the test. Multivariate logistic regression analyses were performed to determine the influencing

factors on the diagnostic accuracy of MSCT. The diagnostic performance of MSCT was assessed using the area under the receiver operating characteristic curve (AUC) of the receiver operating characteristic (ROC) curves, taking 50% or greater diameter stenoses at conventional invasive CAG as the reference standard. All *P* values were two-tailed and a significance level of <0.05 was used. All statistical analyses were performed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Patient characteristics

Table 1 lists the baseline characteristics of the entire study population. In this study, 396 patients were enrolled, including 141 women and 255 men. According to the results of CAG, CAD diagnosis was established in 346 patients and ruled out in 50 patients. On average, the women were older than the men (67 ± 10 vs. 62 ± 11 years, $t = 4.416$,

$P < 0.01$). Hypertension and diabetes were more frequent in the women. The number of male smokers was significantly greater than that of female smokers, and more women had no CAD. Women showed a lower prevalence of lesions in mid-segments or side branches. With regard to calcified plaque on MSCT, and the number of diseased and culprit vessels on invasive CAG, no much difference was found between the two groups.

Multislice computed tomography in all the patients

Table 2 lists the diagnostic accuracy of MSCT in the total population. Of the 396 patients, 328 had obstructive CAD on conventional invasive CAG that were correctly identified by MSCT, resulting in a sensitivity of 95% (95% confidence interval [CI]: 93–97%). Eighteen patients (36%, 18/50) were identified as false positive. On a per-patient level, the sensitivity, specificity, PPV, NPV, total accuracy, and Youden index were 95%, 64%, 95%, 64%, 91%, and 0.59, respectively.

Table 1: Clinical characteristics of the study group

Characteristics	All patients (<i>n</i> = 396)	Women (<i>n</i> = 141)	Men (<i>n</i> = 255)	<i>t</i> or χ^2	<i>P</i>
Age (years), mean \pm SD	64 \pm 10	67 \pm 10	62 \pm 11	4.416	0.007
Risk factors, <i>n</i> (%)					
Hypertension	271 (68.4)	111 (78.8)	160 (62.7)	0.731	0.001
Diabetes mellitus	113 (28.5)	51 (36.2)	62 (24.4)	6.140	0.013
Hypercholesterolemia	112 (28.3)	47 (33.3)	65 (25.5)	2.754	0.097
Family history of CAD	130 (32.8)	38 (27.0)	92 (36.1)	3.431	0.064
Smoking	177 (44.7)	16 (11.3)	161 (63.1)	98.520	<0.001
Symptoms, <i>n</i> (%)					
Atypical angina pectoris	108 (27.3)	42 (30.0)	66 (26.0)	0.731	0.392
Diagnosis, <i>n</i> (%)					
Stable angina pectoris	50 (12.6)	13 (9.2)	37 (14.5)	2.047	0.129
Unstable angina pectoris	245 (61.9)	91 (64.5)	154 (60.4)	0.711	0.416
NSTEMI	8 (2.0)	2 (1.4)	6 (2.4)	0.158	0.527
Asymptomatic	49 (12.4)	12 (8.5)	37 (14.5)	2.723	0.083
Non-CAD	44 (11.1)	23 (16.3)	21 (8.2)	5.611	0.014
Mean LDL-C (mmol/L), mean \pm SD	2.68 \pm 0.84	2.72 \pm 0.86	2.66 \pm 0.82	0.665	0.507
Mean HDL-C (mmol/L), mean \pm SD	1.03 \pm 0.25	1.14 \pm 0.28	0.98 \pm 0.21	6.265	<0.001
Calcified plaque (MSCT), <i>n</i> (%)	253 (63.9)	87 (61.7)	166 (65.1)	0.454	0.501
Number of diseased vessels, <i>n</i> (%)					
0	50 (12.6)	23 (16.3)	27 (10.6)	2.696	0.101
1	102 (25.8)	40 (28.4)	62 (24.3)	0.781	0.377
2	118 (29.8)	39 (27.7)	79 (31.0)	1.186	0.216
3	126 (31.8)	39 (27.7)	87 (34.1)	1.563	0.186
Coronary lesions, <i>n</i> (%)					
LM	57 (14.4)	17 (12.1)	40 (15.7)	0.971	0.325
LAD	355 (89.7)	113 (80.1)	184 (72.4)	2.323	0.090
LCX	190 (48.0)	69 (48.9)	121 (47.6)	0.318	0.805
RCA	209 (52.8)	70 (49.6)	138 (54.3)	0.602	0.372
Lesion segments, <i>n</i> (%)					
Proximal	463 (39.0)	106 (25.1)	227 (29.7)	2.724	0.090
Middle	237 (31.1)	76 (27.0)	174 (34.1)	3.301	0.038
Distal	148 (12.9)	61 (14.4)	107 (14.0)	2.614	0.837
Side branches	198 (17.1)	50 (11.8)	159 (20.8)	12.103	<0.001

SD: Standard deviation; CAD: Coronary artery disease; MSCT: Multislice computed tomography; NSTEMI: Non-ST elevation myocardial infarction; LM: Left main; LAD: Left anterior descending coronary; LCX: Left circumflex coronary; RCA: Right coronary artery.

Table 2: Diagnostic accuracy of multislice computed tomography in the total population (n = 396)

Diagnostic characteristics	Number	TN	TP	FN	FP	95% CI					Youden index
						Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	
Patient level	396	32	328	18	18	95 (93–97)	64 (51–77)	95 (93–97)	64 (51–77)	91 (88–94)	0.59
Vessel level	1584	732	570	186	96	75 (72–78)	88 (86–90)	86 (83–89)	80 (79–81)	82 (76–88)	0.63
LAD	396	63	273	26	34	91 (88–94)*	65 (56–74)*	89 (88–90)	71 (62–80)†	85 (81–89)	0.56
LCX	396	180	112	78	26	59 (52–66)*	87 (83–92)	81 (74–88)	70 (64–76)*	74 (70–78)*	0.46
RCA	396	163	149	61	23	71 (65–77)	88 (83–85)	87 (82–92)	73 (67–79)†	79 (77–81)	0.59
LM	396	326	36	21	13	63 (51–76)†	96 (94–98)*	73 (67–79)†	94 (91–97)*	91 (88–94)*	0.59
Segment level	4252	2893	522	523	314	50 (47–53)	90 (89–91)	62 (59–65)	85 (84–86)	80 (79–81)	0.40
Proximal	1188	554	344	119	171	74 (70–78)‡	76 (73–79)‡	67 (63–71)‡	82 (79–85)	76 (74–78)‡	0.50‡
Middle	762	478	101	136	47	43 (36–50)§	91 (89–93)	68 (61–76)	78 (75–81)‡	76 (73–79)‡	0.34
Distal	1147	956	38	109	44	26 (19–33)‡	96 (95–97)‡	46 (35–57)‡	90 (88–92)‡	87 (85–89)‡	0.22‡
Side branches	1155	905	39	159	52	20 (14–26)‡	95 (94–96)‡	43 (33–53)‡	85 (83–87)	82 (80–84)	0.15‡

* $P < 0.001$, compared with all vessels; † $P < 0.05$, compared with all vessels; ‡ $P < 0.001$, compared with all segments; § $P < 0.05$, compared with all segments. TN: True negative; TP: True positive; FN: False negative; FP: False positive; CI: Confidence interval; PPV: Positive predictive value; NPV: Negative predictive value; LM: Left main; LAD: Left anterior descending coronary; LCX: Left circumflex coronary; RCA: Right coronary artery.

The diagnostic performance of MSCT for detecting significant stenoses in a vessel-based analysis was good. The Youden index was 0.63. Most of the significantly diseased vessels (75%, 570/756) were correctly identified using CT. Ninety-six vessels (12%, 96/828) with nonsignificant stenoses were incorrectly classified as significant stenoses using CT. The diagnostic accuracy of MSCT in detecting left main (LM) CAD is the highest (91% vs. 82%, compared with all vessels, $\chi^2 = 10.120$, $P < 0.05$). MSCT had a lower diagnostic accuracy (74% vs. 82%, compared with all vessels, $\chi^2 = 12.432$, $P < 0.05$) in detecting lesions of left circumflex coronary. On a per-segment basis, the diagnostic values of MSCT in detecting lesions in distal segments and side branches were low, and the Youden indexes for each segment in comparison with all the segments were 0.22 versus 0.4 ($u = 7.493$, $P < 0.05$) and 0.15 versus 0.4 ($u = 6.767$, $P < 0.05$), respectively.

Women compared with men

Table 3 shows the diagnostic accuracy of MSCT in the women compared with that in the men. On a patient-based analysis, the PPV (91% vs. 97%, $\chi^2 = 5.705$, $P < 0.05$) and diagnostic accuracy (87% vs. 93%, $\chi^2 = 5.093$, $P < 0.05$) of MSCT in detecting CAD were lower in the women. The women had a lower Youden index (0.45 vs. 0.70, $u = 2.584$, $P < 0.05$) in MSCT diagnosis. In the CAD population diagnosed using conventional invasive CAG, 93% (110/118) of the female patients and 96% (218/228) of the male patients were correctly identified using MSCT. Eleven women (48%, 11/23) and 7 men (26%, 7/27) with nonsignificant CAD were incorrectly classified as having significant coronary stenoses using CT.

On a per-vessel basis (LM, left anterior descending, left circumflex, and right coronary arteries), 564 coronary arteries in women and 1020 vessels in men were included in the study. The diagnostic accuracy was similar between the women and the men. The Youden index showed no

significant difference. Using MSCT, 76% (186/244) of vessels in the women and 75% (384/512) of vessels in the men were correctly diagnosed. Thirty-eight vessels (13%, 38/290) in the women and 58 vessels (11%, 58/508) in the men with nonsignificant stenoses on invasive CAG were misdiagnosed using CT.

After exclusion of 104 segments (23 for women and 81 for men) owing to small vessel size, motion artifacts, and undetectable distal segments due to total occlusion of the proximal vessel, 1534 coronary segments in the female population and 2718 segments in the male population were included in this study. On a per-segment basis, the NPV (87% vs. 83%, $\chi^2 = 8.563$, $P < 0.05$) and diagnostic accuracy (82% vs. 79%, $\chi^2 = 5.916$, $P < 0.05$) of MSCT in detecting CAD were higher in the women. However, the PPV was relatively low in both groups for all the segments (60% and 63%, respectively) and extremely low in distal segments and side branches (30–50%). Thus, the diagnostic values were low for both groups (Youden index: 0.42 and 0.39, respectively).

Factors that influence the diagnostic accuracy of multislice computed tomography in women

According to the MSCT results with conventional invasive CAG as the reference standard, patients with true positive and true negative results were defined as the accurate diagnosis group. Table 4 shows that the percentage of men was significantly higher in the accurate diagnosis group. Atypical angina pectoris and calcified plaques were less frequent in the accurate group. Multivessel diseases were significantly more frequent in the accurate group. In the multivariate logistic regression analysis, atypical presentation was an independent influencing factor of the diagnostic accuracy of MSCT in the women (odds ratio [OR] = 4.94, 95% CI: 1.16–20.92, Walds = 4.69, $P < 0.05$). Multivessel disease (OR = 31.34, 95% CI: 3.6–272.6, Walds = 9.7, $P < 0.01$) and noncalcified

Table 3: Diagnostic accuracy of multislice computed tomography in women versus men

Characteristics	Number		95% CI					
	Women	Men	Sensitivity (%)		Specificity (%)		PPV (%)	
			Women	Men	Women	Men	Women	Men
Patient level	141	255	93 (88–98)	96 (93–99)	52 (32–72)	74 (57–91)	91 (86–96)*	97 (95–99)
Vessel level	564	1020	76 (71–81)	75 (71–79)	88 (84–92)	89 (86–92)	83 (78–88)	87 (84–90)
LAD	141	255	92 (87–97)	91 (87–95)	64 (50–78)	66 (53–79)	85 (78–92)	91 (87–95)
LCX	141	255	55 (43–67)	55 (43–67)	87 (80–94)	87 (81–93)	77 (65–89)	83 (75–91)
RCA	141	255	76 (66–86)	68 (60–76)	90 (83–97)	86 (80–92)	88 (80–96)	86 (80–92)
LM	141	255	65 (42–88)	63 (48–78)	96 (57–99)	96 (93–99)	69 (46–92)	76 (61–91)
Segment level	1534	2718	51 (46–56)	49 (45–53)	91 (89–93)	90 (89–91)	60 (54–66)	63 (59–67)
Proximal	423	765	78 (71–85)	73 (68–78)	76 (71–81)	76 (72–80)	66 (59–73)	67 (61–72)
Middle	278	484	39 (28–50)	45 (37–53)	92 (88–96)	90 (87–93)	67 (53–81)	69 (60–78)
Distal	416	731	21 (8–34)	28 (21–35)	96 (94–98)	95 (93–97)	36 (16–56)	50 (38–62)
Side branches	417	738	15 (12–18)	22 (15–29)	95 (93–97)	94 (92–96)	30 (13–47)	48 (36–60)

Characteristics	95% CI				Youden index	
	NPV (%)		Accuracy (%)		Women	Men
	Women	Men	Women	Men		
Patient level	60 (39–82)	67 (50–84)	87 (82–93)*	93 (90–96)	0.45*	0.70
Vessel level	83 (79–84)	78 (75–84)	83 (80–86)	82 (80–84)	0.64	0.64
LAD	78 (65–92)	66 (53–79)	83 (77–89)	86 (82–90)	0.56	0.57
LCX	71 (62–80)	69 (62–76)	73 (66–80)	74 (69–79)	0.42	0.48
RCA	81 (73–89)	68 (60–76)	84 (78–90)	76 (71–81)	0.66	0.66
LM	95 (91–99)	93 (90–96)	92 (88–97)	91 (88–95)	0.61	0.59
Segment level	87 (85–89)*	83 (81–85)	82 (80–84)*	79 (78–81)	0.42	0.39
Proximal	85 (81–90)	81 (77–85)	77 (72–81)	75 (72–78)	0.54	0.49
Middle	79 (74–84)	77 (73–81)	77 (72–82)	75 (71–79)	0.31	0.35
Distal	92 (91–93)	88 (86–91)	89 (86–92)	85 (82–88)	0.17	0.23
Side branches	88 (85–91)*	83 (80–86)	84 (81–88)	80 (77–83)	0.10	0.16

* $P < 0.05$, compared with men. CI: Confidence interval; PPV: Positive predictive value; NPV: Negative predictive value; LM: Left main; LAD: Left anterior descending coronary; LCX: Left circumflex coronary; RCA: Right coronary artery.

plaque ($OR = 4.96$, 95% CI: 1.01–24.51, Walds = 3.87, $P < 0.05$) were also independent influencing factors.

The whole population was divided into two groups, namely, the typical and atypical groups, according to angina pectoris symptoms. Table 5 shows that in a patient-based analysis, the PPV (98% vs. 74%, $\chi^2 = 17.283$, $P < 0.001$) and diagnostic accuracy (93% vs. 72%, $\chi^2 = 9.571$, $P < 0.001$) of MSCT in detecting female CAD were significantly higher in the typical group than in the atypical group. The women in the typical group had a higher Youden index (0.69 vs. 0.29, $u = 2.359$, $P < 0.05$) in MSCT diagnosis. Not much difference was observed for MSCT in the diagnosis of male CAD between the two groups.

The diagnostic performance of MSCT to detect coronary stenoses of $\geq 50\%$ was further investigated with respect to the ROC curve. For all the patients, the AUC was 0.84 (95% CI: 0.77–0.90), suggesting a good accuracy. The diagnostic power of MSCT in men was greater than that in women. The AUC were 0.90 (95% CI: 0.83–0.97) for men and 0.74 (95% CI: 0.62–0.87) for women ($Z = 2.194$, $P < 0.05$). In women, patients with typical symptoms had a higher AUC (0.91, 95% CI: 0.83–0.99) than those with atypical symptoms (0.64, 95% CI: 0.45–0.82, $Z = 2.690$,

$P < 0.01$). However, in the men, no significant difference in AUC was found between the typical and atypical groups.

DISCUSSION

Our findings suggest that the PPV (91% vs. 97%, $P < 0.05$) and diagnostic accuracy (87% vs. 93%, $P < 0.05$) of MSCT in detecting CAD were lower in the women than in the men. This result was similar to that of Dewey *et al.*'s study.^[12] A more important finding is that our results suggest that both gender and atypical symptoms may influence the diagnostic accuracy of MSCT.

Many studies have proven that angina symptoms differ between men and women.^[1–3] Men usually present typical symptoms whereas women most often present atypical angina symptoms. These discrepancies often lead to an increase in misdiagnosis rate in female patients.^[1–3] MSCT angiography is an ideal noninvasive modality for detecting obstructive CAD.^[15–17] Numerous studies have proven that significant sex-related differences exist not only in the incidence and prognosis of atherosclerosis disease but also in the accuracy of different clinical examination methods.^[18–20] Anatomic and physiological differences, including body composition, heart rate, coronary calcium

Table 4: Clinical characteristics based on the accuracy of multislice computed tomography

Characteristics	Accurate diagnosis (n = 360)	Inaccurate diagnosis (n = 36)	t or χ^2	P
Age (years), mean \pm SD	64 \pm 11	63 \pm 11	0.521	0.60
Male, n (%)	238 (66.1)	17 (47.2)	5.093	0.02
Risk factors, n (%)				
Hypertension	246 (68.3)	25 (69.4)	0.490	0.89
Diabetes mellitus	104 (29.0)	9 (25.0)	1.050	0.62
Hypercholesterolemia	100 (27.9)	12 (33.3)	1.696	0.49
Family history of CAD	122 (33.9)	8 (22.2)	2.396	0.16
Smoking	162 (45.0)	15 (41.7)	0.875	0.70
Symptoms, n (%)				
Atypical angina pectoris	91 (25.4)	17 (47.2)	8.236	0.01
Mean LDL-C (mmol/L), mean \pm SD	2.69 \pm 0.86	2.58 \pm 0.6	0.834	0.33
Mean HDL-C (mmol/L), mean \pm SD	1.03 \pm 0.24	1.07 \pm 0.33	0.623	0.54
Calcified plaque, n (%)	224 (62.2)	29 (80.6)	4.336	0.03
Number of diseased vessels, n (%)				
Single-vessel	90 (25.0)	12 (33.3)	0.973	0.20
Multivessel	238 (66.1)	6 (16.7)	33.830	<0.001

CAD: Coronary artery disease; MSCT: Multislice computed tomography; LM: Left main; LAD: Left anterior descending coronary; LCX: Left circumflex coronary; RCA: Right coronary artery; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol.

level, and coronary diameter between women and men, may affect the diagnostic performance of MSCT. As we know, Eastern women have even smaller body sizes. Our study proved sex-related differences in the performance of MSCT in detecting obstructive CAD.

In our study, the sensitivity, specificity, PPV, NPV, and accuracy of MSCT in detecting CAD were 95%, 64%, 95%, 64%, and 91%, respectively, on a per-patient level. The per-patient-based specificity and NPV were lower than those in other studies.^[21-23] The sensitivity, specificity, PPV, NPV, and diagnostic accuracy of MSCT on a per-segment level were 50%, 90%, 62%, 85%, and 80%, respectively. Its sensitivity and NPV were also relatively low. Besides the technical problems, smaller body size and vascular lumen diameter may be possible reasons. In addition, our study population was almost 5 years older than that of other studies. The prevalence of calcified plaques was also relatively high in our study.

In our study, the women with typical angina pectoris had higher PPV and diagnostic accuracy in MSCT diagnosis. Thus, the diagnostic accuracy of MSCT may be different in women with atypical symptoms. Several studies previously investigated the diagnostic accuracy of MSCT in female coronary heart disease, yielding inconclusive results. Some studies found no significant difference in the performance of MSCT between women and men.^[8,9] While the study of Meijboom *et al.*^[11] suggested a similar sensitivity in diagnosing coronary stenoses between the sexes, the specificity for detection of obstructive CAD (especially in distal and side coronary branches) was significantly lower in the women than in the men.

Another study reported that MSCT has similar specificity between the sexes but lower sensitivity and accuracy in women.^[12] The inconsistent results between diagnostic studies may be related to the remarkable difference in the number of patients in each study. However, we should consider that the prevalence of CAD is remarkably lower in women than in men. Nonobstruction artery disease and positive remodeling of blood vessels are more common in women.^[7,24] After adjustment for body surface, the diameter of the female coronary artery was still smaller than that of the male coronary artery.^[25] Studies have proven sex-related differences in plaque morphology on coronary computed tomography angiography.^[26,27] Males tended to have more calcified plaques than females, with a greater tendency to have multiple vessel involvement. All of these factors might contribute to the significant differences in the diagnostic accuracy of MSCT between women and men. In our study, the diagnostic value of MSCT in the detection of CAD was lower in the women than in the men. However, it is still a reliable modality for the exclusion of significant coronary artery stenoses in both sexes. Our study suggests that both gender and atypical symptoms might influence the diagnostic accuracy of MSCT.

Our study is limited by its single-center retrospective design and the relatively small number of patients included. The study did not include the data about the prognosis. Quantitative analysis of calcification and morphologies of plaques were not studied due to technical limitations. Meanwhile, age and the prevalence rates of hypertension and diabetes were significantly higher in the women than that in the men, which might influence the results in our study.

Table 5: Diagnostic accuracy of multislice computed tomography in patients with typical or atypical angina symptoms

Characteristics	95% CI							
	Number		Sensitivity (%)		Specificity (%)		PPV (%)	
	Typical	Atypical	Typical	Atypical	Typical	Atypical	Typical	Atypical
Female								
Patient level	98	43	94 (89–99)	89 (80–98)	75 (62–88)	40 (26–54)	98 (96–99)*	74 (61–87)
Vessel level	392	172	74 (67–81)	81 (75–87)	88 (83–93)	86 (81–91)	85 (81–89)†	70 (63–77)
Segment level	1274	559	47 (42–52)	46 (39–53)	88 (86–90)	90 (87–93)	56 (53–59)	46 (42–50)
Male								
Patient level	188	67	97 (95–99)	93 (87–99)	75 (59–81)	73 (62–84)	98 (96–99)	95 (90–99)
Vessel level	752	268	75 (72–78)	72 (67–77)	88 (86–90)	88 (84–92)	87 (85–89)	84 (80–88)
Segment level	2444	871	60 (58–62)	61 (58–64)	88 (87–89)	88 (86–90)	66 (64–68)	65 (62–68)

Characteristics	95% CI				Youden index	
	NPV (%)		Accuracy (%)		Typical	Atypical
	Typical	Atypical	Typical	Atypical		
Female						
Patient level	55 (45–65)	67 (53–81)	93 (88–98)*	72 (59–85)	0.69†	0.29
Vessel level	78 (74–82)†	91 (87–95)	81 (77–85)	84 (77–91)	0.62	0.67
Segment level	83 (81–85)†	89 (86–92)	77 (75–79)†	82 (79–85)	0.35	0.36
Male						
Patient level	67 (60–74)	67 (56–78)	95 (92–98)	90 (83–97)	0.72	0.66
Vessel level	78 (75–81)	79 (74–94)	82 (79–85)	81 (76–86)	0.63	0.60
Segment level	85 (84–86)	86 (84–88)	80 (78–82)	81 (78–84)	0.48	0.49

* $P < 0.001$; † $P < 0.05$, compared with atypical group. CI: Confidence interval; PPV: Positive predictive value; NPV: Negative predictive value.

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Conflicts of interest

There are no conflicts of interest.

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