MULTISLICE COMPUTED TOMOGRAPHY CORONARY ANGIOGRAPHY IN PATIENTS WITH ANGINA PECTORIS

Ilić S. Dragana, Jankovic Sonja

Aim. Multislice computed tomography (MSCT) is a non-invasive method for the heart and coronary arteries imaging.
The aim of the research was to establish the diagnostic exactness of MSCT in the revelation of significant coronary artery disease in patients with angina pectoris, using digital subtraction angiography (DSA) of coronary arteries as the gold standard.
Material and methods. In 78 (56 men, 22 women; average age 64,3±11 years), patients with clinical signs of angina pectoris were done examination of the coronary arteries on 64-slice MSCT in order to detect significant stenoses (>50% luminal narrowing). MSCT of coronary arteries was compared with the invasive coronary angiography.
Results. In 78 patients, 864 segments of coronary arteries were available for evaluation. In all segments of coronary arteries, invasive coronary angiography identified 51 lesions. Forty-five lesions were detected by MSCT. The matching sensitivity and specificity were 88% and 97%. Sensitivity, specificity and positive and negative predictive values in a patient-per-patient analysis were 93%, 93%, 90%, and 96%, respectively.
False-negative results — Seventeen segments of coronary arteries with diameter reduction in range 51% to 75% were missed on the MSCT scan. The major of the missed lesions were located in the left anterior descedenting artery and the left circumflex artery (small side branches). Four segments were missed because of severe calcifications and five because of motion artifacts.
False-positive results — Thirty nine segments were incorrectly classified as significantly because of overestimation.
Conclusion. MSCT coronary angiography is an effective, fast, reliable and non-invasive method for the analysis of the coronary arteries. The best results were obtained in patients with healthy coronary arteries (high percentage of negative predictive value), which can significantly reduce the number of invasive coronary angiography. With the improvement of technical characteristics, CT is gaining more importance in the analysis of coronary stenoses and analysis of atherosclerotic plaque.

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Key words: MSCT coronary arteries, DSA coronary arteriography, angina pectoris.

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DSA — digital subtraction angiography, MSCT — multislice computed tomography, VR — volume rendering, DSCT — dual source computed tomography.

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МУЛЬТИСПИРАЛЬНАЯ КОМПЬЮТЕРНАЯ ТОМОГРАФИЯ-КОРОНАРОГРАФИЯ У БОЛЬНЫХ СО СТЕНОКАРДИЕЙ НАПРЯЖЕНИЯ

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Цель. Мультиспиральная компьютерная томография (МСКТ) представляет собой неинвазивный метод визуализации сердца и коронарных артерий. Целью исследований было установить диагностическую точность МСКТ в выявлении существенных изменений сердца у больных ишемической болезнью со стенокардией напряжения, с помощью цифровой субтракционной ангиографии (DSA) коронарных артерий, как золотого стандарта.
Материал и методы. У 78 (56 мужчин, 22 женщины; средний возраст 64,3±11 лет), пациентов с клиническими признаками стенокардии были проведены обследования коронарных артерий на 64-срезовой МСКТ с целью выявления значимых стенозов (>50% сужения просвета). МСКТ коронарных артерий было сравнено с инвазивной коронарной ангиографией.
Результаты. У 78 больных, 864 сегментов коронарных артерий были доступны для оценки. Во всех сегментах коронарных артерий, при инвазивной коронарной ангиографии выявлено 51 поражение. Сорок пять поражений были обнаружены МСКТ. Сопоставление чувствительности и специфичности были 88% и 97%. Чувствительность, специфичность, положительная и отрицательная прогностическая ценность анализа пациентов были 93%, 93%, 90% и 96%, соответственно.
Ложно-отрицательные результаты — в семнадцати сегментах коронарных артерий с уменьшением диаметра в диапазоне от 51% до 75% были пропущены при сканировании МСКТ. Основные пропущенные поражения локализовались в левой передней артерии, нисходящей и левой артерии (мелкие боковые ветви). Были пропущены четыре сегмента из-за тяжелой кальцификации и пять из-за артефактов движения.
Ложноположительные результаты — тридцать девять сегментов были ошибочно классифицированы из-за переоценки.
Заключение. МСКТ коронарография — это эффективный, быстрый, надежный и неинвазивный метод анализа коронарных артерий. Наилучшие результаты были получены у пациентов со здоровыми коронарными артериями (высокий процент негативной прогностической ценности), что позволяет значительно снизить количество инвазивной коронарной ангиографии. С улучшением технических характеристик, КТ имеет большое значение при анализе коронарных стенозов и анализе атеросклеротических бляшек.

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Ключевые слова: МСКТ коронарных артерий, коронароангиография ДСА, стенокардия.

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Multislice computed tomography (MSCT) is a non-invasive method for the heart and coronary arteries imaging.

In addition, the results of numerous studies comparing MSCT with digital subtraction angiography (DSA) coronary angiography suggested enhanced sensitivity of the technique as well, with no loss in specificity [1].

The aim of this study is to compare the accuracy of the analysis of the coronary vessels with noninvasive method —

MSCT with invasive coronary angiography as the gold standard.

Material and methods

The study group included 78 patients (56 men, 22 women, mean age 64,3±11 years, range 32–80), patients which had stable angina which is a cardiac examination confirmed. Exclusion criteria were contraindications to iodinated contrast, patients with previous stenting coronary arteries and bypass surgery. We also exclude patients with an acute coronary syndrome. All examinations were done in Department of Radiology University Clinical Center Nis, Serbia.

DSA coronary angiography was carried out according to standard techniques after MSCT. Coronary arteries were divided into segments as stated by the classification of the American Heart Association [2]. All coronary segments visualized upon catheterization were included in the investigation. Reduction of diameter more of 50% in relation to a reference segment were considered to represent important stenoses [3].

MSCT was performed using a Multi-Slice Computed Tomography Toshiba Aquilion 64 system (Toshiba Medical Systems, Tokyo, Japan), with a rotation time of 0,33 seconds and a collimation of 64x0,5 mm.

The tube current was 120 kV and 300 mA. Nonionic contrast material was administered in the cubital vein, with an amount of 80 to 90 ml, depending on the total scan time, and a flow rate of 5.0 ml/s (Iopromide /Ultravist 370, Bayer Health Care Pharmaceutical, Germany). Automated detection of peak enhancement in the descending aorta was used for timing of the bolus on +180 Hounsfield units. Data acquisition was administer during an breath hold of 8 to 10 seconds.

During the MSCT examination, electrocardiography was execute simultaneously for retrospective gating of the data. An initial data set was reconstructed with a slice thickness of 0,5 mm, the ECG was edited manually, when the heart rate was irregular. Post processing were done on the workstation (Vitrea 1, Vital Images, Plymouth, Minnesota).

Conventional diagnostic coronary angiography was performed toward standard techniques on Axiom Artis (Siemens, Germany). Contrast material was the same Iopromide (Ultravist 370).

MSCT angiograms were assessed by two radiologist with some years experience. General information on the standing and courses of the coronary arteries were obtained by volume rendering (VR). Then the primary axial slices were inspected for the presence of significant stenoses (≥50% reduction of diameter), assisted by curved multiplanar reconstructions. Segmentation of the coronary arteries was carried out as established by the American Heart Association/American College of Cardiology guidelines [3]. Conventional angiograms were assessed by an experienced observer without knowledge of the MSCT data who identified the available coronary segments on the basis of the American Heart Association/American College of Cardiology guidelines [3]. Each segment was then evaluated on the basis of the evaluation of 2 orthogonal views.

Sensitivity, specificity and positive and negative predictive values for the detection of stenoses on conventional angiography were determined on segmental bases, vessel and patients. All statistical analyses were performed using SPSS software version 21.0 (SPSS, Inc., Chicago, Illinois).

Table 1

Detection of Significant (>50%) Stenosis With 64 –slice Computed Tomography Coronary Angiography

Coronary segment	N	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV
All segments	864	169	639	39	17	169/186 (90%)	639/678 (94%)	169/208 (81%)	639/656 (97%)
LM	74	4	70	0	0	4/4 (100%)	70/70 (100%)	4/4 (100%)	70/70 (100%)
LAD	285	74	181	21	9	74/83 (89%)	181/202 (89%)	74/95 (77%)	181/190 (95%)
Proximal	74	30	35	5	4	30/34 (88%)	35/40 (87%)	30/35 (85%)	35/39 (89%)
Middle	72	31	35	5	1	31/32 (96%)	35/40 (87%)	31/36 (86%)	35/36 (97%)
Distal	70	6	58	4	2	6/8 (75%)	58/62 (93%)	6/10 (60%)	58/60 (96%)
Side branches	69	7	53	7	2	7/9 (77%)	53/60 (88%)	7/14 (50%)	53/55(96%)
LCX	217	23	180	9	5	23/28 (82%)	180/189 (95%)	23/32 (72%)	180/185 (97%)
Proximal	73	10	60	2	1	10/11 (90%)	60/62 (96%)	10/12 (83%)	60/61 (98%)
Middle	72	7	59	4	2	7/9 (77%)	59/63 (93%)	7/11 (63%)	59/61 (96%)
Side branches	72	6	61	3	2	6/8 (75%)	61/64 (95%)	6/9 (66%)	61/63 (96%)
RCA	288	68	208	9	3	68/71 (95%)	208/215 (96%)	68/77 (88%)	208/211 (98%)
Proximal	76	31	41	4	0	31/31 (100%)	41/45 (91%)	31/35 (88%)	41/41 (100%)
Middle	74	28	41	4	1	28/29 (96%)	41/45 (91%)	28/32 (87%)	41/42 (97%)
Distal	70	6	62	1	1	6/7 (85%)	62/63 (98%)	6/7 (85%)	62/63 (98%)
PDA	68	3	64	0	1	3/4 (75%)	64/64 (100%)	3/3 (100%)	64/65 (98%)

Abbreviations: LM — left main coronary artery, LAD — left anterior descending coronary artery, LCX — left circumflex coronary artery, RCA — right coronary artery, PDA — posterior descending artery, TP — true positive, TF — true negative, FP — false positive, FN — false negative, PPV — positive predictive value, NPV — negative predictive value.

Results

In this study were included 78 successive patients (56 males, 22 females; average age 64,3±11 years). The average time period between MSCT and DSA angiography was 45±65 days.

In 864 segments assessed with conventional coronary angiography. The value of sensitivity was 90,86% (169/186, 95% confidence interval [CI]: 88,77% to 94,58%, the value of specificity was 94,25% (639/678, 95% CI: 92,22% to 95,88%), the positive predictive value was 81,25% (169/208, 95% CI: 75,27% to 86.31%) and the negative predictive value 97.41% (639/656, 95% CI: 95,88% to 98,48%) for the detection of significantly stenotic lesions (Table 1).

Nineteen percent (170 of 864), of all segments were classified as heavily calcified, 30,9% (267 of 864) as moderately calcified and 49,4% (427 of 864) as non-calcified.

Table 2

Diagnostic accuracy of multi-slice computed tomography

Variable	Segment analysis	Vessel analysis	Patient analysis
Sensitivity	90%	88%	93%
specificity	94%	97%	93%
PPV	81%	83%	90%
NPV	97%	98%	96%

Abbreviations: PPV — positive predictive value, NPV — negative predictive value.

The diagnostic performance of MSCT coronary angiography for detection of significant obstructive lesions in non-calcified, moderately calcified and heavily calcified segments (Table 2).

False-negative results — Seventeen segments of coronary arteries with diameter reduction in range 51% to 75% were missed on the MSCT scan. The major of the missed lesions were located in the LAD and LCx (small side branches). Four segments were missed because of severe calcifications and five because of motion artifacts.

False-positive results — Thirty nine segments were incorrectly classified as significantly because of overestimation.

The sensitivity for classification of vessels with or coronary artery disease was 88,24% (95% CI: 76,12% to 95,53%), specificity was 96,48% (95% CI: 93,43% to 98,38%), positive predictive value was 83,33% (95% CI: 70,70% to 92,07%) and negative predictive value was 97,63% (95% CI: 94,91% to 99,12%). In the remaining 308 coronary arteries, 45 were correctly identified in 247 vessels.

Thirty one patients with ≥1 significant lesions were identified by conventional coronary angiography.

Twenty-nine of these patients (94%) were correctly identified on MSCT. Single-vessel disease was in nine patients (11,5%), two-vessel lesions was in ten patients

Table 3

Comparative Study by Autors

		Per segment					Per patients			
Author	N	NS (%)	Sens (%)	Specif. (%)	PPV (%)	NPV (%)	Sens (%)	Spec (%)	PPV (%)	NPV (%)
16-MSCT										
Mollet [9]	128	7	92	95	79	98	100	86	97	100
Hoffman [10]	103	6	95	98	87	99	97	87	90	95
Achenboch [11]	50	4	94	96	69	99	100	83	100	86
Mollet [12]	51	0	95	98	87	99	97	84	89	95
Garcia [13]	187	29	85	91	36	99	98	55	50	99
Dewey [14]	129	9	83	86	90	95	93	74	93	92
Hausleiter [15]	129	11	93	87	46	99	-	-	-	-
64-MSCT										
Leschka [16]	53	0	94	97	87	99	100	100	100	100
Raff [17]	70	12	86	95	66	98	95	90	93	93
Leber [18]	59	0	88	97	-	99	94	-	-	-
Pugliese [19]	35	0	99	96	78	99	100	90	96	100
Mollet [20]	52	2	99	95	76	99	100	92	97	100
Ropers [21]	82	4	95	93	56	99	96	91	83	98
Nikolaou [22]	72	10	86	95	72	97	97	72	83	95
Hausleiter [23]	114	8	92	92	54	99	99	75	74	99
Achenbach [24]	100	3	86	99	80	99	-	-	-	-
DSCT										
Nikolaou [25]	20	4	95	93	79	98	-	-	-	-
Scheffel [26]	30	1	96	98	86	99	-	-	-	-
Weustink [27]	100	0	95	95	75	99	99	87	96	95
Achenbach [28]	100	3	96	92	90	99	-	-	-	-

Abbreviation: NS — unseen segments.

(12,8%) and twelve patients were classified as having multivessel disease.

Sensitivity for classification of patients with or without CAD was 93,55% (95% CI: 78.54% to 99,02%), specificity was 93,62% (95% CI: 82,44% to 98,59%), positive predictive value was 90,62% (95% CI: 74,95% to 97,91%) and negative predictive value was 95,65% (95% CI: 85,13% to 99,34%).

Discussion

MSCT has the possibilities to detect significant coronary artery stenosis, which is shown by our 64-slice CT data; notwithstanding, this generation of MSCT scanners also has some technical limitations. Recent studies have reported two major limitations in assessing coronary artery disease with MSCT: rigid atherosclerotic calcification and motion artifacts [4, 5].

It is significant that only 17 segments that are labeled as false negative were not exactly diagnosed because of insufficient image quality (Table 1). In addition, the specificity of 90% was observed, with the sensitivity of 94%, on a segmental basis (Table 2). From the clinical point of view, segmental analysis is very important in the further selection of patients for invasive therapeutic treatment. In our study, a sensitivity of 93% was noted, and specificity of 93%, in the detection of patients with coronary arteries disease. Compared to the previous study, no significant deviation values of sensitivity and specificity, from a segmental to a patient analysis [6, 7]. The current observations examinations are in line with the few investigations with 16-slice, 64-slice MSCT and dual source computed tomography (DSCT) that have been published (Table 3) [9-28].

In spite of rapid technologic advancements, some limitations inherent to MSCT persist. First, for high-quality MSCT images a stable and preferably low heart rate remains essential, and there is often need of the administration of β blockers before the examination. Second, another important issue is the current lack of validated quantification algorithms for MSCT.

Conclusion

MSCT coronary angiography is an effective, fast, reliable and non-invasive method for the analysis of the coronary arteries. The best results were obtained in patients with healthy coronary arteries (high percentage of NPV), which can significantly reduce the number of invasive coronary angiography. With the improvement of technical characteristics, CT is gaining more importance in the analysis of coronary stenoses and analysis of atherosclerotic plaque.

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