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Concordance between coronary computed tomography angiography and coronary angiography in assessing the significance of coronary artery stenosis in patients with multivessel coronary artery disease

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Concordance between coronary computed tomography angiography and coronary angiography in assessing the significance of coronary artery stenosis in patients with multivessel coronary artery disease

Zgodność pomiędzy tomografią komputerową tętnic wieńcowych a koronarografią w ocenie znaczenia zwężenia tętnic wieńcowych u pacjentów z wielonaczyniową chorobą tętnic wieńcowych

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Abstract

Introduction. Coronary artery disease (CAD) is one of the most common cardiovascular problems in Poland and worldwide. In the case of multivessel coronary artery disease (MVD), the matter of further management and treatment is even more complicated. The non-invasive diagnostic methods are commonly used in the initial diagnostics of CAD. The following study aimed to perform a comparative analysis of the results of coronary computed tomography angiography (CCTA) and coronary angiography in relation to the demographic and clinical variables in patients with MVD.

Material and methods. The study was performed on 106 patients with MVD hospitalised in the Cardiology Department of the Central Clinical Hospital in Lodz. The available results of CCTA and coronary angiography were analysed and compared with regard to the significance of coronary artery stenosis in both examinations. Demographic and clinical characteristics of the analysed group of patients were also performed.

Results. The vast majority of the participants were male (n = 69.8%). The average age of the patients was 69.42 ± 8.28 years. Coronary artery disease risk factors were highly prevalent in the study population. The overall concordance in the assessment of the significance of coronary artery stenosis by coronary computed tomography angiography compared with

coronary angiography was 73% (κ = 0.47). The highest concordance in the assessment was noted for the left main coronary artery 78% (κ = 0.5) and the lowest for the circumflex branch 69% (κ = 0.34).

Conclusions. In patients with MVD, there is a moderate concordance between the description of the significance of coronary artery stenosis in CCTA compared to coronary angiography. Coronary computed tomography angiography as a non-invasive imaging is one of the methods in the initial diagnostics of a suspected CAD. The risk factors of CAD are widespread and represent a significant problem in the analysed patient population.

Key words: multivessel coronary artery disease, coronary computed tomography angiography, coronary artery angiography

Introduction

Cardiovascular diseases (CVD) are the most common cause of death, contributing to almost one-third of all deaths around the world [1]. In 2030, according to projections, CVD would cause more than 23 million deaths worldwide [2]. Among these diseases, ischaemic heart disease (IHD) remains the most common cause of death. IHD is estimated to affect 1,655 out of every 100 000 people, amounting to more than 120 million people worldwide [3]. In the vast majority of cases, coronary artery disease (CAD) is caused by a narrowing of the coronary arteries by atherosclerotic plaques.

In the case of significant atherosclerotic involvement of more than one coronary artery or left main coronary artery, one can speak of multivessel coronary artery disease (MVD). Patients with MVD have an increased risk of acute coronary syndromes and sudden cardiac death [4].

To date, many recognised risk factors of CAD have been identified, including an increased low-density lipoprotein (LDL) cholesterol fraction, decreased high-density lipoprotein cholesterol fraction, increased triglycerides, smoking and comorbidities such as hypertension, impaired glucose tolerance or diabetes and atherosclerosis of other arteries. In addition, male gender, older age, genetic predisposition and excessive body weight together with insufficient physical activity contribute to an increased risk of the disease [5].

A number of diagnostic methods are available to help determine the degree of myocardial ischaemia, and thus the approximate degree of stenosis in individual coronary arteries. Non-invasive imaging is an increasingly important option in the diagnostics of IHD,

compared to the invasive method — coronary angiography, which was widely used not so long ago [6].

Material and methods

Study design and population

We have conducted a retrospective study of patients with diagnosed MVD and stable angina. One hundred and six participants were enrolled during the period 2020–2022, after hospitalisation in the Cardiology Department of the Central Clinical Hospital in Lodz. Eligible patients were aged 18 years or older, with a diagnosis of CAD according to the European Society of Cardiology Guidelines [7].

The findings of coronary computed tomography angiography (CCTA) and invasive coronary angiography (ICA) in patients with MVD were analysed and the results of the significance of coronary artery stenosis in both imaging methods were compared.

Coronary computed tomography angiography was performed on an outpatient basis in various computed tomography laboratories in the city of Lodz with the use of different CT scanners with a resolution of at least 64 slices. An iodine contrast agent was used in the examination. Significant stenosis of the coronary arteries was defined by the CCTA described as significant, critical, severe or > 70% of the coronary artery lumen.

Invasive coronary angiography was performed in the Cardiology Department of the Central Clinical Hospital in Lodz. Significant stenosis of the coronary arteries in ICA was defined as more than 50% in the left main coronary artery and more than 70% in the rest of the epicardial arteries. ICA was performed no more than 12 months after the CCTA in the same patient.

Exclusion criteria were defined as permanent atrial fibrillation, acute coronary syndrome or stroke within the last 3 months. The study complied with the Declaration of Helsinki and was approved by the local medical ethics committee. Written informed consent was provided by all patients before they participated in the study.

Subjects' demographic and clinical data

Patient characteristics were collected, such as age, gender, and body mass index (BMI), calculated as weight in kilograms divided by height in meters squared. Clinical information was also acquired from the medical record, such as left ventricular ejection fraction, New York Heart Association functional class, Canadian Cardiovascular Society class, the history of cigarette smoking, alcohol abuse, comorbidities: heart failure, arterial hypertension,

hyperlipidaemia, diabetes mellitus type 2, chronic kidney disease, chronic obstructive pulmonary disease and blood tests such as the concentrations of haemoglobin, N-terminal pro-B-type natriuretic peptide, uric acid, LDL, high-density lipoprotein, total cholesterol, triglycerides and estimated glomerular filtration rate.

Data analysis

All the data from the study were analysed using Python SciPy (v1.10) stats library. Graphical data were presented using the matplotlib (v3.6) package. Categorical data were expressed as numbers and as a percentage of the whole study population. Left ventricular ejection fraction was expressed as a percentage of the heart failure patient group. The normal distribution of the continuous variables was assessed using the Shapiro–Wilk test and a histogram.

After the normality analysis, the continuous variables that followed the normal distribution (age and BMI) were presented by means of the standard deviation. Due to the skewed non-normal distribution of other continuous variables, they are described using the median value with lower and upper quartiles. Cohen's κ was used to determine the concordance between CCTA and ICA results in the assessment of the significance of coronary artery stenosis. The concordance between CCTA and ICA was defined as both examinations showing significant stenosis or an absence of significant stenosis in a coronary artery. In accordance with other authors' suggestions, the κ values in the range of 0.21–0.4 were identified as a fair agreement and the values 0.41–0.6 as a moderate agreement between the diagnostic methods mentioned above [8].

Results

The study population was predominantly male (n = 69.8%). The average age of the study population was 69.42 ± 8.28 years, with a mean BMI of 27.91 ± 4.44 kg/m^2. Chronic heart failure (CHF), chronic kidney disease and diabetes mellitus type 2 were diagnosed in 52.8%, 18.9% and 35.8% of the study population, respectively.

Over 92.5% of the study participants had a history of hypertension, 100% — hyperlipidaemia, and 5.7% — chronic obstructive pulmonary disease. Patients' angina symptoms were most commonly (over 44%) classified as Canadian Cardiovascular Society class II. The detailed characteristics of the study population are presented in Table 1.

The median LDL cholesterol blood concentration was 2.26 mmol/L (1.8–3.02), N-terminal pro-B-type natriuretic peptide: 250.0 pg/mL (100.0–753.8), uric acid: 360.5 µmol/L

(298.48–438.78) and estimated glomerular filtration rate was 77.8 mL/min/1,73m^2 (62.32–89.78). The remaining biochemical parameters are presented in Table 2.

The comparison of CCTA and coronary angiography results took place in 86 patients because the significance of coronary artery stenosis was not assessed in 20 patients due to an excessively high calcium score preventing the use of an iodine contrast agent.

The concordance in the assessment of the significance of coronary artery stenosis by coronary computed tomography angiography compared with coronary angiography was 73% ($\kappa = 0.47$, moderate agreement). The highest concordance in the assessment was noted for the left main coronary artery (78%, $\kappa = 0.5$, moderate agreement) and the lowest for the circumflex branch (69%, $\kappa = 0.34$, fair agreement). The detailed analysis is presented in Figure 1 and Table 3.

Discussion

Although coronary computed tomography angiography is a very good method for coronary artery imaging, the main advantage of this test remains its high negative predictive value [9]. The exclusion of any coronary artery stenosis by CCTA has been shown to be associated with very low mortality in this group of patients (0.28%) [10]. CCTA has a high sensitivity and specificity (97.2% and 87.4%, respectively) confirmed by numerous studies. Its value increases in patients without a history of CAD (97.6% and 89.2%, respectively) and if the patient's heart rate is as close as possible to 60/minute or lower [11, 12]. The quality of this method in the assessment of coronary arteries is diminished by past interventions, such as coronary artery bypass grafting or percutaneous coronary intervention with stent implantation. Arrhythmias or fast heart rate and obesity in patients also reduce the specificity of CCTA. However, the technique of the 64-slice resolution or higher minimises these limitations [13, 14].

Thanks to its high sensitivity and specificity, CCTA is an extremely useful method for identifying patients at high risk of cardiovascular incidents, also in the case of an asymptomatic CAD [15, 16].

Coronary angiography remains the “gold standard” for coronary artery imaging. As a diagnostic and therapeutic modality, it allows real-time visualisation of the contrast flow through the vessel and enables a percutaneous intervention to dilate the artery stenosis at the same time. In relation to CCTA, ICA is distinguished by its higher spatial and temporal resolution. Unfortunately, it is an invasive method that carries a risk of complications related

to the procedure itself, such as bleeding at the insertion site (0.7%) [17] and the risk of death, myocardial infarction or stroke (0.1–0.2%) [18].

Coronary computed tomography angiography is associated with lower sensitivity and specificity in identifying patients with significant stenosis > 70% of the coronary artery lumen and for the arterial segment [19]. This discrepancy between CCTA and ICA results for the significant stenosis currently precludes the planning of coronary revascularisation using CCTA as a single imaging modality. Nevertheless, non-invasive imaging methods like coronary computed tomography angiography are increasingly likely to be the basis for future qualification for revascularisation including percutaneous coronary angioplasty and coronary artery bypass grafting in patients with MVD as demonstrated by the results of the SYNTAX III study [20].

Still, further research is needed to base future decision-making and treatment planning in MVD patients solely on non-invasive imaging i.e., CCTA, and clinical information.

Limitations

There are several limitations to this study. This study was retrospective and involved only one centre. The CCTA examinations were performed by different laboratories and described by different radiologists, which may influence the assessment of stenosis in coronary arteries. In addition, coronary angiography was also performed by different cardiologists. It must be taken into account that CCTA is often subject to limitations due to the differences in the experience level of doctors describing the test result and the quality of the apparatus on which they were performed.

Conclusions

Coronary risk factors are widespread in patients with MVD which is an important issue and highlights the considerable work that needs to be done in educating society about the prevention of CVD. In patients with MVD, there is a moderate agreement between the description of the significance of coronary artery stenosis based on CCTA compared to ICA which rules out the eligibility of CCTA as a standalone preparation method for interventional treatment of these patients nowadays. Nevertheless, the non-invasive methods are in the process of constant perfecting and they constitute the future of cardiology, which may result in a beneficial impact on patients, for example, a reduction of complications associated with invasive procedures.

Conflict of interest

None declared.

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None.

Streszczenie

Wstęp. Choroba wieńcowa jest jednym z najczęściej występujących problemów kardiologicznych zarówno w Polsce, jak i na świecie. W przypadku wielonaczyniowej choroby wieńcowej (MVD) kwestia dalszego postępowania i leczenia jest jeszcze bardziej skomplikowana. Nieinwazyjne metody obrazowania są powszechnie stosowane w diagnozowaniu choroby wieńcowej. Celem niniejszej pracy była analiza porównawcza wyników tomografii komputerowej tętnic wieńcowych (CCTA) i koronarografii w odniesieniu do zmiennych demograficznych i klinicznych u pacjentów z MVD.

Materiał i metody. Badanie przeprowadzono u 106 pacjentów z MVD hospitalizowanych w Klinice Kardiologii Centralnego Szpitala Klinicznego w Łodzi. Analizie poddano dostępne wyniki CCTA i koronarografii, porównując wyniki pod kątem istotności zwężeń w tętnicach wieńcowych w obu badaniach. Przeprowadzono również charakterystykę demograficzną oraz kliniczną analizowanej grupy pacjentów.

Wyniki. Znaczną większość pacjentów stanowili mężczyźni (n = 69,8%). Średnia wieku pacjentów wynosiła 69,42 ± 8,28 lat. Czynniki ryzyka choroby wieńcowej były rozpowszechnione w dużym stopniu w badanej populacji. Całościowa zgodność w ocenie istotności zwężeń w tętnicach wieńcowych w badaniu CCTA w porównaniu z koronarografią wynosiła 73% (κ = 0,47). Największa zgodność w ocenie dotyczyła pnia lewej tętnicy wieńcowej 78% (κ = 0,5), a najmniejsza — gałęzi okalającej 69% (κ = 0,34).

Wnioski. U pacjentów z MVD występuje umiarkowana zgodność pomiędzy opisem istotności zwężeń w tętnicach wieńcowych w badaniu CCTA w porównaniu do koronarografii. Tomografia komputerowa tętnic wieńcowych, jako metoda nieinwazyjna, jest jednym z narzędzi w początkowej diagnostyce przy podejrzeniu choroby wieńcowej. Czynniki ryzyka choroby wieńcowej są szeroko rozpowszechnione i stanowią istotny problem w analizowanej populacji pacjentów.

Słowa kluczowe: wielonaczyniowa choroba wieńcowa, tomografia komputerowa tętnic wieńcowych, koronarografia

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Table 1. Characteristics of the study group — clinical and demographic data

Age (mean, SD)	69.42, 8.28
Gender	
Men (n, %)	74 (69.8)
Women (n, %)	32 (30.2)
BMI [kg/m^2] (mean, SD)	27.91, 4.44
CCS scale	
I (n, %)	16 (15.1)
II (n, %)	47 (44.3)
III (n, %)	40 (37.8)
IV (n, %)	3 (2.8)
NYHA scale	
I (n, %)	13 (12.3)
II (n, %)	75 (70.7)
III (n, %)	17 (16.1)
IV (n, %)	1 (0.9)
HF (n, %)	56 (52.8)
HFpEF (n, % of HF)	43 (76.7)
HFmrEF (n, % of HF)	8 (14.3)
HFrEF (n, % of HF)	5 (9.0)
Smoking	
Never (n, %)	48 (45.3)

In the past (n, %)	38 (35.8)
Current (n, %)	20 (18.9)
Hypertension (n, %)	98 (92.5)
Diabetes mellitus	
Present diabetes mellitus (n, %)	38 (35.8)
Impaired fasting glucose (n, %)	3 (2.8)
Impaired glucose tolerance (n, %)	2 (2.0)
Alcohol abuse (n, %)	1 (0.9)
Dyslipidaemia (n, %)	106 (100)
CKD (n, %)	20 (18.9)
COPD (n, %)	6 (5.7)

% — a percentage of 106 patients; BMI — body mass index; CCS — Canadian Cardiovascular Society angina grade; CKD — chronic kidney disease defined as glomerular filtration rate < 60 mL/min/1,73 m^2; COPD — chronic obstructive pulmonary disease; HF – heart failure; HFmrEF — heart failure with mildly reduced ejection fraction; HFpEF — heart failure with preserved ejection fraction; HFrEF — heart failure with reduced ejection fraction; n — number of patients; NYHA — New York Heart Association Functional Classification; SD — standard deviation

Table 2. Characteristics of a study group — biochemical parameters

Parameter	Median (1^{st} quartile–3^{rd} quartile)
Morphology	
RBC [mln/µL]	4.51 (4.2–4.86)
WBC [1000/µL]	7.32 (6.09–8.52)
Hgb [g/dL]	14.0 (12.8–14.78)
PLT [1000/µL]	213.0 (182.25–252.0)
Lipidogram	
Total cholesterol [mmol/L]	4.15 (3.71–4.95)
HDL [mmol/L]	1.21 (1.05–1.52)
LDL [mmol/L]	2.26 (1.8–3.02)
TG [mmol/L]	1.22 (0.93–1.85)

Others	
Sodium [mmol/L]	139.7 (138.02–140.78)
Potassium [mmol/L]	4.32 (4.12–4.56)
eGFR [mL/min/1,73m^2]	77.8 (62.32–89.78)
Creatine [µmol/L]	81.75 (72.12–97.58)
TSH [µIU/mL]	1.22 (0.73–2.1)
TnT [ng/L]	12.5 (9.0–17.0)
CK-MB mass [ng/mL]	2.8 (2.2–3.78)
NT-proBNP [pg/mL]	250.0 (100.0–753.8)
Uric acid [µmol/L]	360.5 (298.48–438.78)

CK-MB — creatine kinase-myoglobin binding; eGFR — estimated glomerular filtration rate; HDL — high-density lipoprotein; Hgb — haemoglobin; LDL — low-density lipoprotein; NT-proBNP — N-terminal pro-B-type natriuretic peptide; PLT — platelet count; RBC — red blood cells; TG — triglycerides; TnT — troponin T; TSH — thyroid-stimulating hormone; WBC — white blood cells

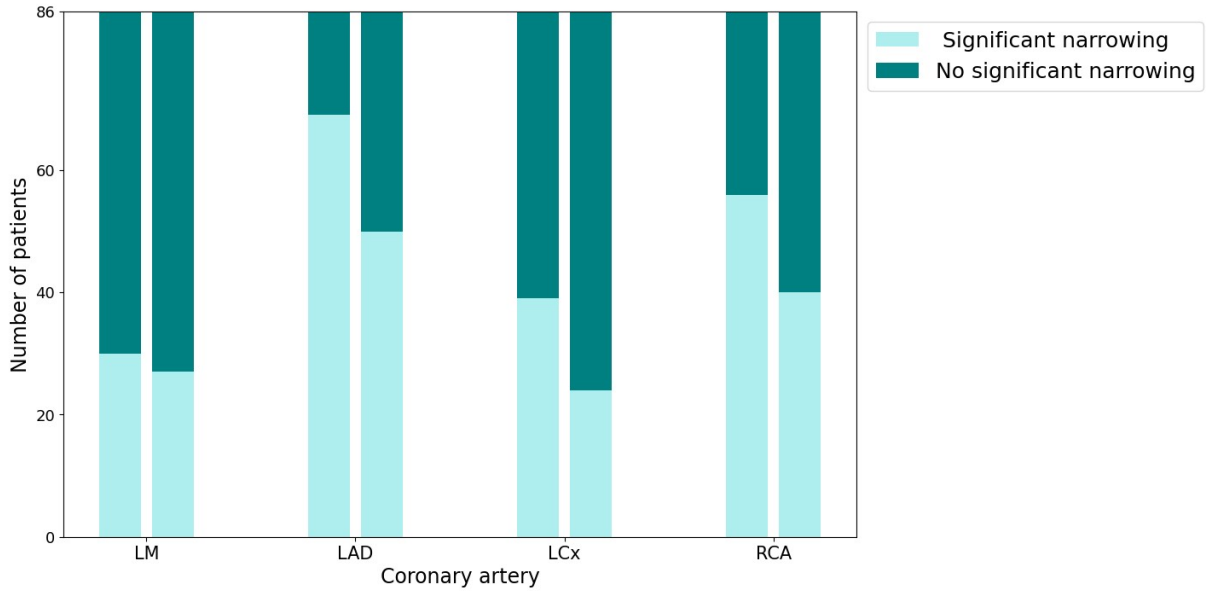

Figure 1. Comparison between coronary angiography (left bar) and coronary computed tomography angiography (right bar) in the assessment of the significant narrowing in coronary arteries; LAD — left anterior descending artery; LCx — left circumflex artery; LM — left main coronary artery; RCA — right coronary artery

Table 3. Diagnostic accuracy of coronary computed tomography angiography in coronary arteries

	LM	LAD	LCx	RCA	Total
Concordance	67 (78%)	63 (73%)	59 (69%)	62 (72%)	251 (73%)
Over-diagnosed	8 (9%)	2 (3%)	6 (7%)	4 (5%)	20 (6%)
Under-diagnosed	11 (13%)	21 (24%)	21 (24%)	20 (23%)	73 (21%)
Cohen's κ	0.50	0.40	0.34	0.45	0.47

LAD — left anterior descending artery; LCx — left circumflex artery; LM — left main coronary artery; RCA — right coronary artery