Evaluation of the SPECT radioisotope perfusion scan in the detection of ischemic heart disease

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Abstract

Objectives: The aim of the study is to determine the diagnostic value of myocardial perfusion scintigraphy (MPS) depending on the location and size of stenosis of a coronary vessel or vessels.
Methods: Results of examinations of patients hospitalized in two hospital departments of the same medical facility were analyzed. Retrospective research material consisted of results obtained for 200 patients with suspected ischemic heart disease (coronary artery disease - CAD). From this group, 83 examinations were selected where results of coronary angiography and perfusion scintigraphy (MPS) were available. The following tests were used for statistical studies: t-Student, Chi², Fisher-Sendecor, Kruskal-Wallis and Willcoxon. The use of these tests allowed for:

- determination of predictive factors favoring development of ischemic heart disease in the analyzed group of patients,
- determination of sensitivity and specificity of MPS, taking the coronary examination as the "gold standard",
- assessment of usefulness of the MPS imaging depending on location of a stenosis within the main coronary vessels,
- evaluation of usefulness of MPS in detection of a multivessel disease.

Results: In the analyzed group of patients, arterial hypertension was the main factor predisposing to CAD (p = 0.016).

The highest sensitivity of MPS in the diagnosis of ischemia was found in the group of patients with stenosis of the right coronary artery (RCA) (p = 0.029) and the circumflex (Cx) and marginal (MB) branches (p = 0.028). A comparative analysis was performed between the degree of narrowing of the above vessels and the degree of perfusion disorders in the MPS study.

There was a correlation between the severity of ischemia in MPS and the degree of stenosis in both RCA (p = 0.011, 95% sensitivity (83.1 - 99.4 CI; negative predictive value 83.3%) and the Cx/MB complex (p = 0.044, sensitivity 94.7% (83.1 - 99.4 CI), negative predictive value - 83.3%).
There was a correlation between the result of the MPS perfusion scan and disease of two or three coronary vessels. There was a 97% agreement between the presence of permanent or transient defects in MPS and the presence of stenosis in 2 or 3 coronary vessels exceeding 80% of the vessel lumen. In the group of patients with stenosis ranging between 50-80%, abnormal results of the MPS occurred in 41.7% of patients.
Conclusion: The results confirm that myocardial perfusion scintigraphy is a very valuable screening test in patients with suspected CAD. This examination shows high sensitivity also in the group of patients with multivessel disease.

Key words: MPS, coronarography, myocardium, SPECT, coronary artery disease

Introduction

Ischemic heart disease is currently one of the most common diseases and the most common cause of death in developed countries. Coronary angiography remains the classic diagnostic examination in ischemic heart disease. It aims to visualize hemodynamically significant stenosis of coronary arteries that may contribute to myocardial ischemia. Coronary angiography allows to determine both location of the stenosis in the area of coronary arteries, as well as to assess its size. The examination result constitutes the basis for planning of interventional treatment. The disadvantage of this method is both its invasive nature and a high cost.

Considering the invasive nature of coronary angiography examination, non-invasive diagnostic screening methods are being sought, that would allow for the qualification of patients for this examination. Such a method should be characterized mainly by high sensitivity, and costs of its implementation should also be much lower. Among the currently proposed methods (angio-CT, MRI, Echo), myocardial perfusion scintigraphy plays an important role. The main goal of the MPS scanning is to indirectly assess hemodynamic significance of a coronary stenosis and to identify indications for interventional treatment.

The MPS scanning has been used since the mid 1970's. It consists in the intravenous administration of a radiotracer ([^{99m}Tc] Tc-MIBI),

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which has the ability to diffuse into myocardial cells, in proportion to the local blood supply, and then measuring the radiation distribution with a gamma camera. Performing the scan during the rest and the exercise/pharmacological stress phase enables assessment of the vascular reserve. Under normal conditions, a distribution of radioactivity proportional to the thickness of the myocardium is observed both in the resting phase and in the stress test. Cardiac infarction (or so called "frozen muscle") is characterized by absence of tracer accumulation in both studies, while ischemia is characterized by reduced accumulation of the radiotracer in a stress scan and normalization in a rest scan. MPS scan with the use of the single photon tomography (SPECT) technique enables precise localization of infarction/ischemia areas and determination of volume of the observed lesions. It is assumed that ischemia exceeding 10% of the volume of the left ventricular muscle requires invasive treatment using angioplasty/by-pass. Ischemia below this value can be treated conservatively [1].

Methods

The study group consisted of patients with suspected CAD, who underwent a coronary angiography and MPS scan. Obtained data allowed for the construction of a retrospective research material containing results for 200 patients. From this group, 83 sets of data were selected in patients who had both examinations performed in the interval no longer than 1 month, laboratory tests and questionnaires assessing selected clinical parameters done.

All patients underwent myocardial perfusion scintigraphy to have the myocardial blood supply assessed at rest and pharmacological stress test (Dipyridamol) according to the standard protocol. The SPECT data were acquired 60 min after intravenous administration of 500–740 MBq technetium-99m MIBI. The images were acquired with the aid of a two-head gamma camera (Varicam Elscint) for 20 s in 32 steps between the right anterior 45° and left posterior 45° (zoom 1.28) then stored in a 64 × 64 matrix. Transverse slices of acquired data were reconstructed by filtered back projection using a Butterworth filter order 5 and cut-off frequency of 0.35 Nyquist. Images were re-orientated according to the long axis of the left ventricle. The test was considered positive if the myocardial reversible perfusion defect was greater than 10% of the muscle of the left ventricle.

All patients have undergone coronary angiography. (X-ray angiography device: Siemens Artis ZEE and Philips Allura XPER FD10). During procedures an iodine-containing non-ionic radiocontrast agent was used. All patients had the same strategy for prevention of radiocontrast agent. Coronary angiography was performed according to the Judkins technique [2]. Diagnosis of CCS and indication for PCI were performed according to current ESC guidelines [3].

The following were recorded in the study group: age, gender, BMI value, diabetes, smoking, chest pain, angioplasty or bypass surgery, hypertension, diagnosis of CAD in a close family member and presence of other chronic diseases.

Statistical analysis

Statistics for continuous variables are presented as a median with the 1st and 3rd quartiles, and for categorical variables as counts and percentages.

Comparisons of groups determined by the SPECT score were made using the Wilcoxon and Kruskal Wallis tests for continuous variables and Fisher's exact test for categorical variables.

The relationship between the MPS scan result and results of coronary angiography was assessed using the Fisher's exact test, and the agreement of these studies (where the coronary result was treated as the "gold standard") was assessed by calculating sensitivity, specificity, positive and negative predictive value along with corresponding confidence intervals. In all analyzes, the significance level was $\alpha = 0.05$. Calculations were performed using the statistical software R 4.0.5 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/).

The study was conducted in accordance with the 1964 Helsinki Declaration and its later amendments and approved by the local ethics committee. Informed written consent was waived by the local ethics committee (Ethics Committee – MEDICAL University of Warsaw) due to the purely retrospective analysis. We hereby confirm that all methods were performed in accordance with the relevant guidelines and regulations.

Results

Examinations carried out in 50 men (60.2%) and 33 women (39.8%) were analyzed. The median age was 67.7 (± 10.4) years. The median BMI was 29.3 (± 4.5).

On the basis of the questionnaire, it was found that chest pain that could indicate CAD was reported by 53 patients (64%), interventional treatment (angioplasty, by-pass) had previously been performed in 55 patients (66%), and hypertension was present in 45 patients (54%). The incidence of CAD in the immediate family was found in 49 patients, other chronic diseases were found in 62 patients. In the described control group, 16 patients had diabetes (19%).

Some patients had two aggravating factors: 10 patients had arterial hypertension and diabetes (12%), 11 patients (13%) had diabetes and family history of CAD, and 24 patients (29%) had hypertension and family history of CAD. Thirteen (15%) patients were previously treated with angioplasty, had arterial hypertension.

In the multivariate analysis of factors contributing to the occurrence of ischemic disease, arterial hypertension ($p = 0.016$) turned out to be a statistically significant factor in the study

group. Hypertension was the dominant factor in the group of patients in whom MPS indicated significant ischemia (Table 1).

Based on coronary angiography, the presence of stenosis and its size were assessed in the left coronary artery trunk (TRUNK), anterior descending artery (LAD), diagonal branch (D), circumferential branch (Cx), marginal branch (MB) and right coronary artery (RCA). The degree of stenosis was determined on the basis of a 4-point scale: 0 - no stenosis; 1 - stenosis not more than 49%; 2 - stenosis 50-79%; 3 - stenosis of more than 80% of the vessel lumen. Additionally, variants were analyzed when the stenoses concerned both LAD and D, as well as Cx and MB. There was also a group of patients with stenosis of two or three major coronary vessels.

The degree of blood flow disturbances in the MPS scan was determined on the basis of a 3-grade scale: 0 - no disturbances in distribution of the radiotracer both during the rest and pharmacological test; 1 - irreversible or reversible changes in perfusion <10% of the left ventricle volume 2 - irreversible or reversible changes in perfusion >10% of the left ventricle volume

The aim of the analysis was to determine whether there is a correlation between the MPS scanning result and location and degree of stenosis of a particular coronary artery. The statistical study was based on two test models, i.e., the rank Kruskal Wallis test and the Wilcoxon test for pairs of observations.

Statistical analysis using the Kruskal test showed a correlation between the degree of RCA stenosis and the result of scintigraphy (p = 0.029) and changes in the Cx and MB vessel complex (p = 0.028).

In the group of patients with normal MPS, RCA stenosis above 80% was found only in 2 patients (17%). In the group with MPS perfusion disorders less than 10% of the myocardial volume, coronary angiography showed a > 80% stenosis in 44% of patients. Similarly, when perfusion disorders covered an area> 10% of the left ventricle volume, vessel stenosis of over 80% occurred in 38% of patients.

The analysis of changes in the Cx/MB complex showed that in the group of patients with normal MPS scan, vessel stenosis exceeding 80% occurred in only 1 patient. In the group of patients with abnormal MPS result, coronary artery stenosis over 80% occurred in 88% of patients.

Statistical analysis showed no correlation between results of coronary angiography and MPS in the group of patients with stenosis of the left coronary artery trunk and LAD.

Additionally, an analysis using the Fisher-Sendecor test was performed (test for variance). For each vessel, apart from statistical significance, the following were also determined: sensitivity, specificity, PPV and NPV. Statistical matrices included all possible variants of positive and negative results in both techniques. The analysis covered: RCA, LCA, TRUNK, LAD, D, Cx, MB and separately LAD with D and Cx with MB. Also using the above test, a statistically significant relationship was found between the degree of RCA stenosis and the Cx/MB complex in the coronary angiography and the MPS result: RCA (p = 0.011), Table 3; Cx/MB (p = 0.044), Table 4.

Table 1 *Patient characteristics – questionnaire data*

Characteristic	Overall, N = 83[1]	SPECT 0, N = 13[1]	SPECT 1, N = 16[1]	SPECT 2, N = 54[1]	p-value[2]
Sex					0.528
F	33 (40%)	7 (54%)	6 (38%)	20 (37%)	
M	50 (60%)	6 (46%)	10 (62%)	34 (63%)	
Age	67 (60, 76)	65 (57, 76)	67 (62, 74)	68 (60, 77)	0.826
BMI	29.4 (26.2, 32.3)	29.7 (26.2, 33.4)	27.3 (26.1, 31.9)	29.5 (26.3, 32.3)	0.735
Diabetes					0.716
negative	67 (81%)	11 (85%)	14 (88%)	42 (78%)	
positive	16 (19%)	2 (15%)	2 (12%)	12 (22%)	
Smoking					0.304
negative	74 (89%)	11 (85%)	16 (100%)	47 (87%)	
positive	9 (11%)	2 (15%)	0 (0%)	7 (13%)	
Chest pain					0.144
negative	30 (36%)	5 (38%)	9 (56%)	16 (30%)	
positive	53 (64%)	8 (62%)	7 (44%)	38 (70%)	
After angioplasty					0.912
negative	14 (17%)	2 (15%)	2 (12%)	10 (19%)	
positive	69 (83%)	11 (85%)	14 (88%)	44 (81%)	
Interventional treatment					0.944
negative	28 (34%)	4 (31%)	6 (38%)	18 (33%)	
positive	55 (66%)	9 (69%)	10 (62%)	36 (67%)	
Hypertension					**0.016**
negative	38 (46%)	7 (54%)	12 (75%)	19 (35%)	
positive	45 (54%)	6 (46%)	4 (25%)	35 (65%)	
Family history of CAD					0.893
negative	34 (41%)	6 (46%)	6 (38%)	22 (41%)	
positive	49 (59%)	7 (54%)	10 (62%)	32 (59%)	
Other chronic disease					0.872
negative	21 (25%)	3 (23%)	3 (19%)	15 (28%)	
positive	62 (75%)	10 (77%)	13 (81%)	39 (72%)	

[1]n (%); Median (IQR)

[2]Pearson's Chi-squared test; Kruskal-Wallis rank sum test; Fisher's exact test

SPECT codes
0 – normal perfusion of the left ventricle in rest and stress examination
1 – irreversible or reversible changes in perfusion <10% of the left ventricle volume
2 – irreversible or reversible changes in perfusion >10% of the left ventricle volume
F – female
M – male

Source: Own elaboration.

Sensitivity of the MPS scan in the group of patients with RCA stenosis was 95% (83.1 - 99.4 C.I.). However, the low specificity, of only 24.4%, was noticeable. The NPV value reached the level of 83.3%, which proves a high level of positive or negative agreement with the coronary angiography result.

Table 4 presents the analysis of efficacy of MPS scanning in the group of patients with vascular stenosis in the Cx/MB complex. Sensitivity of MPS was 94.7% (83.1 - 99.4 C.I.). The NPV value reached the level of 83.3%. As in the previous analysis, high sensitivity of the test was found - 94.7%, but low specificity (23.3%)

Table 2 *Summary of the assessment of major coronary vessels in coronary angiography to the level of myocardial perfusion in SPECT*

Characteristic	0, N = 12[1]	1, N = 32[1]	2, N = 37[1]	p-value[2]	p-value[3]
LCA_codes				0.7	0.5
0	11 (92%)	30 (94%)	36 (97%)		
1	1 (8.3%)	2 (6.2%)	1 (2.7%)		
TRUNK_codes				0.7	0.4
0	8 (67%)	22 (69%)	22 (59%)		
1	4 (33%)	9 (28%)	13 (35%)		
2	0 (0%)	1 (3.1%)	1 (2.7%)		
3	0 (0%)	0 (0%)	1 (2.7%)		
LAD_codes				0.4	0.4
0	3 (25%)	3 (9.4%)	7 (19%)		
1	4 (33%)	13 (41%)	13 (35%)		
2	4 (33%)	6 (19%)	8 (22%)		
3	1 (8.3%)	10 (31%)	9 (24%)		
D_codes				0.7	0.5
0	6 (50%)	8 (25%)	15 (41%)		
1	2 (17%)	14 (44%)	9 (24%)		
2	0 (0%)	3 (9.4%)	6 (16%)		
3	4 (33%)	7 (22%)	7 (19%)		
Cx_codes				0.10	0.4
0	5 (42%)	4 (12%)	9 (24%)		
1	5 (42%)	14 (44%)	15 (41%)		
2	1 (8.3%)	5 (16%)	3 (8.1%)		
3	1 (8.3%)	9 (28%)	10 (27%)		
MB_codes				0.064	0.9
0	7 (58%)	9 (28%)	12 (32%)		
1	5 (42%)	15 (47%)	13 (35%)		
2	0 (0%)	2 (6.2%)	3 (8.1%)		
3	0 (0%)	6 (19%)	9 (24%)		
RCA_codes				**0.029**	0.3
0	5 (42%)	2 (6.2%)	9 (24%)		
1	5 (42%)	11 (34%)	9 (24%)		
2	0 (0%)	5 (16%)	5 (14%)		
3	2 (17%)	14 (44%)	14 (38%)		
LAD_D				0.8	0.5
0	3 (25%)	2 (6.2%)	5 (14%)		
1	2 (17%)	10 (31%)	9 (24%)		
2	2 (17%)	6 (19%)	10 (27%)		
3	5 (42%)	14 (44%)	13 (35%)		
Cx_MB				**0.028**	>0.9
0	5 (42%)	3 (9.4%)	7 (19%)		
1	5 (42%)	13 (41%)	10 (27%)		
2	1 (8.3%)	3 (9.4%)	4 (11%)		
3	1 (8.3%)	13 (41%)	16 (43%)		

[1]n (%)

[2]Kruskal-Wallis rank sum test

[3]Wilcoxon rank sum test

SPECT codes
0 – normal perfusion of the left ventricle in rest and stress examination
1 – irreversible or reversible changes in perfusion <10% of the left ventricle volume
2 – irreversible or reversible changes in perfusion >10% of the left ventricle volume
coronary angiography codes
0 – no stenosis
1 – vessel stenosis up to 49%
2 – vessel stenosis from 50 to 79%
3 – vessel stenosis from 80 to 100%

Source: Own elaboration.

Table 3 *Assessment of sensitivity and specificity of SPECT compared to RCA coronary angiography*

	RCA			
Characteristic	negative	positive	Total	p-value[1]
SPECT				**0.011**
negative	10 (83%)	2 (17%)	12 (100%)	
positive	31 (45%)	38 (55%)	69 (100%)	
Total	41 (49%)	42 (51%)	83 (100%)	

[1]Fisher's exact test

	Estimate	95%C.I.
Sensitivity	95.0	83.1 - 99.4
Specificity	24.4	12.4 - 40.3
Positive predictive value	55.1	42.6 - 67.1
Negative predictive value	83.3	- 97.9

Source: Own elaboration.

Table 4 *Assessment of the sensitivity and specificity of SPECT compared to coronarography of a pair of vessels Cx_MB*

	Cx_MB			
Characteristic	negative	positive	Total	p-value[1]
SPECT				**0.044**
negative	10 (83%)	2 (17%)	12 (100%)	
positive	33 (48%)	36 (52%)	69 (100%)	
unknown	1 (50%)	1 (50%)	2 (100%)	
Total	44 (53%)	39 (47%)	83 (100%)	

[1]Fisher's exact test

	Estimate	95%C.I.
Sensitivity	94.7	82.3 - 99.4
Specificity	23.3	11.8 - 38.6
Positive predictive value	52.2	39.8 - 64.4
Negative predictive value	83.3	- 97.9

Source: Own elaboration.

Table 5 *Comparison of one, two or three vessel disease in coronary angiography with results of perfusion deficit in MPS.*

	SPECT			
Characteristic	0	1,2	Total	p-value[1]
I_II_III				**0.052**
0	6 (21%)	22 (79%)	28 (100%)	
2,3	1 (3.4%)	28 (97%)	29 (100%)	
Total	7 (12%)	50 (88%)	57 (100%)	

[1]Fisher's exact test

SPECT - code
0 – normal perfusion of the left ventricle in rest and stress examination
1 – any irreversible or reversible changes in perfusion
coronary angiography
0 – vessels without stenosis
1 – stenosis in two or three vessels

Source: Own elaboration.

Usefulness of MPS was analyzed in a group of patients with stenosis of two or three coronary vessels. Any area of ischemia was assessed in the analysis. Analysis carried out using the Fisher test is presented in Table 5.

In order to compare the obtained results with published results, an analysis of the MPS (with any perfusion disorders amounted >10% of left ventricle volume) was carried out in all group of patients with a stenosis of one of the coronary arteries over 50% using the Chi² test (Table 6).

***Table 6**. Summary of perfusion impairment in SPECT above 10% compared to vascular stenosis in coronary angiography above 50%.*

	Stenosis > 50% in coronary angiography			
Characteristic	0	1	Total	p-value[1]
Loss of perfusion >10% in SPECT				0.7
0	12 (27%)	32 (73%)	44 (100%)	
1	**9 (23%)**	30 (77%)	39 (100%)	
Total	21 (25%)	62 (75%)	83 (100%)	

[1]Pearson's Chi-squared test

	Estimate	95%C.I.
Sensitivity	48.4	35.5 - 61.4
Specificity	57.1	34.0 - 78.2
Positive predictive value	76.9	60.7 - 88.9
Negative predictive value	27.3	15.0 - 42.8

coronary angiography codes
0 – no stenosis
1 – stenosis > 50%
SPECT codes
0 – normal perfusion
1 – irreversible or reversible changes in perfusion >10 % of the left ventricle volume

Source: Own elaboration.

Table 7 shows that the specificity of MPS for determining any perfusion defects relative to coronary angiography with stenoses greater than 50% of the vessel lumen is 41.7%.

***Table 7**. Summary of vascular stenosis over 50% in coronary angiography compared to impaired perfusion in MPS.*

	Loss of perfusion in SPECT			
Characteristic	0	1	Total	p-value[1]
Stenosis > 50% in coronary angiography				0.2
0	5 (24%)	16 (76%)	21 (100%)	
1	7 (11%)	55 (89%)	62 (100%)	
Total	12 (14%)	71 (86%)	83 (100%)	

[1]Fisher's exact test

	Estimate	95%C.I.
Sensitivity	77.5	66.0 - 86.5
Specificity	**41.7**	15.2 - 72.3
Positive predictive value	88.7	78.1 - 95.3
Negative predictive value	23.8	8.2 - 47.2

SPECT codes
0 – normal perfusion
1 – loss of perfusion
coronary angiography codes
0 – no stenosis
1 – stenosis > 50%

Source: Own elaboration.

Discussion

Early detection of CAD is an important issue for clinical practice. In nuclear medicine, pharmacologic stress with Dipyridamole (vasodilator) is frequently used for the noninvasive detection of CAD with radionuclide myocardial perfusion imaging. However, MPS has some limitations in clinical use, for example, a diagnosis of balanced ischemia, post-myocardial infarction, or cardiomyopathy may cause interference or misdiagnosis [4-6].

In the analyzed group of patients, presence of arterial hypertension (p = 0.016) turned out to be an important factor in the development of CAD. Similar observations indicating the importance of arterial hypertension in the development of CAD were presented by Alqarni et. al. [7] and Nakanishi et.al. [8]. In the study group, however, no statistically significant influence of other factors on the incidence of CAD was found. This part of the study was aimed at characterizing the study group and determining which factors could be responsible for occurrence of CAD in the analyzed group of patients.

Statistical evaluation of results showed that there was a correlation between stenosis within the RCA or the Cx-MB complex and abnormal MPS results. This type of correlation was not found in the group of patients with stenosis related to other coronary vessels, mainly LCA, its trunk and LAD. Sensitivity of the MPS scan in the group of patients with RCA and the Cx-MB complex stenosis was assessed at 95% and 94.7%, respectively. Similar results were presented by Sun et al. (9). These authors demonstrated that the sensitivity of MPS in the group of patients with RCA stenosis was 94.7% [9]. Results presented by Ammann et al. [10] also deserve attention. These authors did not find a significant relationship between significant LAD stenosis and reversible changes in [^{99m}Tc]Tc-MIBI accumulation, while this was the case for Cx and RCA. The above data indicate that sensitivity of the MPS scan may depend not only on the size of stenosis, but also on its location.

The high sensitivity but relatively low specificity of MPS was observed in the presented material. Similar results. has been described earlier by Wackers et al.[11]

However, few data are available regarding the impact of clinical findings in patients with abnormal MPS without significant coronary diameter stenoses. Artefacts due to sub-optimal count density, soft tissue attenuation, and technical problems are well known reasons for so-called "false-positive" MIBI SPECT [12].

Ammann et al. [10] also emphasize the importance of additional factors, such as left ventricular hypertrophy and left bundle branch block. As mentioned above, the study group was dominated by patients with arterial hypertension, which is the most common cause of left ventricular hypertrophy.

Concerning left ventricular hypertrophy, data on analysis of MPS scans for prediction of significant CAD are contradicting. Due to the low specificity of scintigraphy in left ventricular hypertrophy, some investigators recommend that stress

echocardiography should be the method of choice for assessing myocardial function in these patients.[13] Others found that hypertensive patients, with or without left ventricular hypertrophy, should not be excluded from stress myocardial perfusion scintigraphy.[14] Some investigators believe that vasodilation with dipyridamole allows for semiquantitative assessment of reduced myocardial perfusion reserve, yielding positive MPS scans in patients with microvascular disease without significant coronary diameter stenosis [15,16].

Three-vessel coronary artery disease (3VD) is found in ~9% of patients undergoing elective coronary angiography and these patients have a considerably poorer prognosis than those with less extensive disease.[17] Detection of 3VD with non-invasive imaging can be challenging due to the effects of balanced ischaemia leading to false-negative results in up to 20% of cases.[18,19] This limitation has been well documented with MPS, and although its overall sensitivity for detecting coronary artery disease in multi-vessel disease is 80–95%, it often only detects perfusion defects in one territory.[18,20,21] In one MPS study, inducible perfusion abnormalities in all three territories were identified in only 12% of patients with known angiographic 3VD.[22]

Based on the analyzed results, it was shown that sensitivity of MPS in the assessment of any perfusion disorders in the group of patients diagnosed with two- or three-vessel disease based on coronary angiography was 86% and 89%, respectively. Similar results were obtained by Beller et al. [23] and Chung et al [24]. Analysis of [^{99m}Tc]Tc-MIBI accumulation disorders location in this group of patients confirmed, however, that MPS scanning did not allow for an unequivocal differentiation between one and 3VD vessel disease. Coronary angiography should be performed if clinical data suggest presence of 3VD, even if the scintigraphic examination shows a single ischemic area [24].

In order to compare the obtained results with data presented in the literature [22], an analysis of the MPS scan results was carried out in patients with stenosis of a coronary vessel or vessels exceeding 50% of their diameter.

Similarly to the literature data gathered so far, it has been shown that in patients with stenosis of a coronary vessel or vessels greater than 50% of their diameter, normal MPS scan result is found in 48.7% of the examined patients. This result indicates that MPS is a useful diagnostic test that allows determination of a hemodynamic significance of anatomical changes of coronary vessels. Sensitivity of MPS was 77.5%, and the positive predictive value (PPV) was 88.7%. These results are similar to the study by Chung et al. [22], who describe several diagnostic techniques for the diagnosis of CAD. These authors obtained results indicating sensitivity of the MPS scan at the level of 89% and PPV at the level of 84%. Other papers by Varadaraj et al. [25] indicate that the PPV value of the perfusion scan was 93%. Similar observations were reported by Laspas et al. [26]. Sensitivity of MPS in a similar age group was 77.8% (mean age 65.3 years). Similar data on sensitivity of the MPS scan was also presented by Aggeli et al. [27] (80%), Budoff et al. [28] (81%), Johansen et al. [29] (74.6%), Peltier et al. [30] (81.6%), Schepis et al. [31] (76.2%) and Yeih et al. [32] (71.4%).

Currently, new methods of non-invasive examination of myocardial perfusion disorders are being developed (MRI, dynamic MIBI). Magnetic resonance tomography (MRI) perfusion scanning is particularly noteworthy [33]. This examination is characterized by a very good resolution. Thanks to this, better specificity and sensitivity of obtained results are emphasized. This study has also been shown to have a high prognostic value [34-35]. Dynamic SPECT/CT – [^{99m}Tc]Tc-Sestamibi is characterized by greater sensitivity (88%), specificity (96%) and accuracy (94%) compared to classical MPS [36]. The main advantage of these techniques is increased specificity of results. However, availability of these methods is significantly limited, therefore MPS remains the primary screening method in the diagnosis of CAD. It should be emphasized that angiography and MPS are studies that present two different aspects of coronary disease - changes in large coronary vessels and circulatory disorders at the microcirculation level. It should also be noted that MPS takes into account the effect of collateral circulation in the course of coronary artery stenosis.

Presented work has some limitations. The main limitation is the retrospective nature of data. For this reason, it was possible to select only a limited number of patients for further analysis. The second limitation is inhomogeneous nature of the course of the disease in the analyzed group of patients. Majority of patients had arterial hypertension, and many patients were previously treated for CAD. For this reason, authors of this study paid special attention to the scope and statistical methods used. According to the authors, the advantage of this study is the assessment of usefulness of MPS in everyday clinical practice in a group of routinely examined patients with suspected CAD.

Conclusion

The main findings of our study were that in the group of CAD patients with hypertension and/or history of ischemic disease treatment (angioplasty), the MPS scan was very sensitive. However, specificity of this method is much lower. Sensitivity of the MPS scan depends not only on the degree of stenosis of a coronary vessel, but also on its location. Scintigraphic examination is highly sensitive in determination of areas of limited perfusion reserve in patients with coronary multi vessels disease. However, due to its low specificity, this examination cannot be the basis for a final diagnosis. Despite presented limitations of the method, MPS scan still plays an important role as a screening test in the group of patients at intermediate risk of CAD.

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