

The prognostic value of myocardial perfusion scintigraphy compared to coronary angiography in women with positive stress test results

Sylvia Miernik¹, Anna Kaźmierczak-Dziuk¹,
Grzegorz Kamiński², Mirosław Dziuk³

¹Department of Cardiology and Internal Medicine, Military Institute of Medicine, Warsaw, Poland

²Department of Endocrinology and Isotope Therapy, Military Institute of Medicine, Warsaw, Poland

³Department of Nuclear Medicine, Military Institute of Medicine, Warsaw, Poland

[Received 18 I 2012; Accepted 31 I 2012]

Abstract

BACKGROUND: Modern diagnostic strategy in coronary artery disease (CAD) makes it necessary not only to establish a diagnosis but also to assess the cardiovascular risk. It is not clear which strategy should be followed in the case of women with positive ECG stress test results to assess prognosis and start appropriate diagnostics and treatment.

The aim of the study was to assess the prognostic value of myocardial perfusion scintigraphy in comparison with coronary angiography in women suspected of CAD and with positive ECG stress test results.

MATERIAL AND METHODS: The study population comprised 115 women (mean age 58.08 ± 8.8 years) suspected of CAD, with a history of chest pain and positive stress test results, who under-

went myocardial perfusion scintigraphy. In 58 women coronary angiography was performed as the next step of the diagnostic procedure. All the patients were interviewed and had a physical examination, including the assessment of the cardiovascular risk in accordance with the SCORE (Systematic Coronary Risk Evaluation) scale and the probability of CAD (POST-TEST) in accordance with the ESC guidelines. The gated single photon emission computed tomography (GSPECT) with Tc-99m-MIBI was considered positive if moderate perfusion changes were observed in at least two segments or severe reversible perfusion disorders were found, regardless of the number of involved segments. The degree of coronary stenosis was assessed visually and changes greater than 50% stenosis of the luminal diameter were considered haemodynamically significant.

RESULTS: The evaluation period covered 43.2 ± 30.8 months on average. The sensitivity of myocardial perfusion scintigraphy against cardiovascular events was **100%** and the sensitivity of coronary angiography was **92.3%**. The specificity was **93.1%** and **88.9%** respectively.

The PPV of scintigraphy for cardiovascular events was **65%** and of coronary angiography was **70.6%**. The NPV was **100%** and **97.6%** respectively. The accuracy of myocardial perfusion scintigraphy for cardiovascular events was **93.9%** and the accuracy of coronary angiography for cardiovascular events was **89.7%**. The survival analysis confirmed the high prognostic value of SPECT and coronary angiography. However, if compared, myocardial perfusion scintigraphy was a better predictor of survival without cardiovascular events than coronary angiography was ($\chi^2 = 9.39$, $p < 0.01$). The most important factors in assessing the cardiovascular risk in the study population included: positive result of myocardial perfusion scintigraphy, positive result of coronary angiography, and high SCORE and high POST-TEST values.

CONCLUSIONS: Myocardial perfusion scintigraphy is superior to coronary angiography in the prediction of necessary revas-

Correspondence to: Anna Kaźmierczak-Dziuk
Department of Cardiology and Internal Medicine
Military Institute of Medicine
128, Szaserów st, 04-141 Warsaw, Poland
Fax: 22 810 16 99
e-mail: akazmierczak-dziuk@wim.mil.pl

cularisation procedures in women suspected of coronary artery disease and with positive stress test results.

Key words: coronary artery disease in women, GSPECT, predictive value

Nuclear Med Rev 2012; 15, 1: 32–38

Background

Coronary artery disease (CAD) is the main cause of death in the female population [1], and women diagnosed with CAD have worse prognosis compared to men [2]. There is a range of distinct differences related to the CAD in women in terms of the clinical picture, risk factors and value of diagnostic methods [3–6].

According to contemporary standards [7, 8] it is recommended to begin the diagnosis of the coronary artery disease with an ECG stress test, notwithstanding the sex-related differences in the diagnostic value of this procedure. A negative result of the stress test is of major importance in excluding the disease, especially in the case of women with low risk of coronary artery disease prior to the test. On the other hand there is no definite procedure to be followed in the case of women with positive stress test results. Based on the guidelines for the general population, an invasive procedure can be performed in this group. However, it is known that about half of women qualified in the Women's Ischemia Syndrome Evaluation study (WISE) for coronary angiography based on the previous recommendations were found to have no significant changes in the coronary arteries, and negative results of coronary angiography were not related to the expected good prognosis [6].

It is not clear what tests should be carried out in the case of women with positive ECG stress test results so as to ensure that the patient benefits as much as possible from the diagnostic process in terms of disease diagnosis as well as evaluation of the cardiovascular risk.

As a result it was decided to evaluate the diagnostic and prognostic value of myocardial perfusion scintigraphy and coronary angiography in a group of women with positive ECG stress test results.

Material and methods

The study group for the evaluation of the prognostic value of myocardial perfusion scintigraphy and coronary angiography comprised 115 female patients with chest pain and positive ECG stress test results who had been referred for primary CAD diagnostics from across Poland. All the patients gave their consent to undergo the procedures and to provide clinical data for the purpose of long-term evaluation. Also the study was approved by the Bioethics Commission of the Military Physician Association.

The average age of the patients was 58.08 ± 8.8 and 26.1% of the patients were older than 65 years of age. All the patients underwent myocardial perfusion scintigraphy, and 58 of them also coronary angiography as the next stage of the CAD diagnosis process.

Exclusion criteria included: positive history of myocardial infarction or coronary artery revascularisation, presence of pathological Q wave or left bundle branch block in resting ECG, pregnancy, concomitant diseases preventing from performing diagnostic examinations and completion of the evaluation, age

below 18 years, conditions limiting the ability of understanding the nature of the procedures or making an informed decision, lack of patient's consent to participate in the study.

Clinical evaluation

Prior to the imaging examination, all the patients were interviewed to evaluate the risk of atherosclerosis, pain level and received medication. The clinical classification of chest pain was performed as recommended by the European Society of Cardiology (ESC) [7].

Typical chest pain was evaluated according to the classification criteria of the Canadian Cardiovascular Society (CCS) [9]. All the patients were evaluated for the risk of cardiovascular events in accordance with the Systematic Coronary Risk Evaluation (SCORE) scale of the European Society of Cardiology [10]. Physical examination included full assessment of heart rate, arterial pressure, body height, body weight and waist circumference.

ECG stress test

All the patients underwent ECG stress test. The test was performed on a treadmill according to the Bruce protocol. The patients received no beta-adrenolytics for 48 hours prior to the test. During the test their clinical condition, ECG and arterial pressure were monitored. According to the study assumptions, all the patients had positive ECG stress test results. Additionally, the maximum pulse rate, number of the achieved metabolic equivalents (MET), stage and reason for termination, if any, were analysed. Each patient was evaluated for the post-test probability of coronary artery disease (POST-TEST) according to the recommendations of the European Society of Cardiology [7]. Also the post-test normalisation of heart rate was assessed based on the heart rate recovery (HRR) value calculated as a difference between the maximum heart rate and the heart rate after 1 minute.

Myocardial perfusion scintigraphy

Gated myocardial perfusion scintigraphy was carried out for all the patients with Tc-99m-MIBI single photon emission computed tomography (SPECT). The examination based on a 2-day protocol was performed following intravenous administration of 740 MBq Tc-99m-MIBI at the end of the stress test and after 2 days in resting condition. The isotope was injected one minute prior to the completion of the treadmill stress test. Gated single photon emission computed tomography (GSPECT - Gated SPECT) was performed to enable evaluating both perfusion and left ventricular function. No adjustments for absorption were included. The analysis of left ventricular perfusion disorders was carried out using the XpertPro system with the Cedars Emory Quantitative Analysis (CEQUAL) software. A 16-segment model of the left ventricular muscle was applied [11]. The results of perfusion examination in specific segments of the left ventricle - magnitude and intensity of perfusion disorders — were evaluated on a semi-quantitative basis: 1 — insignificant, 2 — moderate, 3 — significant [11]. Moderate reversible perfusion disorders involving at least 10% of the left ventricular muscle or significant reversible perfusion disorders, regardless of the number of involved segments, were considered a positive result of the examination. Additionally, a Hermes Nuclear Diagnostics station with Quantitative Gated SPECT (QGS) software was used for the assessment of GSPECT results. The software

made it possible to calculate post-test and resting parameters of left ventricular function, such as: left ventricular ejection fraction, end-diastolic volume and end-systolic volume.

Coronary angiography

A typical coronary angiography procedure was performed in 58 women using Philips Integris 2000 with standard projections during the test [12]. The degree of stenosis was assessed visually on a semi-quantitative basis: 0 — no stenosis, 1 — up to 50% stenosis, 2 — 50–70% stenosis, 3 — greater than 70% stenosis of the coronary artery luminal diameter. Stenosis greater than 50% of the luminal diameter was considered haemodynamically significant in coronary angiography. Also the number of coronary vessels with significant stenosis was analysed.

Analysis of clinical data for long-term evaluation

The patients were evaluated at the beginning and at the end of the evaluation period. The average evaluation period covered 43.2 ± 30.8 months. The occurrence of cardiovascular events was analysed, and a cardiovascular event was defined as: percutaneous coronary angioplasty or coronary artery bypass graft surgery, myocardial infarction, cardiac arrest, death, cerebral stroke, transient cerebral ischemic episode, percutaneous vascular procedures and vascular surgeries on non-coronary arteries, implantation of cardiac stimulation systems.

Statistical analysis

Individual numerical values were presented as an average \pm standard deviation. The classic t-Student for independent sample tests was used to determine the significance of differences between average values. Two groups of data, collected according to the unrelated data model, were compared on an ordinal scale using the Mann-Whitney test described by Santner and Duffy. The survival assessment was based on the Kaplan-Meier estimator and the log-rank test was used to compare the data. Each clinical factor was evaluated in terms of prognostic value based on the Cox regression model. To evaluate the independent prognostic value of the analysed parameters a multiple factor analysis was performed together with a discriminant analysis which belongs to multidimensional scaling methods. The value $p < 0.05$ was assumed as statistically significant [13].

Results

The clinical profile of the study population is shown in Table 1.

Myocardial perfusion scintigraphy was performed for all the patients, but in the case of 49 patients it was carried out both stress test and in resting condition, and in the case of 66 patients the examination in resting condition was not carried out at all on account of normal perfusion results in the ECG stress test. Perfusion disorders were determined for 26 patients: in 6 patients the changes were observed in 1 segment, in 13 — 2 segments, in 5 — 3 segments and in 2 patients — 4 segments. In 14 patients perfusion disorders showed moderate reversibility and in 12 patients significant reversibility. Positive perfusion scintigraphy results were obtained for 20 patients (17.4%). All the patients had normal rate of ejection fraction as well as end-systolic and end-diastolic volumes.

Table 1. Clinical profile of the study population

	n = 115
Age (years)	58.08 \pm 8.8
Arterial hypertension	76 (66.1%)
Type 2 diabetes	6 (5.2%)
Hyperlipidaemia	74 (64.3%)
BMI	26.95 \pm 3.67
Metabolic syndrome	44 (38.3%)
Smoking	51 (44.3%)
Physical activity	
Low	32 (27.8%)
Moderate	72 (62.6%)
High	11 (9.6%)
Positive family history	40 (34.8%)
Chest pain	
Non-coronary	48 (41.7%)
Atypical	41 (35.7%)
Typical	26 (22.6%)
CCS:	
I	2 (1.7%)
II	23 (20%)
III	1 (0.9%)
Other problems	28 (24.3%)
Score risk \geq 5%/10 years	5.11 \pm 4.86
	45 (39.1%)
Pre-test (%)*	36.77 \pm 29.8

*Pre-test probability of coronary artery disease

58 women underwent both myocardial perfusion scintigraphy and coronary angiography. The decision regarding coronary angiography was based mainly on the clinical picture, taking into particular consideration persistent chest pain in the case of patients with positive results of myocardial perfusion scintigraphy. Positive coronary angiography results were obtained for 17 patients (29.3%). The average stenosis of the luminal diameter was 0.91 ± 1.23 and the average number of involved coronary vessels 0.62 ± 0.89 .

Analysis by cardiovascular events

The average evaluation period covered 43.2 ± 30.8 months. During the evaluation period 13 cardiovascular events (11.3% of the population) occurred, including: 8 percutaneous coronary angioplasty procedures, 4 coronary artery bypass graft surgeries, 1 cerebral stroke.

The patients were qualified for revascularisation procedures based on their clinical picture (chest pain) and results of additional tests (positive result of coronary angiography indicative of significant stenosis of coronary arteries and significant reversible perfusion disorders in the regions supplied with blood via the stenosed coronary arteries as observed in myocardial perfusion scintigraphy).

The groups of patients with a positive history of cardiovascular events and those with a negative history of such events were com-

Table 2. Comparison of the clinical data for patients with a negative history of cardiovascular events and those with a positive history of cardiovascular events

Group I	Patients with a negative history of cardiovascular events	Patients with a positive history of cardiovascular events	P
	N = 102	N = 13	
Age (years)	57.39 ± 8.86	63.46 ± 6.63	<0.02
Arterial hypertension	65 (63.7%)	11 (84.62%)	Not significant
Type 2 diabetes	3 (2.9%)	3 (23.1%)	< 0.0001
Hyperlipidaemia	69 (67.6%)	5 (38.5%)	Not significant
BMI	26.97 ± 3.68	26.77 ± 3.70	Not significant
Metabolic syndrome	40 (39.2%)	4 (30.8%)	Not significant
Smoking	43 (42.2%)	8 (61.54%)	Not significant
Physical activity			Not significant
Low	29 (28.4%)	3 (23.1%)	
Moderate	63 (61.8%)	9 (69.2%)	
High	10 (9.8%)	1 (7.7%)	
Positive family history	33 (32.4%)	7 (53.8%)	Not significant
Chest pain			< 0.001
Non-coronary	47 (46.1%)	1 (7.7%)	
Atypical	37 (36.3%)	4 (30.8%)	
Typical	18 (17.6%)	8 (61.5%)	
CCS:			< 0.001
I	2 (2.0%)	0 (0.0%)	
II	16 (15.6%)	7 (53.8%)	
III	0 (0.0%)	1 (7.7%)	
Other problems	27 (26.5%)	1 (7.79%)	Not significant
Score risk ≥ 5%/10 years	4.62 ± 4.62	9.0 ± 5.13	< 0.001
	35 (34.3%)	10 (76.9%)	< 0.01
Pre-test (%)*	32.62 ± 28.08	69.28 ± 22.41	< 0.0001

*Pre-test probability of coronary artery disease

Table 3. Comparison of stress test results for patients with a negative history of cardiovascular events and those with a positive history of cardiovascular events

ECG stress test	Patients with a negative history of cardiovascular events	Patients with a positive history of cardiovascular events	P
	N = 102	N = 13	
Duration of stress test (min)	5.73 ± 2.52	4.52 ± 1.94	Not significant
Number of achieved mets	7.87 ± 2.95	4.45 ± 1.36	< 0.001
Number of stress test stages	2.31 ± 0.88	1.83 ± 0.41	Not significant
Maximum heart rate during stress test (min)	153.85 ± 22.78	132.4 ± 9.71	< 0.01
% of the predicted maximum heart rate	95.49 ± 13.53	87.4 ± 6.96	Not significant
HRR*	38.23 ± 23.91	25.0 ± 3.0	< 0.01
Post-test (%)**	44.06 ± 29.53	80.46 ± 17.83	< 0.0001

*Heart rate recovery; **post-test probability of coronary artery disease

pared in terms of their clinical data and the results of the stress test, myocardial perfusion scintigraphy and coronary angiography. The results of the analysis are shown in Tables 2–4.

Table 2. The patients with a positive history of cardiovascular events were older to a statistically significant extent and considerably more often diagnosed with Type 2 diabetes. Typical chest

pain was observed more frequently to a statistically significant degree in the patients s/p cardiovascular events compared to those with a negative history of such events. The CCS level was also significantly higher in the group s/p cardiovascular events. Non-coronary problems were observed more frequently in the group with a negative history of cardiovascular events. Both the

Table 4. Comparison of myocardial perfusion scintigraphy and coronary angiography results for patients with a negative history of cardiovascular events and those with a positive history of cardiovascular events

	Patients with a negative history of cardiovascular events N = 102	Patients with a positive history of cardiovascular events N = 13	P
Positive scintigraphy results	7 (6.9%)	13 (100%)	< 0.0001
Magnitude	0.2 ± 0.55	2.0 ± 0.0	< 0.0001
Intensity	0.15 ± 0.41	1.77 ± 0.44	< 0.0001
Positive coronary angiography results	5 (11.1%) [†]	12 (92.3%)	< 0.0001
Degree of luminal diameter stenosis	0.4 ± 0.75	2.69 ± 0.85	< 0.0001
Number of involved vessels	0.29 ± 0.5	1.77 ± 1.01	< 0.0001

[†]n = 45

Table 5. Comparison of the prognostic value of myocardial perfusion scintigraphy and coronary angiography

	Myocardial perfusion scintigraphy	Coronary angiography
Prognostic value of results in predicting cardiovascular events		
Sensitivity	100%	92.3%
Specificity	93.1%	88.9%
Predictive value of positive results	65%	70.6%
Predictive value of negative results	100%	97.6%
Accuracy of results in predicting cardiovascular events	93.9%	89.7%

risk of cardiovascular events evaluated according to the SCORE scale and the pre-test probability of coronary artery disease were to a statistically significant degree higher in the group with a positive history of cardiovascular events compared to the group with a negative history of such events.

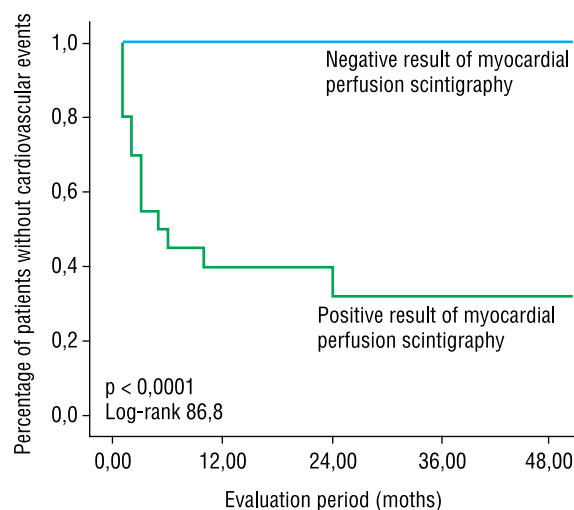
Table 3. The number of the achieved metabolic equivalents and the maximum heart rate were significantly lower in the group with a positive history of cardiovascular events compared to the group with a negative history of such events. The HRR value was significantly lower in the group with a positive history of cardiovascular events. The post-test probability of coronary artery disease was to a statistically significant extent higher in the group with a positive history of cardiovascular events compared to the group with a negative history of such events.

Table 4. Positive results of myocardial perfusion scintigraphy and coronary angiography were observed more frequently in the group with a positive history of cardiovascular events.

Based on the conducted analyses the prognostic value of myocardial perfusion scintigraphy and coronary angiography in predicting cardiovascular events was calculated. The results are shown in Table 5.

Table 5. The analysis of survival without cardiovascular events depending on the results of myocardial perfusion scintigraphy and coronary angiography was carried out. The results of the survival analysis are shown in Figures 1 and 2.

Figure 1. Negative results of myocardial perfusion scintigraphy were obtained for 95 patients (82.6%) and positive results for 20 patients (17.4%). In the group with negative results of myocardial perfusion scintigraphy no cardiovascular events were observed. In the group with positive scintigraphy results only 35% suffered no cardiovascular events. The average survival period without

**Figure 1.** Survival curves without cardiovascular events for patients with negative and positive results of myocardial perfusion scintigraphy

cardiovascular events in the group with positive scintigraphy results was 20.55±32.07 months.

Figure 2. Negative results of coronary angiography were obtained for 41 patients (70.7%) and positive results for 17 patients (29.3%). In the group with negative results of coronary angiography no cardiovascular events were observed in 97.6% of the patients and in the group with positive results of coronary angiography 29.4% of the patients suffered no cardiovascular events. Positive results of coronary angiography were correlated with shorter time — to a statistically significant degree — to the occurrence of a cardiovascular event ($p < 0.0001$). The average

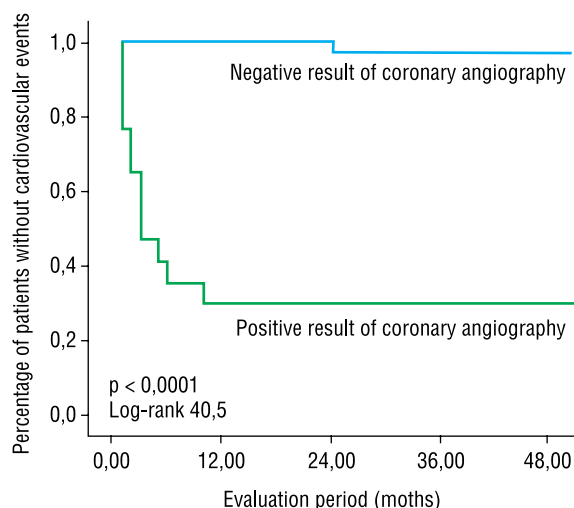


Figure 2. Survival curves without cardiovascular events for patients with negative and positive results of coronary angiography

time to the occurrence of an event in the group with negative results was 54.98 ± 33.35 and in the group with positive results 15.76 ± 30.2 months. Both in the case of scintigraphy and coronary angiography survival curves without cardiovascular events become separated at an early stage and enable good differentiation of the population in terms of the higher risk of cardiovascular events. It is noticeable that in the group with negative results of myocardial perfusion scintigraphy no patients were observed to have cardiovascular events. The comparative analysis demonstrated that myocardial perfusion scintigraphy had a higher value compared to coronary angiography for the evaluation of survival without cardiovascular events ($\chi^2 = 9.39$; $p < 0.01$).

The statistical power of each component of the patients' evaluation was compared with the suspicion of coronary artery disease in terms of the best prognosis of cardiovascular events. The results of the analysis are shown in Figure 3.

Figure 3. Based on the analysis it was demonstrated that the major factors contributing to the higher probability of cardiovascular events included diagnosed Type 2 diabetes ($\chi^2 = 9.45$;

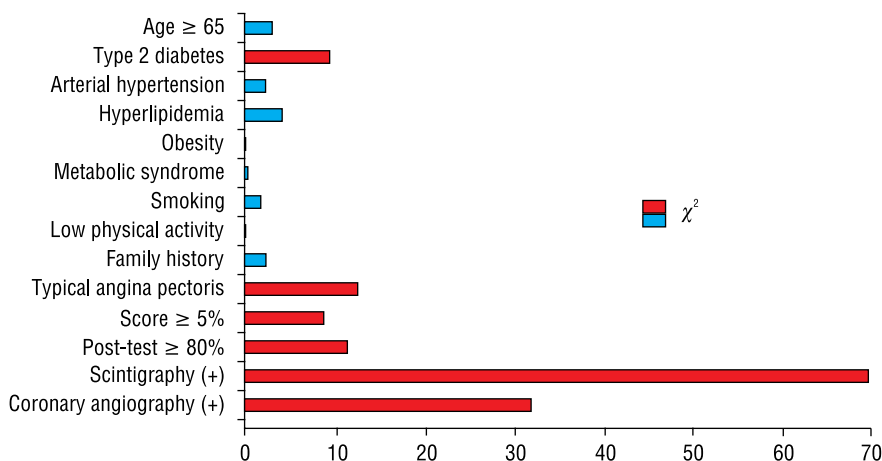


Figure 3. Statistical power (χ^2) for the components of evaluation of the patients suspected of CAD in predicting cardiovascular events. Statistically significant parameters are shown in red

$p < 0.05$) and also the determined high risk of cardiovascular events evaluated according to the SCORE scale ($\chi^2 = 8.79$; $p < 0.05$ for SCORE $\geq 5\%$) as well as high post-test probability of coronary artery disease calculated according to the recommendations of the European Society of Cardiology ($\chi^2 = 11.42$; $p < 0.05$ for POST-TEST $\geq 80\%$). The determination of typical chest pain appeared to be of substantial importance ($\chi^2 = 12.69$; $p < 0.001$). However, the highest statistical power was determined for a positive result of myocardial perfusion scintigraphy ($\chi^2 = 69.92$; $p < 0.0001$) and a positive result of coronary angiography ($\chi^2 = 32.09$; $p < 0.0001$).

The multiple factor analysis showed that the presence of Type 2 diabetes (tolerance 0.77) and SCORE value (tolerance 0.39) have an independent prognostic value in predicting cardiovascular events in the study population, and also the CCS class (tolerance 0.04) and the presence of typical angina pectoris (tolerance 0.03) contribute to a small, although significant extent to the discrimination process.

Discussion

The study showed that myocardial perfusion scintigraphy is highly sensitive (100%) and specific (93.1%) in predicting cardiovascular events which included mostly revascularisation procedures in the study population. The analysis of survival showed that a negative scintigraphy result guarantees very good prognosis in the case of the patients suspected of CAD as no patients with negative scintigraphy results were observed to have cardiovascular events, including any necessary revascularisation procedures, which contributes to a 100% predictive value of negative scintigraphy results. Metz et al. [14], in a meta-analysis aimed at summarising the prognostic value of myocardial perfusion scintigraphy for patients suspected of CAD, demonstrated that the predictive value of negative results of this examination was extremely high, regardless of patient's sex and received medication, and equal to 98.8%. Thus, results obtained in this study are consistent with the calculations carried out in the meta-analysis referred to above.

Performance of coronary angiography in the case of patients diagnosed with coronary artery disease makes it possible

to enhance the risk stratification with an additional prognostic value attributable to the intensity and magnitude of atherosclerotic changes in coronary arteries. Since the publication of the Coronary Artery Surgery Study (CASS) results [15], coronary angiography has continued to be the gold standard in the evaluation of patients suspected of CAD, however more and more often its prognostic value is considered disputable, especially in the context of CAD in the female population. In the WISE study [7] it was demonstrated that a non-pathological result of coronary angiography is not correlated with good prognosis in the female population. In the study conducted by Sharaf et al. [6] 9.4% of women without significant changes in coronary arteries confirmed during angiography died or suffered non-fatal myocardial infarction over the following 4 years. However, in this study, contrary to the WISE study, it was shown that coronary angiography has a high prognostic value in predicting cardiovascular events which can be explained by the fact that the women included in the WISE study belonged to American population which according to epidemiological surveys is subject to greater exposure due to cardiovascular diseases [16]. A more probable reason for the higher prognostic value of coronary angiography can be the fact that the end points of the evaluation period in this study were mostly revascularisation procedures. It seems that the evaluation period in this study was too short for a full assessment of long-term prognosis in the case of patients with significant changes in coronary arteries and for definite confirmation of the predictive value of both positive and negative results of coronary angiography for such hard end points as myocardial infarction and cardiovascular death.

The assessment of survival without cardiovascular events in the study population with positive ECG stress test results was indicative of high prognostic value of negative results of both myocardial perfusion scintigraphy and coronary angiography. However, the comparative analysis would suggest that myocardial perfusion scintigraphy, and in particular a negative result thereof, has a higher prognostic value in predicting cardiovascular events than coronary angiography. This fact is especially significant in the case of patients suspected of coronary artery disease for whom the observed end points were mostly revascularisation procedures. In the material in this study it was shown that if no stress-induced myocardial ischemia was observed in the functional examination, e.g. perfusion imaging, then despite the determined significant coronary stenosis no revascularisation was performed and more importantly, no cardiovascular events were reported in the case of these patients. Similar results were obtained in the study of Nallamothu et al. [17] in which 2700 patients suspected of CAD underwent myocardial perfusion scintigraphy and it was determined that the lack of perfusion disorders was correlated to a statistically significant extent with lower percentage of both serious cardiovascular complications and necessary revascularisation procedures. In the Polish study [11] it was also demonstrated based on a group of 174 patients suspected of CAD that scintigraphy is more useful compared to coronary angiography in evaluating the risk of future cardiovascular events, however no analysis of sex-related differences in the prognostic value of isotopic examination was performed for the study population.

In the Economics of Myocardial Perfusion Imaging in Europe (EMPIRE) study [18] the authors showed that myocardial perfusion

scintigraphy in the case of patients suspected of CAD enables not only accurate determination of diagnosis and prognosis, but also contributes to reducing costs as a result of the elimination of an unnecessary invasive procedure. However, in the Polish population coronary angiography is used for diagnosing CAD in 22.5% of women suspected thereof, while myocardial perfusion scintigraphy in only 0.8% [19]. This fact can be attributable to relatively high accessibility of invasive procedures, but also to the widely accepted — since the publication of the CASS results [15] — belief that the primary purpose of the evaluation of patients suspected of coronary artery disease is to visualise any coronary artery stenoses. On the other hand the WISE study results [20] indicate that such methodology is unsuccessful when diagnosing coronary artery disease in the female population. Due to the differences in the clinical picture and in the primary diagnostics in this population, for a significant percentage of cases it is difficult to determine correct diagnosis, and thus, to evaluate the risk of cardiovascular complications on an individual basis for each patient. The results obtained in this study confirm the existing diagnostic problems. It would seem plausible that it is necessary to take into consideration all the clinical data to select such a group of female patients for whom, on account of the intensity of symptoms, risk factors and stress test results, performance of coronary angiography would be most beneficial as a result of qualification for possible revascularisation or intensified prevention of future adverse cardiovascular events. It was shown in this study that the following factors are of fundamental importance in the evaluation of patients suspected of coronary artery disease: diagnosed Type 2 diabetes, presence of typical chest pain, evaluation of the cardiovascular risk according to the SCORE scale and the post-test probability of coronary artery disease according to the POST-TEST scale.

Conclusions

The results obtained in this study are indicative of high prognostic value of myocardial perfusion scintigraphy in the case of women with positive ECG stress test results. It was determined that the lack of reversible perfusion disorders implies very good prognosis.

In the population of women suspected of coronary artery disease and with positive ECG stress test result myocardial perfusion scintigraphy is a better predictor of necessary revascularisation compared to coronary angiography.

It was shown in this study that the evaluation of the cardiovascular risk according to the SCORE scale and of the post-test probability of coronary artery disease according to the recommendations of the European Society of Cardiology are of critical importance in the diagnostics and assessment of prognosis in the case of women suspected of coronary artery disease.

References

1. Stramba-Badiale M, Fox K.M, Priori SG et al. Cardiovascular diseases in women: a statement from the policy conference of the European Society of Cardiology. *Eur Heart Journal* 2006; 27: 994–1005.
2. Daly C, Clemens F, Lopez Sendon JL et al. Cardiovascular disease in women. gender differences in the management and clinical outcome of stable angina. *Circulation* 2006; 113: 490–498.

3. Kwok Y, Kim C, Grady D, Segal M, Redberg R. Meta-analysis of exercise testing to detect coronary artery disease in women. *Am J Cardiol* 1999; 83: 660–666.
4. Nowicka A, Wierzbowiecki M, Szymanowska K et al. Elektrokarдиографiczny test wysiłkowy, echokardiograficzna próba z dobutaminą oraz scyntygrafia perfuzyjna Tc99mSPECT w rozpoznawaniu choroby wieńcowej u kobiet. *Folia Cardiol* 2001; 8 (suppl D): D45–D52.
5. Shaw LJ, Bairey Merz CN, Pepine CJ et al. Insights From the NHLBI-Sponsored Women's Ischemia Syndrome Evaluation (WISE) Study. Part I: Gender Differences in Traditional and Novel Risk Factors, Symptom Evaluation, and Gender-Optimized Diagnostic Strategies. *J Am Coll Cardiol* 2006; 47 (suppl 3):4S–20S.
6. Sharaf BL, Shaw L, Johnson BD. Any measurable coronary artery disease identified in women presenting with ischemic chest pain is associated with adverse outcome: findings from the National Heart, Lung, and Blood Institute — sponsored Women's Ischemia Syndrome Evaluation (WISE) study angiographic core laboratory. *J Am Coll Cardiol* 2004, 43 (suppl A): 292 A.
7. Fox K, Garcia MAA, Ardissino D et al. Guidelines on the management of stable angina pectoris. The Task Force on the Management of Stable Angina Pectoris of the European Society of Cardiology. *Eur Heart J* 2006; 27: 1341–1381.
8. Mieres JH, Shaw LJ, Hendel RC et al. American Society of Nuclear Cardiology consensus statement: Task Force on Women and Coronary Artery Disease. The role of myocardial perfusion imaging in the clinical evaluation on coronary artery disease in women. *J Nucl Cardiol* 2003; 10: 95–101.
9. Campeau L. Grading of angina pectoris. *Circulation* 1976; 54: 522–523 (letter).
10. De Backer G, Ambrosioni E, Borch-Johnsen K et al. European guidelines on cardiovascular disease prevention in clinical practice. Third Joint Task Force of European and other Societies on Cardiovascular Disease Prevention in Clinical Practice. *European Journal of Cardiovascular Prevention and Rehabilitation* 2003; 10 suppl 1.
11. Dziuk M. Ocena ryzyka zdarzeń sercowo-naczyniowych na podstawie scyntygrafii perfuzyjnej i tomografii komputerowej. Wydawnictwo Sowa, Warszawa 2005.
12. Kern MJ. Coronary Blood Flow and Myocardial Ischemia. In: Braunwald's heart disease. A textbook of cardiovascular medicine, Seventh Edition. Elsevier Saunders. Philadelphia 2005: 1103–1487.
13. Santner TJ, Duffy DE. The statistical analysis of discrete data. Springer, Berlin 1989.
14. Metz Louise D, Beattie M, Hom R et al. The Prognostic value of Normal Exercise Myocardial Perfusion Imaging and Exercise Echocardiography. A Meta-Analysis. *J Am Coll Cardiol* 2007; 49: 227–237.
15. Emond M, Mock MB, Davis KB et al. Long-term survival of medical treated patients in the Coronary Artery Surgery Study (CASS) Registry. *Circulation* 1994; 90: 2645–2657.
16. von Mering GO, Arant CB, Wessel TR et al. Abnormal coronary vasomotion as a prognostic indicator of cardiovascular events in women: results from the National Heart, Lung, and Blood Institute-sponsored Women's Ischemia Syndrome Evaluation (WISE), *Circulation* 2004; 109: 722–725.
17. Nallamothu N, Pancholy SB, Lee KR, Heo J, Iskandrian AS. Impact of exercise single-photon emission computed tomographic thallium imaging on patient management and outcome. *J Nucl Cardiol* 1995; 2: 334–338.
18. Underwood SR, Godman B, Salyani S, Ogle JR, Ell PJ. Economics of Myocardial Perfusion Imaging in Europe — The EMPIRE study. *Eur Heart J* 1999; 20: 157–166.
19. Głównczyńska R, Pietrasik A, Starczewska ME, Filipiak KJ, Opolski G. Rozpoznawanie choroby wieńcowej w warunkach podstawowej opieki zdrowotnej. *Przew Lek* 2006; 6: 42–45.
20. Bairey Merz CN, Shaw LJ, Reis SE et al. Insights From the NHLBI-Sponsored Women's Ischemia Syndrome Evaluation (WISE) Study. Part II: Gender Differences in Presentation, Diagnosis and Outcome With Regard to Gender-Based Pathophysiology of Atherosclerosis and Macrovascular and Microvascular Coronary Disease. *J Am Coll Cardiol* 2006; 47 (suppl 3): 21S–29S.