

Evaluation of the relations between the presence of the metabolic syndrome and the degree of visceral obesity and the severity of coronary artery disease by coronary angiography

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Abstract

Background: The prevalence of the metabolic syndrome (MetSy) steadily increases worldwide.

Aim: To evaluate the relation between the presence of MetSy and visceral obesity and the presence of coronary lesions, and to assess correlations between waist circumference and body mass index (BMI) and coronary lesions.

Methods: We studied 105 patients who underwent elective coronary angiography. The study population was divided into four groups depending on the presence of MetSy and visceral obesity. Coronary angiographic evaluation was performed by an invasive cardiologist. For ultimate objective evaluation of the degree of coronary stenoses, quantitative coronary angiography was performed. Based upon coronary angiography results, patients were divided into four groups depending on the severity of coronary artery disease (CAD): with no coronary lesions, with haemodynamically insignificant lesions (1–69% stenosis), with haemodynamically significant lesions (> 70%) in 1 or 2 vessels, and with multivessel disease (> 70% stenoses in 3 vessels or a > 50% stenosis in the left main coronary artery).

Results: Normal coronary arteries were significantly more commonly found in patients without obesity and MetSy (50% of patients). Haemodynamically significant lesions were most frequently found among obese patients with MetSy (40% of patients) and among obese patients without MetSy (38.1% of patients). Concomitant presence of obesity among patients with MetSy (i.e., MetSy with obesity as compared to MetSy without obesity) was not found to be significantly related to the severity of CAD. In addition, advanced CAD was significantly more frequent in obese patients with MetSy compared to the other groups. Isolated visceral obesity in patients without MetSy (i.e., obese patients without MetSy as compared to non-obese patients without MetSy) was found to correlate with haemodynamically significant coronary lesions. When we evaluated nonparametric correlations between waist circumference, BMI; and the severity of CAD, BMI did not correlate with coronary lesions ($r = 0.08$, $p = 0.37$). In contrast, a significant correlation was found between waist circumference and the severity of CAD ($r = 0.55$, $p < 0.001$). Haemodynamically significant lesions were more significantly more frequent in patients with MetSy compared to patients without MetSy (76% vs. 24%, $p < 0.001$). Haemodynamically significant lesions were found in 67.7% of patients with isolated visceral obesity compared to 23.2% of non-obese patients without MetSy. In multivariate analysis, CAD was significantly more likely among patients with MetSy regardless of the analysed model (OR 5.3, 95% CI 1.1–25.8, $p < 0.05$).

Conclusions: 1. The presence of MetSy significantly correlates with haemodynamically significant coronary lesions. 2. The degree of visceral obesity significantly correlates with the severity of CAD. 3. BMI does not correlate with the severity of CAD. 4. Isolated visceral obesity is a weaker determinant of haemodynamically significant coronary lesions compared to MetSy with associated obesity. 5. MetSy is associated with significantly more advanced coronary lesions, i.e. multivessel disease.

Key words: metabolic syndrome, visceral obesity, severity of coronary artery disease

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INTRODUCTION

The prevalence of the metabolic syndrome (MetSy) steadily increases worldwide. In the 2001 National Cholesterol Education Program Adult Treatment Panel (NCEP ATP III) guidelines, MetSy was defined as the presence of at least 3 of the following 5 criteria: increased waist circumference, hypertriglyceridaemia or its treatment, low high density lipoprotein (HDL) cholesterol level or its treatment, hypertension or its treatment, and increased fasting glucose level or diabetes treatment. According to the 2005 International Diabetes Federation (IDF) guidelines, MetSy is diagnosed based on the finding of central obesity plus at least 2 of the remaining 4 findings as defined in the NCEP ATP III criteria. A consensus statement on the diagnosis of MetSy was published in 2009 [1], including essentially the same biochemical and clinical criteria as in the NCEP ATP III and IDF guidelines. However, the consensus highlighted the inability to define a clear cut-off value defining abdominal obesity, calling for different definitions depending for geographical region and ethnicity. In Poland, MetSy is estimated to affect 5.8 million people aged 20–74 years, with the prevalence of 23% among men and 20% among women [2]. In The International Day for Evaluation of Abdominal Obesity (IDEA) study, abdominal obesity as defined according to the NCEP ATP III criteria was found in 29% of men and 48% of women [3].

The primary aim of our study was to evaluate relations between the degree of visceral obesity and the presence of MetSy and the severity of coronary artery disease (CAD). Secondary aims of the study included evaluating whether visceral obesity without MetSy is a vascular risk factor that correlates with coronary atherosclerosis similarly to MetSy, whether MetSy is related to multivessel CAD, and to what degree waist circumference and body mass index (BMI) correlate with the severity of CAD.

METHODS

Study group

The study was approved by a local ethics committee at the Medical University of Warsaw. All patients gave written informed consent for the participation in the study. We studied 105 patients with a suspicion of CAD who were admitted for elective coronary angiography to the Department of Cardiology, Hypertension and Internal Diseases, II Faculty of Medicine, at the Medical University of Warsaw.

Inclusion and exclusion criteria

In the present study, we included patients aged 40–70 years without previously confirmed CAD who were referred for coronary angiography due to a suspicion of CAD. Exclusion criteria included urgent coronary angiography due to an acute coronary syndrome (ACS), a history of ACS, concomitant systemic disease that might affect levels of inflammation markers, i.e. chronic connective tissue disease, liver disease, inflammatory renal disease, active infections and infections during

6 weeks prior to study inclusion, chronic obstructive lung disease, previous coronary angiography with a diagnosis of coronary artery stenoses, severe valvular heart disease requiring coronary angiography before surgical treatment, diabetes duration of > 10 years, lacking data on serum lipid levels before initiation of lipid-lowering therapy, and lipid-lowering therapy initiated more than 1 year before the present study.

Study subgroups

The study population was divided into 4 subgroups: patients with MetSy as defined by the NCEP ATP III criteria and visceral obesity (obese MetSy group), patients with MetSy but no visceral obesity (non-obese MetSy group), patient with visceral obesity but no MetSy (obese non-MetSy group), and patients without MetSy and visceral obesity (non-obese non-MetSy group). When coronary angiographic findings were analysed, each subgroup was further subdivided into 4 subsets depending on the severity of CAD categorised based on the degree of coronary stenoses and the number of affected vessels: subjects with no coronary lesions (normal coronary arteries), with haemodynamically insignificant lesions (1–69% stenosis) regardless of the number of affected vessels, with haemodynamically significant lesions (> 70%) in 1 or 2 vessels, and with multivessel CAD (> 70% stenoses in 3 vessels or a > 50% stenosis in the left main coronary artery).

Study conduct

The study was conducted in the period from April 1, 2005, to July 30, 2007. Patients referred for coronary angiography underwent clinical interview, physical examination, and routine laboratory testing. Positive family history was defined as a cardiovascular event in parents or siblings before 65 years of age in women and 55 years of age in men. BMI was calculated as body mass in kg divided by the square of height in cm. In all subjects, waist circumference was measured in fasting conditions using the same standardised procedure at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest. According to the NCEP ATP III criteria, visceral obesity was defined as waist circumference > 88 cm in women and > 102 cm in men. Coronary angiography was performed using standard procedures by an experienced invasive cardiologist. For ultimate objective evaluation of the degree of coronary stenoses, quantitative coronary angiography was performed. The degree of stenosis was expressed as percent vessel lumen reduction. Based on automatic detection of the borders of the arterial lumen opacification (using display greyscale), lumen diameter reduction was calculated by the computer in relation to a reference vessel segment, defined as a normal segment directly adjacent to the evaluated lesion.

Statistical analysis

Statistical analysis was performed using the STATISTICA 7.0.61.0 software (StatSoft, Inc.). Descriptive statistics were

Table 1. Clinical characteristics of the study subgroups

	MetSy (+) Ob (+) N = 40	MetSy (+) Ob (-) N = 10	MetSy (-) Ob (+) N = 21	MetSy (-) Ob (-) N = 43	P
Age [years]	62.5 ± 9.1	56 ± 9.4	58.9 ± 10.3	61.2 ± 8.6	NS
Women	45%	60%	62%	47%	NS
Smoking	9 (22.5%)	4 (40%)	3 (14.3%)	6 (17.6%)	NS
Hypertension	39 (97.5%)	10 (100%)	14 (66.6%)	26 (76.4%)	< 0.05*
Duration of hypertension [years]	11.6 ± 9.8	9.7 ± 7.6	7.5 ± 5.4	11.9 ± 8.9	NS
Diabetes	22 (55%)	3 (30%)	0 (0%)	3 (8.8%)	< 0.05**
Duration of diabetes [years]	5.67 ± 3.6	7.35 ± 3.7	NA	7.33 ± 4.6	NS
Positive family history	21 (52.5%)	6 (60%)	4 (19.05%)	5 (14.7%)	< 0.05***

*p < 0.05 MetSy (+) Ob (-) vs. MetSy (-) Ob (+)

**p < 0.05 MetSy (+) Ob (+) vs. MetSy (-) Ob (+), MetSy (-) Ob (-)

***p < 0.05 MetSy (+) Ob (-) vs. MetSy (-) Ob (-)

MetSy (-) — metabolic syndrome absent; MetSy (+) — metabolic syndrome present; Ob (-) — obesity absent; Ob (+) — obesity present; NA — not applicable; NS — non-significant

Table 2. Drug treatment in the study subgroups

Drug	MetSy (+) Ob (+) N = 40	MetSy (+) Ob (-) N = 10	MetSy (-) Ob (+) N = 21	MetSy (-) Ob (-) N = 43	P
Statin	34 (45.3%)	8 (10.7%)	13 (17.3%)	20 (26.7%)	NS
Fibrate	5 (12.5%)	1 (10%)	1 (4.8%)	2 (5.9%)	NS
ACE inhibitor	33 (82.5%)	10 (100%)	9 (42.9%)	21 (61.8%)	0.001
Sartan	3 (7.5%)	0 (0%)	3 (14.3%)	2 (5.9%)	NS
Beta-blocker	36 (90%)	8 (80%)	15 (71.4%)	24 (70.6%)	NS
Antiplatelet agent	34 (85%)	9 (90%)	15 (71.4%)	18 (52.9%)	0.01
Insulin	10 (25%)	2 (20%)	0 (0%)	2 (5.9%)	0.01
Oral hypoglycemic drug	14 (35%)	2 (20%)	0 (0%)	2 (5.9%)	0.001

MetSy (-) — metabolic syndrome absent; MetSy (+) — metabolic syndrome present; Ob (-) — obesity absent; Ob (+) — obesity present; NS — non-significant

calculated for all variables in study subgroups. Quantitative variables were shown as mean values and standard deviations. Categorical variables were shown as percentages. Normally distributed variables were compared using parametric tests (Student *t* test). Analysis of variance (ANOVA) was used to compare mean values of quantitative variables in more than 2 groups. In case of non-normal variable distribution or nonhomogenous variance, nonparametric tests were used (Kolmogorov-Smirnov or Mann-Whitney test). Categorical variables were compared using the χ^2 test, with Yates' correction for sample sizes of $n < 10$. Relations between variables were evaluated using the Pearson correlation coefficient (for normally distributed variables) or the Spearman correlation coefficient (for non-normally distributed variables or when one of the variables was categorical). Multivariate logistic regression analysis was used to minimize the effect of other potential confounders. In all analyses, $p < 0.05$ was considered statistically significant.

RESULTS

We studied 40 patients in the obese MetSy group, 10 patients in the non-obese MetSy group, 21 patients in the obese non-MetSy group, and 43 patients in the non-obese non-MetSy group. Gender proportions and age did not differ significantly between any of the subgroups. Table 1 shows clinical characteristics of the study group. Hypertension and diabetes type 2 were significantly more common in patients with MetSy. Table 2 summarises drug treatment used in the study subgroups, with no significant differences in the rates of statin, fibrate, sartan, and beta-blocker use. Table 3 shows the severity of coronary atherosclerosis in the study subgroups. Normal coronary arteries were significantly more commonly found in patients without obesity and MetSy (50% of patients). Haemodynamically significant lesions were most frequently found among obese patients with MetSy (40% of patients) and among obese patients without MetSy (38.1% of patients).

Table 3. Severity of coronary artery disease in relation to the presence of metabolic syndrome and obesity

Severity of coronary atherosclerosis	MetSy (+)	MetSy (+)	MetSy (-)	MetSy (-)	P
	Ob (+)	Ob (-)	Ob (+)	Ob (-)	
	N = 40	N = 10	N = 21	N = 43	
Normal coronary arteries (N) ¹	3 (7.5%)	1 (10%)	7 (33.3)	17 (50%)	< 0.001 ¹
Nonsignificant lesions (NSL) ²	4 (10%)	4 (40%)	5 (23.8%)	12 (35.3%)	0.04 ²
Significant lesions (SL) ³	16 (40%)	2 (20%)	8 (38.1%)	3 (8.8%)	0.01 ³
Multivessel disease (MVD) ⁴	17 (42.5%)	3 (30%)	1 (4.7%)	2 (5.9%)	< 0.001 ⁴
(SL+MVD) ⁵	33 (82.5%)	5 (50%)	9 (42.8%)	5 (14.7%)	< 0.001 ⁵

¹p < 0.01 MetSy (+) Ob (+) vs. MetSy (-) Ob (+), MetSy (+) Ob (+) vs. MetSy (-) Ob (-)

²p < 0.01 MetSy (+) Ob (+) vs. MetSy (-) Ob (-)

³p < 0.01 MetSy (+) Ob (+) vs. MetSy (-) Ob (-), MetSy (-) Ob (+) vs. MetSy (-) Ob (-)

⁴p < 0.01 MetSy (+) Ob (+) vs. MetSy (-) Ob (+), MetSy (+) Ob (+) vs. MetSy (-) Ob (-)

⁵p < 0.01 MetSy (+) Ob (+) vs. MetSy (-) Ob (+) MetSy (+) Ob (+) vs. MetSy (-) Ob (-)

Table 4. Mean body mass index (BMI) and waist circumference in relation to the severity of coronary artery disease (CAD)

CAD severity	N	NSL	SL	MVD	P
Waist circumference [cm] ¹	89.1 ± 10.3	95.1 ± 11.4	103.2 ± 9.1	105.23 ± 10.5	< 0.001
BMI [kg/m ²]	28.1 ± 3	28.3 ± 4.2	28.4 ± 3.7	30 ± 5.3	NS

¹p < 0.001 N vs. SL; N vs. MVD; NSL vs. SL; NSL vs. MVD

N — normal coronary arteries; NSL — nonsignificant lesions; SL — significant lesions; MVD — multivessel disease; NS — non-significant

Concomitant presence of obesity among patients with MetSy (i.e., MetSy with obesity as compared to MetSy without obesity) was not found to be significantly related to the severity of CAD. In addition, advanced CAD was significantly more frequent in obese patients with MetSy compared to the other groups. Isolated visceral obesity in patients without MetSy (i.e., obese patients without MetSy as compared to non-obese patients without MetSy) was found to correlate with haemodynamically significant coronary lesions. Table 4 shows mean waist circumference and BMI depending on the number of affected coronary arteries, with significant differences between groups found only for waist circumference. To confirm these findings, we evaluated nonparametric correlations between waist circumference, BMI; and the severity of CAD. In this analysis, BMI did not correlate with CAD severity ($r = 0.08$, $p = 0.37$). In contrast, a significant correlation was found between waist circumference and the severity of CAD ($r = 0.55$, $p < 0.001$; Fig. 1). Haemodynamically significant lesions were more significantly more frequent in patients with MetSy compared to patients without MetSy (76% vs. 24%, $p < 0.001$). Haemodynamically significant lesions were found in 67.7% of patients with isolated visceral obesity compared to 23.2% of non-obese patients without MetSy. We also performed multivariate logistic regression analysis using appropriate statistical models including established risk factors for CAD that might confound our findings. The calculated odds ratio (OR) described the strength of the association between significant CAD and MetSy or visceral obesity. Significant CAD was defined as haemodynamically significant coronary lesions (stenosis > 70%) or multivessel disease. As shown in Table 5,

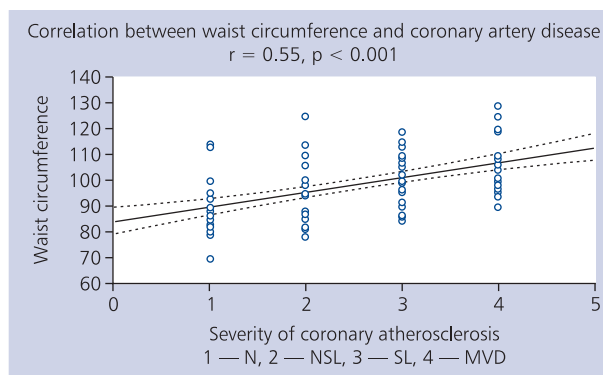


Figure 1. A significant nonparametric correlation ($r = 0.55$, $p < 0.001$) between waist circumference and the severity of coronary artery disease; N — normal coronary arteries; NSL — nonsignificant lesions; SL — significant lesions; MVD — multivessel disease

CAD was significantly more likely among patients with MetSy regardless of the analysed model. A similar approach was used for waist circumference. Table 6 shows a significant association between waist circumference and CAD in all evaluated models. In similar models constructed for BMI, the probability of CAD was not found to increase with rising BMI values (Table 7).

DISCUSSION

In our study group, hypertension and diabetes were more frequent among obese patients with MetSy, likely due to the fact that both conditions are among the criteria for MetSy. Some authors (e.g., Kahn et al. [4]) are sceptical towards

Table 5. Probability of coronary artery disease (CAD) in patients with metabolic syndrome

Metabolic syndrome	MODEL 1 ¹ (CAD) OR (95% CI), p	MODEL 2 ² OR (95% CI), p	MODEL 3 ³ OR (95% CI), p	MODEL 4 ⁴ OR (95% CI), p
Risk of CAD	5.58 (1.8–16.6), p = 0.002	6.08 (1.9–18.7), p = 0.002	6.02 (2.2–34.7), p = 0.002	5.3 (1.1–25.8), p = 0.03

¹adjusted for age, gender, body mass index, and family history²adjusted for variables as in Model 1 + smoking³adjusted for variables as in Model 2 + hypertension and diabetes⁴adjusted for variables as in Model 3 + triglycerides, HDL cholesterol, and LDL cholesterol

CI — confidence interval; OR — odds ratio

Table 6. Probability of coronary artery disease (CAD) in relation to waist circumference

Waist circumference	MODEL 1 ¹ OR per 1 cm OR (95% CI), p	MODEL 2 ² OR (95% CI), p	MODEL 3 ³ OR (95% CI), p	MODEL 4 ⁴ OR (95% CI), p
Risk of CAD	1.23 (1.1–1.3), p < 0.001	1.19 (1.09–1.4), p < 0.001	1.21 (1.1–1.3), p < 0.001	1.19 (1.1–1.4), p < 0.001

¹adjusted for age, gender, body mass index, and family history²adjusted for variables as in Model 1 + smoking³adjusted for variables as in Model 2 + hypertension and diabetes⁴adjusted for variables as in Model 3 + triglycerides, HDL cholesterol, and LDL cholesterol

CI — confidence interval; OR — odds ratio

Table 7. Probability of coronary artery disease (CAD) in relation to body mass index

Body mass index	MODEL 1 ¹ OR per 1 kg/m ² OR (95% CI), p	MODEL 2 ² OR (95% CI), p	MODEL 3 ³ OR (95% CI), p	MODEL 4 ⁴ OR (95% CI), p
Risk of CAD	1.01 (0.98–1.1), p = NS	1.03 (1.02–1.09), p = NS	0.99 (0.98–1.11), p = NS	1.06 (0.99–1.1), p = NS

¹adjusted for age, gender, body mass index, and family history²adjusted for variables as in Model 1 + smoking³adjusted for variables as in Model 2 + hypertension and diabetes⁴adjusted for variables as in Model 3 + triglycerides, HDL cholesterol, and LDL cholesterol

CI — confidence interval; OR — odds ratio; NS — non-significant

the current definition of MetSy, arguing that established diabetes type 2 should not be a component of this definition. Diabetes type 2 is a significant cardiovascular risk factor by itself and in these patients, the diagnosis of MetSy does not add any new clinically useful information and does not result in any treatment changes [4]. A number of studies showed that among patients with essential hypertension, MetSy is significantly more common compared to the general population [5–7]. Angiotensin-converting enzyme inhibitors were more frequently used in patients with MetSy, both obese and non-obese, likely due to the same reasons as discussed above.

Some authors question the appropriateness of diagnosing MetSy due to its large variability in the general population due to both varying genetic determinants and variable gene expression in response to a range of environmental factors. In 2005, Kahn et al. [4] published a critical appraisal of the MetSy, mainly focusing on the actual relation between the diagnosis of MetSy and the risk of cardiovascular disease. One study that evaluated the relation between MetSy and coronary atherosclerosis was the analysis by Hitsumoto et al. [8] who evaluated the association of MetSy with early coronary

atherosclerotic plaques and their characteristics in 70 patients found to have normal coronary arteries by coronary angiography, subsequently verified by intravascular ultrasound. In this study, it was shown that all parameters of MetSy affected the characteristics of coronary plaques. In addition, coronary atherosclerotic plaques in patients with MetSy were found to be larger, more eccentric, and more lipid-laden. Olijhoek et al. [9] studied the severity of atherosclerotic process in relation to the presence of MetSy in patients with established cardiovascular disease, using carotid intima-media thickness (IMT) measurements. Patients with MetSy were found to have increased carotid IMT (0.98 vs. 0.92 mm, $p < 0.01$). In the study by Aleksander et al. [10], the prevalence of CAD was 8.7% in patients with no MetSy and no diabetes, 7.5% in patients with diabetes only ($p < 0.05$), 13.9% in patients with MetSy only, and as much as 19% in patients with both MetSy and diabetes. Negative findings regarding the effect of MetSt on the rate and severity of CAD were reported by Judith [11] who evaluated a female population and found that MetSy was not an independent predictor of progression of atherosclerosis. Timoteo et al. [12] studied 270 patients

admitted for elective coronary angiography, evaluating the relation between MetSy defined using the IDF criteria and the severity of atherosclerosis based on angiographic findings and IMT measurements. No significant difference in the rate of CAD was found in relation to the presence of MetSy; patients with or without MetSy also did not differ by carotid IMT (0.97 mm vs. 0.96 mm). In the study by Carlos [13], when age, education, smoking, alcohol abuse, and BMI were taken into account, MetSy without diabetes was associated with a nearly 5-fold increased risk of incident CAD (OR 4.95, 95% CI 3.4–8.05), and MetSy with diabetes was associated with 8-fold increased risk (OR 8.00, 95% CI 4.39–14.6). These associations were not observed, however, when components of MetSy were independently included into the model. The authors concluded that MetSy did not seem to be a better predictor of CAD than the sum of its components. In a Polish study in 141 men aged below 55 years, no difference in the number of stenosed coronary arteries and the severity of atherosclerosis was found between groups with and without MetSy [14]. In a smaller study, significant differences in the severity of CAD were found between the evaluated subgroups. Normal coronary angiographic findings were characteristic for patients with no MetSy, including those with “isolated” visceral obesity. The most advanced CAD was found in patients with MetSy, both with or without visceral obesity. No significant difference in the severity of atherosclerosis between subgroups with MetSy and visceral obesity and with MetSy without visceral obesity may suggest that MetSy, regardless of the presence of visceral obesity, correlates with the severity of CAD more strongly than waist circumference. On the other hand, the fact that among subjects without MetSy, haemodynamically significant lesions were found more frequently in patients with visceral obesity than in those with neither MetSy nor visceral obesity may suggest that visceral obesity precedes the development of MetSy. In apparently healthy subjects, it has an adverse effect on vascular endothelium, promoting atherogenesis. The results of our multivariate analysis seem to confirm this hypothesis.

Debate continues which parameter of obesity, BMI or waist circumference, correlates better with the severity of coronary atherosclerosis. This issue was evaluated in several studies. The IDEA study showed that visceral obesity, as defined by waist circumference, was linearly related to the incidence of CAD regardless of BMI. A more critical view on the value of visceral obesity as an independent risk factor for CAD was provided by another study published in 2007. In this analysis, waist circumference was associated with an increased risk of diabetes (OR 5.03, 95% CI 2.8–8.8, $p < 0.05$) but not cardiovascular disease, when conventional risk factors were taken into account, and BMI was not related to the risk of either diabetes or cardiovascular disease [15]. Rexrode et al. [16] studied the relation between abdominal obesity and CAD in women aged 45–65 years. Among women with

waist circumference > 96.5 cm, the relative risk of CAD was 3.06 (95% CI 1.54–6.10) compared to women without visceral obesity (waist circumference < 71.1 cm). In this study, BMI was not significantly related to the incidence of CAD. Also in the INTERHEART study, BMI had no significant effect on the risk of myocardial infarction after adjustment for other conventional risk factors for CAD. In this study, both waist circumference and waist-to-hip ratio (WHR) were found to be related to the risk of myocardial infarction after adjustment for confounders (OR 1.33 and 1.75, respectively, $p < 0.00115$). In the present study, a significant association between waist circumference and the severity of coronary atherosclerosis was found in the overall study population ($r = 0.55$, $p < 0.001$), which was not found for BMI. In all statistical models used, a unit increase in waist circumference was associated with an approximately 20% increase in the probability of CAD.

Until now, few studies in the literature directly evaluated the relation between waist circumference and angiographically confirmed CAD. Most clinical studies evaluated endpoints of fatal or non-fatal coronary event in relation to visceral obesity or BMI, the 2 parameters being often considered categorical variables. In the above cited study by Rexrode et al. [16], waist circumference was treated as continuous variable and had a significant effect on the risk of incident CAD which increased by about 30% per each 1 inch (2.5 cm) increase in waist circumference [17]. In the study by Kortelainen et al. [18], anthropomorphic parameters were related to the severity of CAD as evaluated by autopsy in men aged more than 40 years who died from non-cardiac causes. When adjusted for age, the degree of left and right coronary artery stenosis was found to correlate with WHR ($r = 0.46$, $p < 0.01$). In contrast, no significant relation was found between the severity of CAD and BMI [18]. In the study by Hauner et al. [19], WHR was found an independent predictor of atherosclerotic lesions when body mass, HDL cholesterol, triglyceride level, and hypertension were taken into account ($p = 0.01$). In our study, a different definition of visceral obesity was used, patients with previous myocardial infarction were excluded, and haemodynamically significant coronary lesions were defined as 70% stenosis, which likely explains a lower proportion of patients with angiographically confirmed CAD (49% vs. 72.4% in the study by Hauner et al. [19]). Despite these differences, our findings and findings by Hauner et al. [19] are similar, suggesting that waist circumference may be a predictor of haemodynamically significant coronary lesions.

Currently, BMI is the obesity parameter which is most commonly used to evaluate cardiovascular risk, although obesity is defined by the World Health Organisation as body fat percentage of $> 25\%$ in men and $> 35\%$ in women. As shown in several studies, BMI may not be an accurate measure of the actual body fat content. Some studies showed better outcomes in patients with CAD and slightly increased BMI, the phenomenon which has become known as the

obesity paradox. During a 2-year follow-up in the study by Uretsky et al. [20], death, myocardial infarction, and stroke were less frequent in subjects with overweight and obesity compared to those with normal body mass. In the study by Zeller et al. [21], a unit increase in BMI was associated with a 5% reduction in mortality risk during 1 year of follow-up, but this association was lost when other variables were taken into account. In the present study, BMI was not related to the severity of CAD. Similar results were reported by Niraj et al. [22]. This may be explained by the fact that BMI is not an accurate measure of the relationship between body fat and lean body mass (LBM), factors that exert opposing effects on prognosis in patients with CAD. Of note, patients with CAD are usually older and characterised by lower LBM, which may result in misleadingly “normal” BMI values in subjects with actual excess of body fat. This mechanism may explain apparently discordant results of epidemiological studies on the relation between mildly elevated BMI and cardiovascular events. BMI is a measure of both body fat and LBM (the latter being associated with fitness) and thus patients with low muscle mass and moderately increased body fat percentage may show normal BMI despite excess fat. On the other hand, patients with CAD, particularly those physically active and thus with high muscle mass and low body fat percentage, may be miscategorised as overweight based on increased BMI [23]. Our findings indicate that waist circumference should be more widely used in clinical practice, and it is justified to include its measurements as a part of routine physical examination.

CONCLUSIONS

1. The presence of MetSy significantly correlates with haemodynamically significant coronary lesions.
2. The degree of visceral obesity significantly correlates with the severity of CAD.
3. BMI does not correlate with the severity of CAD.
4. Isolated visceral obesity is a weaker determinant of haemodynamically significant coronary lesions compared to MetSy with associated obesity.
5. MetSy is associated with significantly more advanced coronary lesions, i.e. multivessel CAD.

Conflict of interest: none declared

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Ocena związku obecności zespołu metabolicznego i stopnia otyłości trzewnej z zaawansowaniem choroby wieńcowej w koronarografii

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Streszczenie

Wstęp: Częstość występowania zespołu metabolicznego (MetSy) rośnie systematycznie na całym świecie.

Cel: Celem badania była ocena związku występowania MetSy i otyłości trzewnej z obecnością zmian w naczyniach wieńcowych oraz ocena stopnia korelacji obwodu pasa i wskaźnika masy ciała (BMI) ze zmianami w naczyniach wieńcowych.

Metody: Do badania włączono 105 pacjentów, u których wykonano koronarografię w trybie planowym. Populację podzielono na 4 podgrupy: w zależności od obecności MetSy i otyłości trzewnej. Oceny angiograficznej dokonywał kardiolog inwazyjny. W celu ostatecznej obiektywizacji stopnia zwężenia zmian w naczyniach wieńcowych przeprowadzono analizę ilościową metodą cyfrowej angiografii ilościowej (QCA). Po przeanalizowaniu wyników koronarografii zmiany w naczyniach wieńcowych podzielono na 4 grupy zaawansowania choroby wieńcowej (CAD): bez zmian w naczyniach wieńcowych, ze zmianami nieistotnymi hemodynamicznie (% zwężenia: 1–69%), ze zmianami istotnymi hemodynamicznie (> 70%), w 1 lub 2 naczyniach, osoby z chorobą wielonaczyniową (zmiany > 70% w 3 naczyniach lub 1 zwężenie pnia lewej tętnicy wieńcowej > 50%).

Wyniki: Prawidłowy obraz naczyń wieńcowych istotnie częściej stwierdzano w grupie bez otyłości i bez MetSy — u 50% badanych. Zmiany istotne hemodynamicznie najczęściej obserwowano w grupie z MetSy z otyłością (40,0%) oraz w grupie osób otyłych bez MetSy (38,1%). Wykazano, że współwystąpienie otyłości w grupie z MetSy (MetSy z otyłością vs. MetSy bez otyłości) nie wiąże się znamienne statystycznie z zaawansowaniem miażdżycy naczyń wieńcowych. Ponadto w grupie z MetSy z otyłością istotnie częściej stwierdzano zaawansowaną miażdżycę niż w pozostałych grupach. Izolowana otyłość wisceralna u osób bez MetSy (osoby otyłe bez MetSy vs. nieotyłe bez MetSy) koreluje z wystąpieniem zmian miażdżycowych istotnych hemodynamicznie w koronarografii. W teście korelacji nieparametrycznej między obwodem talii, BMI a zaawansowaniem CAD dla zmiennych BMI vs. zaawansowanie CAD nie wykazano istotnego związku ($r = 0,08$; $p = 0,37$). Natomiast dla modelu obwód talii vs. zaawansowanie CAD korelacja była znamienna statystycznie ($r = 0,55$; $p < 0,001$). W analizie statystycznej opartej na teście χ^2 wykazano przewagę obecności zmian istotnych hemodynamicznie wśród osób z MetSy vs. osób bez MetSy (odpowiednio 76% vs. 24%; $p < 0,001$). Wśród pacjentów z izolowaną otyłością trzewną odsetek chorych z istotnymi hemodynamicznie zmianami wynosił 67,7% vs. osoby bez MetSy i bez otyłości trzewnej — 23,2%. Wyniki analizy wieloczynnikowej wskazują na istotne statystycznie zwiększenie prawdopodobieństwa stwierdzenia CAD wśród pacjentów z rozpoznaniem MetSy bez względu na analizowany model (OR 5,3; 95% CI 1,1–25,8; $p < 0,05$).

Wnioski: 1. Występowanie MetSy jest znamienne skorelowane z obecnością istotnych zmian miażdżycowych w tętnicach wieńcowych. 2. Wielkość otyłości trzewnej w istotny sposób koreluje ze stopniem zaawansowania zmian w tętnicach wieńcowych. 3. Wartość BMI nie wiąże się ze stopniem zaawansowania zmian w tętnicach wieńcowych. 4. Izolowana otyłość trzewna w mniejszym stopniu warunkuje obecność istotnych zwężeń w tętnicach wieńcowych w porównaniu z rozpoznaniem MetSy skojarzonego z otyłością. 5. Zespół metaboliczny wiąże się ze znamienne większym zaawansowaniem zmian w tętnicach wieńcowych pod postacią obecności wielonaczyniowej CAD.

Słowa kluczowe: zespół metaboliczny, otyłość trzewna, zaawansowanie choroby wieńcowej

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