Original article

Endothelial function in patients with chest pain and normal coronary angiograms

Zofia Grąbczewska[1], Maciej Thews[2], Krzysztof Góralczyk[3], Jacek Kubica[1]

[1] Chair and Department of Cardiology and Internal Diseases, A. Jurasz University Hospital, Bydgoszcz, Poland
[2] Chair and Department of General and Vascular Surgery, A. Jurasz University Hospital, Bydgoszcz, Poland
[3] Chair and Department of Pathophysiology, *Collegium Medicum*, Nicolaus Copernicus University, Toruń, Poland

Abstract

Background: A normal coronary angiogram is found in about 20% of patients who undergo coronary angiography due to chest pain. In some of them syndrome X is diagnosed. Endothelial dysfunction is one possible cause of this pathology.

Aim: To compare the endothelial function estimated by two different methods in patients with typical or atypical anginal pain and with no chest pain.

Methods: Fifty-three patients who underwent coronary angiography due to suspected coronary artery disease and who had a normal coronary angiogram were included in the study: 34 patients had typical anginal pain (group 1) and 19 patients had atypical chest pain (group 2). The control group consisted with 20 subjects without chest pain. The plasma concentration of such endothelial markers as von Willebrand factor (vWF), thrombomodulin (TM), endothelin 1 (ET-1), tissue plasminogen activator (tPA), plasminogen activator inhibitor type 1 (PAI-1) and C-reactive protein were measured. We also determined endothelial-dependent brachial arterial dilatation (flow-mediated dilation, FMD).

Results: The groups of patients were different with regard to the factors of known effects on endothelial function but endothelial markers were not different in all groups with two exceptions. The concentration of tPA was the highest in patients with typical chest pain and the concentration of PAI-1 was the highest in patients without chest pain. The FMD values were low in all patients and there were no significant differences in the FMD values between the three analysed groups. We did not find any correlation between the concentration of examined endothelial markers and FMD. A non-significant relationship between the presence of classical risk factors and decreased FMP was observed. We have found a significant relationship between the number of risk factors and FMD, tPA, PAI-1 and hsCRP.

Conclusions: The assessment of endothelial function using FMD or estimation of endothelial markers is not useful to differentiate chest pain.

Key words: endothelium, dysfunction, methods of examination

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Introduction

Normal endothelial function is essential for efficient performance of the human cardiovascular system. All atherosclerotic classical risk factors, dietary factors and lifestyle, including physical activity, influence endothelial function [1, 2]. Endothelial dysfunction is considered the initial stage of atherosclerotic degeneration development [3-5]. This is a systemic process that involves all vascular beds [5, 6]. Severity of endothelial dysfunction does not correlate directly with the extent of atherosclerotic lesions [7]. Endothelial dysfunction has been shown to be reversible [1, 5]. Endothelial function can be evaluated by means of many methods [6, 8]. One widely accepted tool is the assessment of radial artery reactivity to hyperaemia induced by compression (functional method) [2, 8-10]. Endothelial function may also be evaluated based on the assessment of quantities of endogenous substances released from endothelial cells (biochemical method). It is not known so far if abnormal concentration of endothelium-derived compound correlates with abnormal vasomotor function [11].

Address for correspondence:
Zofia Grąbczewska MD, Katedra i Klinika Kardiologii i Chorób Wewnętrznych, Szpital Uniwersytecki im. dr. A. Jurasza, ul. Marii Skłodowskiej-Curie 9, 85-094 Bydgoszcz, tel.: 48 52 585 40 23, fax: 48 52 585 40 24, e-mail: z.grabczewska@cm.umk.pl
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Patients with anginal chest pain and normal coronary arteries account for approximately 15 to 20% of all patients undergoing coronary angiography [12]. In some of them diagnosis of syndrome X with underlying endothelial dysfunction may be justified.

The aim of this study was to assess endothelial function in patients with typical or atypical chest pain and no significant coronary artery lesions, and compare them to asymptomatic subjects. This study attempted to answer the question whether there is any relationship between various endothelial function parameters and whether endothelial function assessment might be useful to distinguish patients with typical from those with atypical chest pain or to help in selecting them for coronary angiography.

Methods

Patients

The study group consisted of 73 individuals. Thirty-four (46.5%) of them presented typical (group 1) and 19 (26.1%) atypical chest pain (group 2), and 20 (27.4%) presented no chest pain (group 3). Patients forming groups 1 and 2 were selected from a population of subjects in whom coronary angiography was performed due to chest pain and coronary angiograms were found normal. All examined individuals gave informed written consent to participate in this study and the protocol was approved by the Local Ethical Research Committee. In all patients medical history regarding presented complaints, comorbidities, risk factors and used medications was collected prior to physical examination. On the same day, blood samples were collected to measure concentrations of endothelial parameters and C-reactive protein. In the meantime, relaxation of brachial artery in response to hyperaemia induced by compression occluding the vessel was assessed in standard conditions.

Assessment of brachial artery relaxation

This examination was performed using an Allegra (Siemens) device equipped with a 7.5 MHz linear probe in standard conditions (the same time of day, in a room with constant air humidity at 23°C) in the patient being in a supine position after a 10-minute rest. Right brachial artery was localised 3 cm above the antecubital fossa. Standard flow haemodynamic parameters and maximal arterial lumen diameter were measured on the open artery (M_1). Next, the sphygmomanometer cuff was placed around the forearm 3 cm below the antecubital fossa and inflated to the pressure of 300 mmHg for 3 to 5 minutes. Two minutes after deflating the cuff, arterial lumen diameter during diastole was measured (M_2). After a few minutes the patient received 0.4 mg of sublingual nitroglycerin. Within 2 to 4 minutes after its administration, final measurement of maximal lumen diameter (M_3) was taken. Arterial flow-mediated dilatation (FMD) was calculated according to the formula $[(M_2 - M_1)/M_1] \times 100\%$, and endothelial-independent vessel dilatation (also called nitroglycerin-mediated dilation, NMD) was evaluated as follows: $[(M_3 - M_1)/M_1] \times 100\%$.

Biochemical measurements

Serum concentrations of the following endothelial functional parameters were measured by means of ELISA method: von Willebrand factor (vWF) (DAKO poly- and monoclonal antibodies), thrombomodulin (TM) (American Diagnostica), tissue plasminogen activator antigen (tPA:Ag) and antigen of tissue plasminogen activator type 1 inhibitor (PAI-1:Ag) (Biopool), as well as endothelin (ET-1) (Biomedica). Serum concentration of C-reactive protein was measured using high-sensitivity nephelometric method (hsCRP) (DADE Boehring).

Statistical analysis

Statistical analysis was carried out with STATISTICA computer software (StatSoft®). Variables following a normal distribution were expressed as means (M) and standard deviations (SD). Nonparametric variables were presented as medians (Me) and quartiles (Q). Statistical significance of differences between the groups was assessed by means of Student t-test and Mann-Whitney U-test. Differences between qualitative variables were calculated using χ^2 test. A p value ≤ 0.05 was regarded as significant.

Results

Clinical characteristics of the examined group are shown in Table I. Patients in group 1 were markedly older than in the two other groups. Groups 1 and 2 did not differ from each other in terms of prevalence of classical risk factors and medications of a potential impact on endothelial function. Arterial hypertension was noted significantly less frequently in the group 3 than group 1 patients, while significantly more patients in both groups 1 and 2 were smokers. Female gender predominated in all groups (from 55.8% to 60%).

The results of measurements of examined endothelial function parameters and hsCRP in the three patient groups are presented in Table II. The FMD value was the highest in the group of patients manifesting typical chest pain, however, the difference was NS. Group 1 patients also had significantly higher tPA:Ag and hsCRP concentrations than group 2 and 3 patients, but markedly lower PAI-1:Ag concentration than group 3 patients, though higher than group 2. No statistically significant differences with respect to other endothelial function markers were noted between the three examined patient groups.

The relationship between classical risk factors and parameters of endothelial function is presented in

Table I. Characteristics of examined patients

Parameter	Group 1 (n=34)	Group 2 (n=19)	Group 3 (n=20)	p
Age [years]	57.5±11.2	52.3±7.7	46.5±9.8	**0.0006*** **0.0042*****
Female gender	19 (55.8%)	11 (57.8%)	12 (60%)	NS
Body mass index	26.7±3.9	26.4±4.5	24.5±3.8	NS
Risk factors				
Hypertension	23 (67.6%)	10 (52.6%)	4 (20%)	**0.0019***
Diabetes mellitus	3 (8.8%)	4 (21%)	0	NS
Hyperlipidaemia	16 (47%)	8 (42%)	7 (35%)	NS
Smokers	3 (8.8%)	4 (21%)	10 (50%)	**0.002***
Administered drugs having impact on endothelial function				
Statins	23 (67.6%)	12 (63.2%)	0	NS 1-2 **<0.0001*** **<0.0001****
Angiotensin-converting enzyme inhibitors	22 (64.7%)	9 (47.3%)	2 (10%)	NS*** **0.0003*** **0.0253****

** 1 vs. 3, ** 2 vs. 3, *** 1 vs. 2*

Table II. Endothelial function parameters and C-reactive protein concentration

Parametr	Group 1 (n=34)	Group 2 (n=19)	Group 3 (n=20)	p
FMD [%]	4.94	2.30	2.01	NS
vWF:Ag	147.08	147.08	159.44	NS
TM [ng/ml]	1.34	1.45	1.25	NS
ET-1 [ng/ml]	0.65	0.46	0.76	NS
tPA:Ag [ng/ml]	6.76	5.94	4.60	**0.05**
PAI-1:Ag [ng/ml]	39.83	25.11	54.29	**0.02*** **0.01***** **0.0003****
hsCRP [mg/l]	1.80	1.02	0.99	**0.03**

*Abbreviations: see 'Methods'. * 1 vs. 2, ** 2 vs. 3, *** 1 vs. 3*

Table III. Regarding each classical atherosclerosis risk factor, FMD was lower in the subgroup of patients presenting at least one of them than in patients free from these risk factors, although the differences were NS. Dyslipidaemia was associated with markedly elevated ET-1 and hsCRP concentrations. Hypertension was related to markedly higher tPA:Ag or hsCRP concentration while PAI-1:Ag level was influenced significantly by smoking.

It is known that coexistence of multiple risk factors increases the global atherosclerosis risk and accelerates its progression. Thus, we evaluated the impact of the number of coexisting risk factors present in each individual patient on the endothelial parameters and FMD (Table IV). We found that PAI-1:Ag and hsCRP concentrations significantly increased parallel to the increasing number of coexisting risk factors. The FMD value was also shown to be associated with increasing number of risk factors – maximal values were noted in individuals with no classical atherosclerosis risk factors and decreased together with the increasing number of risk factors. The differences, however, were not statistically significant.

According to the earlier published study [3], we accepted the FMD value ≥7% to be normal. In the examined group, FMD ≥7% (with mean value 10.3%) was present in 17 of 73 subjects (23.2%). In this group, the majority of patients presented atypical chest pain (41%), individuals with typical angina symptoms accounted for 35% and 23% of them were free from any chest pain. In the remaining 56 (76%) patients, the FMD value was less than 7%. Among them, more patients suffered from typical angina (58%) than atypical symptoms (21.5%) or were

Table III. Classical risk factors and endothelial function markers in the whole examined group

Risk factor	Number of patients	Parameter						
		FMD [%]	vWF:Ag	TM [ng/ml]	ET-1 [ng/ml]	tPA:Ag [ng/ml]	PAI-1:Ag [ng/ml]	hsCRP [mg/l]
Dyslipidaemia (+)	36	2.44	151.17	1.33	0.85	6.94	39.83	1.62
Dyslipidaemia (–)	28	2.60	160.67	1.43	0.47	6.00	39.86	0.90
p		NS	NS	NS	**0.05***	NS	NS	**0.013***
Hypertension (+)	35	2.32	147.08	1.41	0.56	6.55	38.83	1.69
Hypertension (–)	36	4.34	155.46	1.33	0.67	5.42	38.24	1.06
p		NS	NS	NS	NS	**0.02***	NS	**0.03***
Diabetes mellitus (+)	7	2.50	147.08	1.84	1.12	7.73	40.65	1.49
Diabetes mellitus (–)	66	2.63	155.25	1.33	0.62	6.18	38.07	1.22
p		NS	NS	NS	NS	NS	NS	NS
Smokers (+)	17	2.30	155.66	1.34	0.65	5.20	52.86	1.40
Smokers (–)	56	2.85	147.08	1.43	0.62	6.21	36.09	1.22
p		NS	NS	NS	NS	NS	**0.02***	NS

*Abbreviations: see 'Methods'. * 1 vs. 3*

Table IV. Median values of FMD, endothelial function markers and hsCRP in relation to number of atherosclerosis risk factors in the examined group of patients

Parameter	Number of risk factors				p
	0	1	2	3 and more	
Number of patients	9	19	27	18	NS
FMD [%]	5.88	1.96	2.43	2.53	NS
vWF:Ag	161.38	161.38	139.53	155.25	NS
TM [ng/ml]	1.21	1.45	1.32	1.39	NS
ET-1 [ng/ml]	0.29	0.69	0.65	0.51	NS
tPA:Ag [ng/ml]	4.40	6.21	7.19	8.79	NS
PAI-1:Ag [ng/ml]	31.58	31.24	41.61	40.02	**0.04*** **0.02**** **0.03*****
hsCRP [mg/l]	0.47	1.08	1.44	2.93	**0.01***** **0.0007******

*Abbreviations: see 'Methods'. * 0 vs. 1, ** 0 vs. 2, *** 0 vs. 3, **** 1 vs. 3*

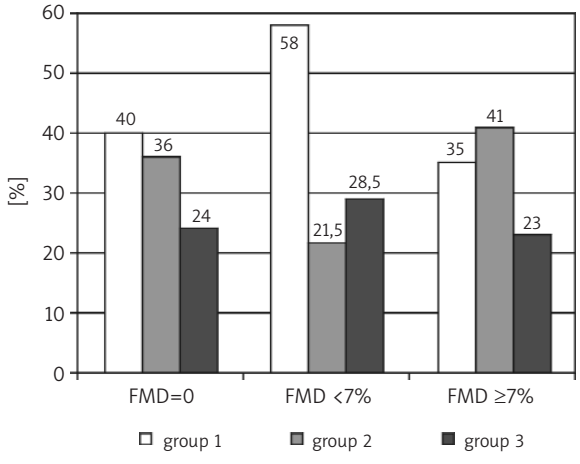

Figure 1. FMD values in study group

asymptomatic (28.5%). Mean FMD value was 2.26% in this patient group (Figure 1).

Concentrations of endothelial function parameters and hsCRP were compared between patient groups with FMD <7% and FMD ≥7% – differences were NS for any of the examined parameters.

Values of examined endothelial function markers in the group of subject with FMD <7% are outlined in Table V. The FMD value was the highest in the group of individuals with typical anginal symptoms and differed significantly compared to the two other groups. Significant differences were also found for PAI-1:Ag (the lowest in group 1 and highest in group 3) and hsCRP concentrations (the highest in group 1 and the lowest in group 3). A group of patients in whom hyperaemia provoked no brachial artery dilatation (FMD=0%) was also identified. It consisted of 25 subjects and 40% of

Table V. Endothelial function parameters in the group of patients with FMD <7%

Parameter	Group 1 (n=28)	Group 2 (n=12)	Group 3 (n=16)	p
FMD [%]	3.19	1.12	1.49	**0.03*** **0.05****
vWF:Ag	151.17	146.16	164.86	NS
TM [ng/ml]	1.31	1.43	1.25	NS
ET-1 [ng/ml]	0.59	0.56	0.47	NS
tPA:Ag [ng/ml]	35.52	28.66	54.29	**0.002**** **0.004*****
PAI-1:Ag [ng/ml]	6.53	6.84	4.90	NS
hsCRP [mg/l]	1.76	1.10	0.90	**0.03****

*Abbreviations: see 'Methods'. * 1 vs. 2, ** 1 vs. 3, *** 2 vs. 3*

them manifested typical angina pain, 36% had no chest pain and 24% presented atypical pain. Patients of group 1 (with typical angina) were most numerous both in the group of patients with FMD <7% and among individuals with FMD value equal to 0.

Among patients with typical chest pain symptoms, 67% had angiotensin-converting enzyme inhibitors (ACE-I) prescribed, although not always agents with proven endothelial effects. Moreover, 64% of these patients also received statins (although not always meeting treatment goals). None of the patients in group 3 received statins (in spite of detected dyslipidaemia) and only 2 subjects used ACE-I. A comparable percentage of group 2 and group 1 patients used medications (Table I). The NMD assessment as a parameter independent from endothelial function was not used in this study.

Discussion

Investigations have been focused on endothelium for about 20 years due to the strategic place of endothelium and its endocrine as well as paracrine function. Normally functioning endothelium keeps blood liquid within the vascular bed and controls vascular tone [13]. Phenotype of activated endothelium is determined by increased vWF, ET-1 and PAI-1:Ag concentrations. It is known that endothelial dysfunction represents the earliest stage of atherogenesis. Pathological endothelial function was detected in young adults free from symptomatic ischaemic heart disease but with family disease burden [14, 15].

A close relationship between coronary and peripheral artery endothelial function was previously documented [6, 10]. Thus, one of the methods used to evaluate endothelial function is testing of brachial artery dilatation response to passive hyperaemia (FMD). This noninvasive method is easy to use and reproducible. As previously reported, hyperaemia may increase flow by as much as 20% [2]. However, no reference FMD values have been defined and mean FMD differs widely between studies, overlapping between populations [16]. In some studies, a value of 5% [17], 7% [3], 8% [6] or even 10% [9] is considered normal. Additionally, one must remember that FMD may fluctuate by as much as 20 to 25% if measured on consecutive days [2].

In our study, mean FMD was low in all examined groups of patients, although it reached the lowest values in patients without chest pain (differences NS). The FMD level is influenced by many factors, such as baseline artery diameter [2] (smaller arteries feature relatively higher capacity to dilate), site and duration of occlusive compression of the brachial artery [16], and type of consumed meals (lipid-rich meals impair FMD more than carbohydrate-rich meals) [18, 19]. It is possible that relatively low FMD values among our patients were related to a large mean brachial artery diameter at baseline (4.27 mm in group 1, 4.12 mm in group 2 and 4.09 mm in group 3, respectively). Correlations between decreased FMD and hyperlipidaemia, hypertension, diabetes mellitus, smoking and BMI [20, 21] as well as older age, hypertension, diabetes mellitus and postmenopausal period [1] have also been shown [1]. In our group of patients, decreased FMD values were found in subjects with each of the classic atherosclerosis risk factors. Lack of significant differences may be due to the relatively small number of subjects.

A test of artery dilation response represents an indirect index of endothelial cells' capacity to release nitric oxide. Nitric oxide is only one of the large family of compounds released by endothelium. However, no correlation between FMD and concentrations of such endothelium-derived substances [11] has been documented so far.

In our study, no correlation between FMD values and concentration of vWF, TM, ET-1 or tPA:Ag was noted. However, a positive correlation between PAI-1:Ag concentration and FMD was found in group 1 ($r=0.383$; $p=0.025$), i.e. in the group of subjects with intermediate PAI-1:Ag concentrations and the highest FMD values. In many reports, endothelial dysfunction was associated with inflammatory mediators [5]. In our study, a positive correlation between hsCRP and PAI-1:Ag concentration was seen in group 3 ($r=0.488$; $p=0.029$), i.e. in patients

with the lowest hsCRP values and the highest PAI-1:Ag concentrations. It was a group in which smoking rather than hsCRP concentration could have a more pronounced impact on the concentration of PAI-1:Ag.

The examined groups of patients did not differ significantly with respect to the majority of studied parameters of endothelial function in spite of obvious differences in the prevalence of factors having an impact on its function. The group of patients with typical chest pain had increased tPA:Ag and PAI-1:Ag concentrations as compared to the patients with atypical chest pain. Such a constellation is a marker of the elevated serum fibrinolytic potential [22]. However, the highest FMD values documented in group 1 suggest the highest dilatative radial artery response among study groups. Meanwhile, high PAI-1:Ag concentrations accompanied by low tPA:Ag levels in individuals free from angina suggest that smoking, relatively prevalent in this patient group, could have had the predominant effect on PAI-1 concentration.

The patients from groups 1 and 2 used ACE-I and statins significantly more often than those from group 3. Among patients using ACE-I, increased concentrations of tPA:Ag and ET-1 as compared to patients not receiving these medications were noted, though the differences were not significant. This may be related to the fact that ACE-I increase bradykinin concentrations and lead to the stimulation of fPA:Ag release [23]. Bradykinin also stimulates nitric oxide release, which may be reflected by the highest FMD value in group 1. However, the much lower FMD value in group 2 is difficult to explain. In our study, subjects from group 3 presented decreased endothelial function expressed particularly as low FMD value and high PAI-1:Ag concentration. This may be related to the fact that none of the patients in this group used statins and only 10% received ACE-I. Moreover, the rate of smokers was the highest in this group and smoking was shown earlier in many studies to be associated with increased PAI-1:Ag concentrations. We documented higher hsCRP concentrations in patients taking statins compared to those not receiving these agents, an observation consistent with findings of other authors [6]. In groups 1 and 2, lower ET-1 and TM concentrations were noted among patients using statins. These differences however were NS. Published reports lack data on this issue.

We expected that the group of patients with typical chest pain and normal coronary arteries, i.e. patients likely with some form of microvascular angina, would have markedly impaired endothelial function expressed as the lowest FMD values and the highest vWF, ET-1 and PAI-1:Ag concentrations as compared to subjects with atypical chest pain or healthy individuals. Our results do not support such an assumption.

We also speculated that demonstrating endothelial dysfunction would help to make a decision to perform coronary angiography in patients with atypical chest pain. Differences regarding some parameters usually involved groups 1 and 3. There were no differences between groups 2 and 3. Endothelial function evaluation did not prove to be useful to establish the cause of chest pain and did not help in deciding whether or not to proceed with invasive studies. We suppose that the use of statins and ACE-I in group 1 resulted in the best endothelial function despite the highest risk factor burden in this group. It is conceivable that the results of this study would have been different if enrolled patients had not taken drugs with a potential impact on endothelial function. For ethical reasons, such a study being conducted is highly unlikely.

Conclusions

1. Endothelial function assessed by means of percent change of FMD value in a group of patients without angiographic evidence of lesions in the coronary arteries did not differ between patients with typical and atypical symptoms or control subjects.
2. Values of FMD were not found to have a statistically significant association with concentrations of endothelial function parameters such as vWF, TM, tPA:Ag, PAI-1:Ag or ET-1.
3. Concomitant risk factor burden significantly increased hsCRP level and tPA:Ag concentration and decreased FMD.
4. Assessment of endothelial function by means of the methods used in the study did not help to establish the underlying cause of chest pain.

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Parametry funkcji śródbłonka u chorych z bólami w klatce piersiowej i niezmienionymi angiograficznie tętnicami wieńcowymi

Zofia Grąbczewska[1], Maciej Thews[2], Krzysztof Góralczyk[3], Jacek Kubica[1]

[1] Katedra i Klinika Kardiologii i Chorób Wewnętrznych, Szpital Uniwersytecki im. dr. A. Jurasza, Bydgoszcz

[2] Katedra i Klinika Chirurgii Ogólnej i Naczyń, Szpital Uniwersytecki im. dr. A. Jurasza, Bydgoszcz

[3] Katedra i Zakład Patofizjologii, *Collegium Medicum*, Uniwersytet im. M. Kopernika, Toruń

Streszczenie

Wstęp: Chorzy z bólami w klatce piersiowej i niezmienionymi angiograficznie tętnicami wieńcowymi stanowią ok. 20% chorych poddawanych koronarografii.

Cel: Ocena funkcji śródbłonka w grupie chorych z typowymi bólami dławicowymi i niezmienionymi angiograficznie tętnicami wieńcowymi i porównanie ich z grupą chorych z nietypowymi bólami w klatce piersiowej i osobami zdrowymi.

Metodyka: Badaniem objęto 73 osoby – 34 chorych z typowymi bólami dławicowymi (grupa 1.), 19 chorych z nietypowymi bólami w klatce piersiowej (grupa 2.) oraz 20 osób zdrowych, bez bólów w klatce piersiowej (grupa 3.). U 53 chorych wykonano koronarografię z powodu zgłaszanych dolegliwości typu dławicowego i nie stwierdzono zmian w tętnicach wieńcowych. U wszystkich oceniano funkcję śródbłonka, badając metodą ELISA stężenia w osoczu takich parametrów, jak czynnik von Willebranda (vWF), trombomodulina (TM), endotelina 1 (ET-1), tkankowy aktywator plazminogenu (tPA), inhibitor tkankowego aktywatora plazminogenu typu 1 (PAI-1), oraz oceniając ultrasonograficznie zdolność dylatacyjną tętnicy ramiennej w odpowiedzi na przekrwienie (ang. *flow mediated dilation*, FMD). Badano również stężenie w surowicy białka C-reaktywnego metodą wysoce czułą (hsCRP).

Wyniki: Badane grupy chorych różniły się między sobą w zakresie czynników wpływających na funkcję śródbłonka. Chorzy z grupy 1. i 2. byli istotnie starsi niż osoby z grupy 3. (p=0,0006 i p=0,0042), częściej też chorowali na nadciśnienie tętnicze (p=0,0019). Pacjenci z grupy 3. znamiennie częściej byli palaczami papierosów (p=0,002). W ocenie funkcji śródbłonka różnice znamienne statystycznie dotyczyły stężenia tPA (wartości najwyższe w grupie 1.) i PAI-1 (wartości najwyższe w grupie 3.). Wartości FMD we wszystkich grupach badanych były niskie (grupa 1. – 4,19%, grupa 2. – 1,19%, grupa 3. – 1,49%) i nie było między nimi różnic statystycznie istotnych. W grupie chorych z typowymi bólami dławicowymi wartości FMD były najwyższe i łączyło się to być może z częstszym w tej grupie stosowaniem leków z grupy inhibitorów konwertazy angiotensyny (p <0,0001) i statyn (p <0,0003). Nie stwierdziliśmy korelacji między stężeniami badanych parametrów śródbłonkowych a FMD. Wpływ klasycznych czynników ryzyka na funkcję śródbłonka wyraził się wyższym stężeniem ET-1 w grupie chorych z hiperlipidemią w stosunku do osób bez zaburzeń lipidowych (p=0,005), wyższym stężeniem tPA w grupie chorych z nadciśnieniem tętniczym (p=0,02) i wyższym stężeniem PAI-1 w grupie osób palących papierosy (p=0,02). Obecność hiperlipidemii i nadciśnienia tętniczego wiązała się również ze znamiennie wyższym stężeniem hsCRP. Stwierdziliśmy trend ku korelacji pozytywnej między obecnością klasycznych czynników ryzyka miażdżycy a niższym FMD, ale bez istotności statystycznej, a także istotny statystycznie wpływ wzrastającej liczby współwystępujących czynników ryzyka na FMD, tPA, PAI-1 i hsCRP.

Wnioski: 1. Funkcja śródbłonka oceniana za pomocą procentowej zmiany FMD w grupie chorych bez angiograficznych zmian w tętnicach wieńcowych nie różni się pomiędzy chorymi z typowymi i nietypowymi bólami dławicowymi oraz osobami zdrowymi. 2. Wartości FMD nie wykazują statystycznie istotnych powiązań ze stężeniem takich parametrów funkcji śródbłonka, jak vWF, TM, tPA:Ag, PAI-1:Ag czy ET-1. 3. Współistniejące czynniki ryzyka wpływają istotnie na poziom hsCRP oraz stężenie tPA:Ag, a także zmniejszają FMD, ale bez znamienności statystycznej różnic. 4. Ocena funkcji śródbłonka żadną ze stosowanych w badaniu metod nie pomaga w różnicowaniu przyczyn bólów w klatce piersiowej.

Słowa kluczowe: śródbłonek, dysfunkcja, metody oceny

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Adres do korespondencji

dr n. med. Zofia Grąbczewska, Katedra i Klinika Kardiologii i Chorób Wewnętrznych, Szpital Uniwersytecki im. dr. A. Jurasza, ul. Marii Skłodowskiej-Curie 9, 85-094 Bydgoszcz, tel.: 48 52 585 40 23, faks: 48 52 585 40 24, e-mail: z.grabczewska@cm.umk.pl

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