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Pulse wave velocity after exercise test and cardiovascular risk assessment

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ABSTRACT

Objectives: Assessing pulse wave velocity (PWV) represents the most simple and non-invasive method to determine arterial stiffness. Our goal is to analyze PWV after the exercise test in coronary revascularized patients and its implications in stratifying secondary cardiovascular disease prevention programs.

Material and method: We analyzed 63 coronary patients that were interventionally revascularized. Patients were included in a cardiovascular rehabilitation program. We analyzed: age, fasting glycemia, effort systolic blood pressure, the lipid profile and the E/A report. Using the Complior device we determined PWV at maximum 15 minutes after the exercise test. We determined as risk factors: arterial hypertension, type 2 diabetes, CT>175 mg/dl, TG>150 mg/dl and LDL>100 mg/dl. Taking into account the presence of the risk factors we regrouped the initial group as it follows: group 1 – coronary patients with 1-2 risk factors and group 2 – coronary patients with more than 3 risk factors.

Results: After the exercise test, PWV had an augmented value for the whole group. Coronary patients who only had 1-2 risk factors and PWV after the exercise test of =10 m/s had a good lipid profile and diastolic function. Coronary patients with more than 3 risk factors and PWV of >10 m/s had a metabolic risk profile.

Conclusions: Assessing PWV after the exercise test allows us to stratify the risk when starting the rehabilitation program (10 m/s=PWV>10 m/s) as well as modulate the secondary cardiovascular disease prevention measures.

Key words: arterial stiffness, pulse wave velocity, cardiovascular risk

INTRODUCTION

During the last decade, the clinical implications of the arterial stiffness concept in the field of the atherothrombotic cardiovascular disease have been reconsidered (1-4).

Assessing the pulse wave velocity (PWV) represents the most simple and non-invasive method to determine arterial stiffness. Carotid-femoral pulse wave velocity is being recognized as the gold standard in assessing the arterial stiffness (5).

Our goal is to analyse PWV after the exercise test of the coronary revascularized patients

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and its implications in stratifying the secondary cardiovascular disease prevention programs. ❑

MATERIAL AND METHOD

We analyzed a group of 63 coronary interventionally revascularized patients. Patients had already been included in a cardiac rehabilitation program and they were at about 6 months after the revascularization time. Selection criteria were: sinus rhythm, conserved left ventricle ejection fraction, fasting glycemia < 300 mg/dl and serum triglycerides values < 400 mg/dl.

The variables analyzed were: age, fasting glycemia, effort systolic blood pressure-SBP, the lipid profile (total cholesterol – CT, triglycerides – TG, HDL cholesterol – HDL and LDL cholesterol – LDL). The LDL value was calculated using Friedewald formula and non HDL was defined according to Adult Treatment Panel III – ATP III: non HDL=CT-HDL (6). The diastolic function of the left ventricle was assessed using an echocardiographic determination of the E/A report. Using the Complior device we determined PWV at maximum 15 minutes after the exercise test. No pharmacological treatment was given 12 hours prior to PWV assessment. The exercise test was performed using a cycloergometer with a modified Bruce protocol 25-50-75 watt. We determined as risk factors: arterial hypertension, type 2 diabetes mellitus, CT> 175 mg/dl, TG> 150 mg/dl, LDL>100 mg/dl. Depending on the presence of the risk factors, we regrouped the initial group as it follows: group1- coronary patients with 1-2 risk factors and group 2- coronary patients with = 3 risk factors. Statistics: Percents were calculated. Variables were calculated as mean value± standard deviation. Non pair T Student test was used. P values = 0, 05 were considered statistically significant. ❑

RESULTS

After the exercise test, PWV registered an increased value for the entire group: 11, 88±3, 08 m/sec. From the entire group (n=63), most part of the coronary patients (58, 73%) had an increased value of PWV after the exercise test (FIGURE 1).

Regarding the coronary patients with PWV values registered after the exercise test <10 m/sec, there were no significant differences between group 1 and 2 regarding the baseline characteristics (TABLE 1).

We noticed significant differences between the two groups regarding the diastolic function,

quantified through the E/A report (1 ± 0, 44 vs. 0, 7 ± 0,009; p=0,002), LDL (85,41 ±10,43 mg/dl vs. 99,11 ± 22,40 mg/dl; p=0,02) and HDL (37,33 ± 8,9 mg/dl vs. 35,33 ± 4,09; p=0,03). Actually, the patients who only had 1-2 risk factors and had a PWV after the exercise test of = 10m/sec, had a better lipid profile (LDL = 85 mg/dl; HDL=37 mg/dl) and did not have a diastolic dysfunction of the left ventricle.

Analyzing the PWV after the exercise test of > 10 m/sec determinants in the presence of more than 3 risk factors demonstrated significant differences in the baseline characteristics: the components of the proatherogenic lipid profile (excepting LDL), the fasting glycemia and the left ventricle diastolic dysfunction (TABLE 2). Coronary patients with = 3 risk factors and a PWV after the exercise test of > 10 m/sec had a metabolic risk profile (hyperglycemia- dyslipidemia with LDL=105mg/dl and non HDL= 137 mg/dl) but with a diastolic function of the left ventricle better than in patients with only 1-2 risk factors (0,99±0,70).

Analyzing the factors that influenced the PWV after the exercise test for the coronary patients with 1-2 risk factors we have noticed that the PWV after the exercise test behavior was different: 8,10 ± 0,61 m/s vs. 13,28 ± 1,68 m/s (p=0,001). Factors that significantly interfere with this behavior were the fasting glycemia (95, 75 ± 26, 85 mg/dl, p= 0, 000002) and the serum triglycerides level (140, 43±11, 95 mg/dl, p=0, 01) (TABLE 3). Decreased PWV mean values after the exercise test sustain a conserved vascular „elasticity" that can be modulated by its two determinants: fasting glycemia and the serum triglycerides.

Coronary patients with = 3 risk factors had different and statistically significant values (p<0, 03) of the PWV after the exercise test (TABLE 4). We have noticed increased values for patients
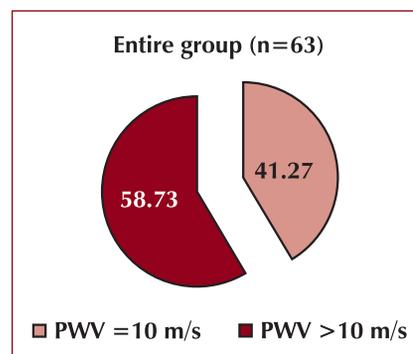

FIGURE 1. PWV values distribution for the entire group (n=63)

Baseline characteristics	PWV after exercise test ≤ 10 m/s		p
	Group 1 (1-2 RF)	Group 2 (≥3 RF)	
Age	50,91 ± 16,03	57,88 ± 12,22	NS
glycemia	81,08 ± 4,88	81,33 ± 3,70	NS
PWV after ex. test	8,10 ± 0,61	7,88 ± 0,66	NS
SBP effort	172,5 ± 15,15	177,22 ± 15,83	NS
CT	149 ± 12,56	173,11 ± 20,13	NS
TG	131,75 ± 24,33	163,44 ± 25,30	NS
Non HDL	113,91 ± 22,55	142,66 ± 29,01	NS
LDL	85,41 ± 10,43	90,11 ± 22,40	0,02
HDL	37,33 ± 8,9	35,33 ± 4,09	0,03
E/A	1 ± 0,44	0,7 ± 0,09	0,0002

TABLE 1. Baseline characteristics of patients that achieved PWV after ex. test= 10 m/s, depending on risk factors

Baseline characteristics	PWV after ex. test > 10 m/s		p
	Group 1 (1-2 RF)	Group 2 (≥3 RF)	
Age	57,18 ± 12,63	59,96 ± 9,66	NS
PWV after ex. test	13,28 ± 1,68	14,14 ± 1,43	NS
SBP effort	176,25 ± 13,96	163,84 ± 13,80	NS
HDL	39,18 ± 6,70	35,46 ± 7,49	NS
glycemia	97,75 ± 26,85	133,96 ± 59,93	0,002
CT	149,75 ± 14,38	173,65 ± 29,38	0,005
TG	140,43 ± 11,95	169,76 ± 26,21	0,002
LDL	82,56 ± 15,72	105,53 ± 28,66	0,01
Non HDL	112,81 ± 15,68	137,73 ± 28	0,02
E/A	0.89 ± 0,31	0,99 ± 0,70	0,001

TABLE 2. Baseline characteristics of patients that achieved PWV after ex. test> 10 m/s, depending on risk factors

Baseline characteristics	PWV after ex. test ≤ 10 m/s	PWV after ex. test> 10 m/s	p
Age	50,91 ± 16,03	57,18 ± 12,13	NS
SBP effort	172,5 ± 15,15	176,25 ± 13,96	NS
CT	149 ± 12,56	149,75 ± 14,38	NS
HDL	37,33 ± 8,9	39,18 ± 6,70	NS
LDL	85,41 ± 10,43	82,56 ± 15,72	NS
nonHDL	113,91 ± 22,55	112,81 ± 15,68	NS
E/A	1 ± 0,44	0.89 ± 0,31	NS
glYcemia	81,08 ± 4,88	97,75 ± 26,85	0,000002
PWV after ex. test	8,10 ± 0,61	13,28 ± 1,68	0,001
TG	131,75 ± 24,33	140,43 ± 11,95	0,01

TABLE 3. Factors responssible for incresed PWV after exercise test in coronary patients with 1-2 risk factors

who cumulated more than 3 risk factors (14, 14±1, 43 vs. 13, 28±1, 68 m/s, p<0, 05) comparing to those with 1-2 risk factors. Two factors influenced this behavior: type 2 diabetes and the left ventricle diastolic dysfunction. ❑

DISCUSSIONS

An increased PWV during effort is a mea sure of decreased arterial distensibility and it is correlated with an increased end-diastolic volume, with increased myocardial oxygen uptake and with the left ventricle dysfunction.

Many studies suggest the connection between the vascular endothelium and the arterial stiffness (7,8). Moreover, it has been estimated that we can modulate the vascular behavior through physical training and pharmacological secondary prevention interventions depending on the PWV after the exercise test behavior. Siche et al., specify that the PWV increases in effort, approximately with 1m/sec/stage of effort and they demonstrate that the optimal value after the exercise test is under 10 m/sec (9).

In our study, the patients had a different PWV behavior after the exercise test. Decreased PWV after the exercise test demonstrates a conserved vascular distensibility. This behavior was encountered with coronary patients who had a low cardio-metabolic risk. Thus, the patients with 1-2 risk factors achieved primary (LDL) and secondary (non HDL) lipid target and did not remain with a ventricle diastolic dysfunction. Patients with more than 3 risk factors achieved a LDL ATP III recommended target but they were still in a proatherogenic condition for non HDL. This means that by focusing our intervention on those determinants of the PWV we can ameliorate the vascular condition of the coronary subjects.

Data extracted from the literature sustain this assertion (10). Kerry J. Stewart found a significant correlation between the flow mediated vasodilatation in brachial artery and the difference between the effort and the rest systolic arterial pressure ($r^2=0$, 20, p<0, 02) (11). Stewart specifies that the tensional exaggerated effort response might be the expression of an altered endothelium dependent vasodilatation.

Increased PWV after the exercise test suggests a reserved prognostic significance. Safar et al. analyzed the intervention of the risk factors – arterial hypertension, body mass index,

Baseline characteristics	PWV after exercise test ≤ 10 m/s	PWV after exercise test > 10 m/s	p
Age	57,88 ± 12,22	59,96 ± 9,66	NS
SBP effort	177,22 ± 15,83	163,84 ± 13,80	NS
CT	173,11 ± 20,13	173,65 ± 29,38	NS
TG	163,44 ± 25,30	169,76 ± 26,21	NS
HDL	35,33 ± 4,09	35,46 ± 7,49	NS
LDL	90,11 ± 22,40	105,53 ± 28,66	NS
nonHDL	142,66 ± 29,01	137,73 ± 28	NS
glycemia	81,33 ± 3,70	133,96 ± 59,93	0,00001
PWV after ex. test	7,88 ± 0,66	14,14 ± 1,43	0,03
E/A	0,7 ± 0,09	0,99 ± 0,70	0,000004

TABLE 4. Baseline characteristics of coronary patients with = 3 risk factors

dyslipidemia, hypertriglyceridemia and hypoglycemia – over the vascular behavior. They demonstrated that PWV was significantly higher in those with more than 3 risk factors (p< 0,001) comparing to with those with 0-2 risk factors. Moreover, an increased PWV in coronary patients with metabolic syndrome might represent a vascular ageing process. Also, the pulse pressure progression was less sensitive than the PWV progression. In our study we found a positive and significant relation with the key factors involved in the increase of the arterial stiffness: the type 2 diabetes, dyslipidemia (with low HDL and high non HDL) and the left ventricle diastolic dysfunction. We consider that the relation between the increased PWV after the exercise test with diabetes and left ventricle diastolic dysfunction has a reserved prognostic significance because of the risk of developing left ventricle hypertrophy in effort. For this group of coronary patients the main measure to achieve is an optimal control of modifiable risk factors.

It is appreciated that the main independent predictors of the cardiovascular risk are: the systolic arterial blood pressure, the pulse pressure and PWV. Since the arterial hypertension, obesity, type 2 diabetes and the metabolic syndrome are responsible for the increase of the arterial stiffness they become directly responsive for the endothelial dysfunction (12-14). ❑

CONCLUSION

1. Coronary interventional revascularized patients had a PWV after the exercise test behavior that was related to diabetes, dyslipidemia (non HDL and HDL) and left ventricle diastolic dysfunction.

2. Decreased PWV after the exercise test demonstrates an increased arterial distensibility. We consider this behavior as a possible favorable prognostic factor when initiating the cardiac rehabilitation program, this behavior being related to reaching lipid targets (LDL and non HDL), to the absence of the left ventricle diastolic dysfunction as well as to a low (0-2) number of associated risk factors.

3. Increased PWV after the exercise test has a reserved prognostic significance when starting the cardiac rehabilitation programme.

4. The prevalence of this altered arterial distensibility response after the exercise test was high in coronary patients with = 3 risk factors.

5. Assessing the PWV after the exercise test allows stratifying the prognostic risk when starting the cardiac rehabilitation program (10m/s = PWV >10 m/s) as well as modulating cardiovascular disease prevention measures. ❑

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