DOI: 10.20514/2226-6704-2020-10-2-139-147

O. S. Ivanova*, E. Yu. Maychuk, I. V. Voevodina

Federal State Budgetary Educational Institution of Higher Professional Education (FSBEI HPE) «A. I. Yevdokimov Moscow State University of Medicine and Dentistry» of the Ministry of Health of Russian Federation, Moscow, Russia

Assessment of Risk Factors of Cardiovascular Diseases and Arterial Stiffness in Women of Different Ages

Abstract

Objective: a comprehensive study of the prevalence and structure of risk factors (RF) for cardiovascular diseases (CVD), daily changes in central aortic pressure and arterial stiffness in healthy women of different age groups. **Materials and methods:** the study involved 161 women aged 18 to 65 years with one or more CVD RFs. All volunteers filled in a questionnaire and underwent daily monitoring of blood pressure with determination of arterial stiffness and daily changes in central aortic pressure, determination of carotid-femoral pulse wave velocity and vascular stiffness using volume sphygmography. **Results:** the patients were divided into 3 groups: group 1: 52 women of young age from 18 to 30 years (23.8 ± 5.3 years); group 2: 54 women from 31 years to menopause (41 ± 5.9 years); group 3: 55 women in the postmenopausal period (55.4 ± 5.8 years). High prevalence of modifiable CVD RFs was revealed among women of different ages: smoking, non-compliance with dietary recommendations, lack of physical activity. Obstetric and gynecological disorders prevailed in younger age groups. In group 1, the studied indicators corresponded to normal across most parameters. Significant differences in central and peripheral pressure, arterial stiffness parameters, with the exception of carotid-femoral pulse wave velocity (cfPRV), were revealed in group 2 in comparison with young women. A comparative analysis of groups 2 and 3 showed a significant deterioration in the parameters characterizing the degree of arterial stiffness, the contribution of the reflected wave and the associated dysfunction of the left ventricle. **Conclusion:** a comprehensive examination of arterial stiffness allows to identify subclinical changes in the vascular wall and evaluate their progression in women of different age groups.

Key words: *arterial stiffness, women, risk factors*

Conflict of Interests

The authors state that this work, its theme, subject and content do not affect competing interests

Funding Sources

The authors declare no funding for this study

Article received on 01.31.2020

Accepted for publication in 2020

For citation: Maychuk E. Yu., Voevodina I. V., Ivanova O. S. Assessment of Risk Factors of Cardiovascular Diseases and Arterial Stiffness in Women of Different Ages. The Russian Archives of Internal Medicine. 2020; 10(2): 139-147. DOI: 10.20514/2226-6704-2020-10-2-139-147

BP — blood pressure, HDP — hypertensive disorders during pregnancy, DPI — double product index, BMI — body mass index, cfPRV — carotid-femoral pulse wave velocity, LV — left ventricle, MS — metabolic syndrome, DM — diabetes mellitus, BPDM — blood pressure daily monitoring, CVD — cardiovascular diseases, CVS — cardiovascular system, RF — risk factor, AI — augmentation index, Aix75 — augmentation index, reduced to heart rate = 75 bpm, ASI — arterial stiffness index, CAVI — cardio-ankle vascular index, dp/dt max ao — the maximum rate of increase in blood pressure in the aorta, ED — ejection duration, PPA — pulse pressure amplification, PEP — preejection period, PWVao — the velocity of the pulse wave in the aorta, RWTT — reflected wave transit time, SEVR — subendocardial viability ratio

* Contacts: Elena Yu. Maychuk, e-mail: ivolgadoc@yandex.ru

ORCID ID: https://orcid.org/0000-0002-0866-785X

Introduction

Despite the improvement of diagnostic and treatment methods, CVDs still lead in the structure of morbidity and mortality. In recent years, CV mortality among women from has increased in European countries, and has become 9% higher than that among men. In this regard, the interest of researchers in the problem of women's health is growing, and multicenter studies are being conducted, research centers are being set up, and the list of special female CVD RFs is being studied and expanded. In various countries, recommendations are being developed on the prognosis and prevention of CVD in women with a history of obstetric and gynecological abnormalities [1, 2].

In our country, smoking among women is on the rise. The development of endothelial dysfunction in women smokers leads to an increase in arterial stiffness, and with the onset of menopause, this process is only gaining momentum [3]. The SAPALDIA study [4] and The Anglo-Cardiff Collaborative Trial [5] identify smoking as a predictor of increased arterial stiffness. According to the Rotterdam study, the consumption of fruits and vegetables, adequate physical activity and the avoiding of smoking contribute to the improvement of vascular stiffness [6]. Similarly, moderate alcohol consumption among women leads to a decrease in pulse wave velocity (PWV) [7]. The presence of occupational hazards, including night shift work, has a much greater detrimental effect on women than on men. The results of a large prospective study conducted among nurses (Gu F. et al., 2015) indicate that night shift work for 5 years or more contributed to a significant increase in the risk of death for cardiac reasons [8]. Obstetric and gynecological abnormalities are of great importance as CVD RFs. Hypertensive disorders during pregnancy (HDP) contribute to the development of vascular and metabolic disorders [2], increase the stiffness of the vascular wall, namely the augmentation index (AI) [9], predisposing women to the development of CVD. The negative detrimental effect of estrogen deficiency during menopause on vascular function, which is associated with a risk of CVD, has been proven. Arterial stiffness is significantly higher in women with early, including surgical, menopause [10]. For young women, metabolic syndrome (MS) poses a greater threat to reproductive health, and when menopause occurs, it causes CVD. The development of MS and diabetes mellitus (DM) leads to a progressive deterioration in vascular function. Postpartum and menopausal MS are of particular importance. Many studies show a direct correlation of gestational diabetes with the development of CVD and their fatal complications, which is partially mediated by an increased risk of type 2 diabetes in future [11].

The aim of this study is a comprehensive study of the prevalence and structure of CVD RFs, the daily changes in central aortic pressure and arterial stiffness in healthy women of different age groups.

Materials and Methods

The study protocol was approved by the Ethics Committee of the A.I. Yevdokimov Moscow State University of Medicine and Dentistry (A.I. Yevdokimov MSMDU). Prior to enrollment in the study, all participants gave written informed consent.

A cross-sectional comparative study was conducted in which 161 women aged 18 to 65 years with one or more CVD RFs with various medical specialties took part. All the patients were divided into 3 groups: group 1: 52 women of young age from 18 to 30 years (23.8 ± 5.3 years); group 2: 54 women from 31 years to menopause (41 ± 5.9 years); group 3: 54 women in natural or surgical menopause (55.4 ± 5.8 years). The women did not receive treatment during the examination period. All volunteers underwent clinical examination, measurement of anthropometric indices, survey, blood pressure daily monitoring (BPDM) with determination of arterial stiffness and daily changes in central aortic pressure, determination of carotid-femoral PWV (cfPWV) and vascular stiffness by volume sphygmography.

The survey was performed using a questionnaire specially developed for the purpose of scientific research and improving the quality of the collection of anamnesis history taking into account literature data ("National Recommendations for Cardiovascular Prevention" Russian Society of Cardiology, 2011; European Guidelines for the Prevention of Cardiovascular Diseases in Clinical Practice, European Society of Cardiology, 2016).

This questionnaire was used in the project "Three ages of women" [12]. The questions on the questionnaire are aimed at identifying complaints, CVD RFs, the presence of chronic diseases and the features of obstetric and gynecological history.

During anthropometry, height, weight, waist circumference (WC) and hip circumference (HC) were measured, body mass index (BMI) was calculated using the Ketle formula (BMI = body weight (kg) / height $(m)^2$).

The cfPWV was determined non-invasively by the Doppler method from the carotid to the femoral artery using the Pulse Trace PWV ultrasound Doppler device (Micro Medical, UK). The distance traveled by the pulse wave was determined between the points of application of the sensors above the carotid and femoral arteries and multiplied by a factor of 0.8.

Volumetric sphygmography was used to study arterial stiffness using a sphygmomanometer and a VaSera VS-1500N sphygmograph (Fukuda Denshi, Japan).

BPDM was performed using the blood pressure (BP) daily monitoring system with the BPLab ® oscillometric method using the Vasotens technology (Petr Telegin Ltd., Nizhny Novgorod).

Statistical Methods

For statistical processing, the statistical package Statistica for Windows 10.0 was used. To check for the normality of distributions, the Shapiro—Wilk test was used (to assess the possibility of using parametric or nonparametric criteria for comparing the groups under consideration; this criterion was chosen for checking for normality because it has the greatest power). A comparative analysis of quantitative variables was carried out using the Student's parametric T-test for dependent populations (according to the results of the previous test for normality, the distribution of parameters in the groups did not differ from the normal one; the choice of this criterion was determined by its greatest power for the groups under consideration). A comparative analysis of qualitative categorical variables was carried out using contingency tables with the chi-square (χ^2) test. The differences were considered significant at $p < 0.05$. The data are presented as M ± SD, where M is the mean value, and SD is the standard deviation.

Results

A comparative analysis revealed a significant difference in the social status, level of employment and education of the women in group 1 compared to the other two groups ($p < 0.01$), while no differences were seen between groups 2 and 3. Group 1 was mainly composed of full-time and evening students at the A.I. Yevdokimov MSMDU. Women with secondary vocational education were predominant in groups 2 (74%) and 3 (56.4%), most of them worked as nurses. The analysis of social status revealed a significant predominance of 40 women (76.9%) who were never married in group 1, while there were predominantly married women in groups 2 and 3.

Most of the patients assessed their health as satisfactory or good, with a significant predominance of positive characteristics in group 1 ($p < 0.01$).

The general characteristics of the groups according to the presence of CVD RF, the characteristics of obstetric and gynecological history and the results of the comparative analysis are presented in Table 1.

More than half of the patients had various complaints with significance predominance of members of group 3 (postmenopausal women). A high percentage of occupational hazards in groups is noteworthy, namely night shift work, which undoubtedly increases the risk of CVD in women. Among the patients, a large number of women smokers were identified and most of all (50%) in group 1, which was mainly composed of students. However, women of groups 2 and 3 showed a great commitment to smoking. Most of the patients do not follow a diet and do not consume the recommended 400 grams of fruits and vegetables per day. Only a few recognize themselves as physically inactive. Most women claim regular exercise and walking. Despite this, more than a quarter of women lead a predominantly sedentary lifestyle, and half of them have complaints during exercise. Women with moderate exercise at least for 150 min/week or with intense exercise at least for 75 min/week, or with a combination thereof with equivalent load were considered physically active. A sedentary lifestyle is a variant of a lifestyle with lack of physical activity: work in a sitting position combined with inactive leisure

time. There are complaints of shortness of breath and palpitations during physical exertion, including among women in group 1 (50%). It should be noted that there was no significant difference in the frequency of complaints during exercise in groups 2 and 3.

Analysis of the obstetric and gynecological history showed a high frequency of pregnancy pathologies. HDP, edema and proteinuria of pregnant women occupy leading positions. A significantly greater number of pregnancy pathologies were detected in groups 1 and 2. In group 1, 100% of women giving birth had pregnancy pathologies, of which 2/3 noted an increase in blood pressure during pregnancy. More than half of women who had a pregnancy had an abortion. About half of the women of group 2 underwent gynecological operations. Surgical menopause was noted in 12 (21.8%) women of group 3.

Table 1. *General characteristics of groups according to CVD RFs and obstetric and gynecological history*

Groups	Group 1	Group 2	Group 3
n	52	54	55
Mean age (M ± SD)	23.8 ± 5.3	41 ± 5.9	55.4 ± 5.8
Complaints, abs (%)	29 (55.8) #	37 (69.5) #	49 (89)
Family history of CVD, abs (%)	37 (71.1)	35 (64.8)	38 (69)
Occupational hazards, abs (%)	14 (26.9) *	31 (57.4)	22 (40)
Smoking, abs (%)	26 (50)	23 (42.6)	21 (38.2)
Daily smoking, abs (% of smokers)	18 (69.2)	20 (86.9)	19 (90.5)
Secondhand smoke, abs (% of smokers)	10 (19.2)	2 (3.7)	1 (1.8)
Duration of smoking more than 10 years, abs (% of smokers)	6 (23) *#	20 (87)	19 (90.5)
Desire to quit smoking, abs (% smokers)	17 (65.3)	15 (65.2)	15 (71.4)
Alcohol consumption, abs (%)	38 (23.6)	47 (87)	44 (80)
Dieting, abs (%)	14 (26.9)	14 (25.9)	18 (32.7)
Eating less than 400g of fruits and vegetables per day, abs (%)	41 (78.8)	44 (81.5)	39 (70.9)
Salt consumption over 5 g/day, abs (%)	7 (13.5)	12 (22.2)	10 (18.2)
Physically inactive, abs (%)	2 (3.8) *	8 (14.8)	7 (12.7)
Sedentary lifestyle	17 (32.7) *	14 (25.9)	20 (36.4)
Exercise Complaints, abs (%)	26 (50) **	37 (68.5)	35 (63.6)
Mean age of menarche (M ± SD)	12.56 ± 0.96	12.78 ± 1.87	12.78 ± 1.42
Menstrual irregularities, abs (%)	20 (38.5)	21 (38.9)	15 (27.3)
History of pregnancy, abs (%)	9 (17.3) *#	48 (88.8) ##	52 (94.5)
Number of women giving birth, abs (%)	7 (13.5)	43 (89.6)	51 (98)
Pregnancy pathologies, abs (% giving birth)	7 (100) #	37 (86) #	32 (62.7)
HDP abs (% giving birth)	5 (71.4)	17 (45.9)	12 (37.5)
Edema during pregnancy, abs (% giving birth)	3 (42.8)	26 (70.3)	16 (50)
Proteinuria during pregnancy, abs (% giving birth)	3 (42.8)	9 (24.3)	7 (21.9)
Anemia during pregnancy, abs (% giving birth)	3 (42.8)	16 (43.2)	4 (12.5)
Caesarean section, abs (% giving birth)	4 (57.1)	9 (20.9)	7 (13.7)
Abortion, abs (% of pregnancies)	5 (55.6) *#	26 (54.2)	36 (69.2)
Miscarriages, abs (% of pregnancies)	1 (11.1) *#	10 (20.8)	13 (25)
Fetal macrosomia, abs (% of pregnancies)	0 (0) *#	7 (16.3)	9 (17.6)
Gynecological surgery, abs (%)	10 (19.2) *#	24 (44.4)	33 (60)

Note: * — Significant difference (p < 0,01) with the parameters in group 2
** — Significant difference (p < 0.05) with the parameters in group 2
# — Significant difference (p < 0,01) with the parameters in group 3
— Significant difference (p < 0.05) with the parameters in group 3

Table 2. *Anthropometric data*

	All examined	Group 1	Group 2	Group 3
n	**161**	**52**	**54**	**55**
Height (M ± SD), cm	164.9 ± 5.9	166.3 ± 6.2 **	163.9 ± 5.5	164.6 ± 6
Body weight (M ± SD), kg	71.3 ± 14.7	60.5 ± 8.5 *#	75.6 ± 15.5	77.3 ± 12.9
BMI (M ± SD), kg/m²	26.3 ± 5.68	21.7 ± 3.3 *#	28.2 ± 6.3	28.6 ± 4.4
WC (M ± SD), cm	84.3 ± 15.7	71 ± 8.2 *#	88.4 ± 15.9	92.8 ± 12.6
HC (M ± SD), cm	103.8 ± 9.2	97.3 ± 6.6	106.5 ± 9.4	106.7 ± 8.5
WC/HC (M ± SD)	0.8 ± 0.12	0.73 ± 0.06	0.83 ± 0.1	0.86 ± 0.13

Note: * — Significant difference (p < 0,01) with the parameters of group 2
** — Significant difference (p < 0.05) with the parameters of group 2
# — Significant difference (p < 0,01) with the parameters of group 3

Table 3. *Parameters of daily monitoring of central aortic pressure and peripheral blood pressure in groups*

Groups: / (M ± SD)	Group 1	Group 2	Group 3
Mean SBP (mm Hg)	110.3 ± 8 *#	120.4 ± 11.9	122.8 ± 13.1
Mean DBP (mm Hg)	69.2 ± 5.5 *#	76.5 ± 7.9	78.2 ± 8.3
Mean BP (mm Hg)	83.7 ± 6.2*#	93 ± 8.9	96.3 ± 10.1
Mean PBP (mm Hg)	41.2 ± 5.4 ##	44 ± 8.7	44.6 ± 8.5
SBP variability (mm Hg)	12.5 ± 2.7 *#	15.5 ± 5	15.5 ± 3.9
DBP variability (mm Hg)	10.4 ± 2.3 *##	12.5 ± 3.6	11.7 ± 3
MBP variability (mmHg)	10.9 ± 2.3 *#	13.4 ± 3.8	12.9 ± 3.3
PBP variability (mm Hg)	9.2 ± 2.1 *#	11.3 ± 3.5	11.8 ± 3.8
Mean SBPao (mmHg)	100.4 ± 7.2 #	111.8 ± 10.7	115.1 ± 12.3
Mean DBPao (mmHg)	71.1 ± 6.3 #	79.1 ± 8.1	80.5 ± 8.7
SBPao variability (mmHg)	11 ± 2.5 *#	13.8 ± 4.3	13.7 ± 3.4
DBPao variability (mmHg)	10.7 ± 2.3 *##	12.8 ± 3.6	11.8 ± 3
PBPao variability (mmHg)	6.7 ± 1.5 *#	8.4 ± 2.5	9 ± 2.7
SBPao DND (%)	11.2 ± 5.1 *	13.2 ± 6.6	10.5 ± 8.5
DBPao DND (%)	16.9 ± 7.4 *	18.6 ± 7.4	15.8 ± 7.8
DPI day (mmHg/min)	88.9 ± 17.2 *	102.2 ± 16.6	93.5 ± 19.2
DPI night (mmHg/min)	62 ± 10.9 *##	71.4 ± 13	70.1 ± 13.4
DPI variability	22.6 ± 4.8 ##	23.7 ± 6.6 #	20.6 ± 5
AIao (%)	0.7 ± 7.4 *#	12.4 ± 7.5	13.6 ± 9.1
AIao to heart rate 75 (%)	1.9 ± 6.8 *#	15.1 ± 8.8	17.7 ± 7.3
PPA (%)	139.5 ± 6.2 *#	133.6 ± 6.6 #	128.3 ± 5.8
PPA to heart rate 75 (%)	140 ± 5.1 *#	132.1 ± 3.5	129.1 ± 15.7
ED (ms)	319.2 ± 22.2 *#	333.9 ± 27.1 #	356.2 ± 28.7
ED to heart rate 75 (ms)	316.7 ± 13.4 *#	336.9 ± 12.5	339.8 ± 17.4
SEVR (%)	123.5 ± 11.9 #	121.4 ± 9.7 ##	114.6 ± 17
SEVR to heart rate 75 (%)	122.2 ± 11.8	123.6 ± 11.7	120.7 ± 10
AIao variability (%)	11 ± 2.4 *#	13.8 ± 3.7	14.9 ± 4
PPA variability (%)	11.9 ± 2.2	11.2 ± 2.7 ##	10 ± 2.8

Note: * — Significant difference (p < 0,01) with the parameters of group 2
** — Significant difference (p < 0.05) with the parameters of group 2
# — Significant difference (p < 0,01) with the parameters of group 3
— Significant difference (p < 0.05) with the parameters of group 3
SBP — systolic blood pressure, DBP — diastolic blood pressure, MBP — mean hemodynamic blood pressure, PBP — pulse blood pressure, SBPao — central (aortic) systolic pressure, DBPao — central (aortic) diastolic pressure, DND — degree of nighttime decrease

Table 4. *Arterial stiffness parameters by groups*

Groups: (M± SD)	Group 1	Group 2	Group 3
	Doppler ultrasound		
cfPWV	7.77 ± 2.5	10.8 ± 4	11.9 ± 4.4
	Volumetric sphygmography		
R_CAVI	5.75 ± 0.5 **	6.57 ± 0.8 #	7.65 ± 0.9
L_CAVI	5.81 ± 0.6 **	6.65 ± 0.8 #	7.64 ± 1
R_AI	0.79 ± 0.1 **	1.01 ± 0.2 ##	1.09 ± 0.2
PEP	96.9 ± 21	95.6 ± 15.9 #	103.4 ± 13.5
ET	307.7 ± 16.2 #	308.3 ± 18.6 #	320.4 ± 21.2
	BPDM with an oscillometric method and using Vasotens Technology		
PWVao (m/s)	5.7 ± 0.7 **	8.05 ± 1.3 #	9.75 ± 1.1
PWVao (m/s) MBP100 HR 60	8.1 ± 1 *	9.9 ± 1.5 ##	10.5 ± 1.3
AIx (%)	–51.1 ± 10.6 *	–23.2 ± 10.7 #	–11.8 ± 8.4
AIx75 (%)	–49.7 ± 12.5 **	–25.2 ± 8.3 #	–15.8 ± 9.9
ASI (mm Hg)	126.7 ± 12.2 **	134 ± 15.5 ##	143 ± 20.4
RWTT (ms)	153 ± 12.7 **	129.6 ± 11.9 ##	124.9 ± 10.5
RWTT (ms) MBP 100 HR 60	170.2 ± 14.4 **	144.1 ± 16.2 ##	137.4 ± 12
dp/dt max ao (mm Hg)	556.1 ± 125.7 #	543.5 ± 121.6 #	480.4 ± 96.2
dPdt variability	163.6 ± 37.8 **	185.3 ± 68.6 ##	157.5 ± 55.4
RWTT variability	22.3 ± 4.9 **	18.8 ± 4.6	18.3 ± 4.6
PWVao variability	0.9 ± 0.2 **	1.1 ± 0.3	1.1 ± 0.2
CAVIao variability	1.4 ± 0.4 **	1.8±0.5 #	2.15 ± 0.5
IE variability	0.1 ± 0.03 **	0.1 ± 0.03	0.1 ± 0.03

Note: * — Significant difference (p < 0,01) with the parameters of group 2
** — Significant difference (p < 0.05) with the parameters of group 2
# — Significant difference (p < 0,01) with the parameters of group 3
–Significant difference (p < 0.05) with the parameters of group 3

The data obtained indicate a high prevalence of various CVD RFs among women who are medical workers. In a comparative analysis, the frequency of such RFs as smoking, alcohol consumption, non-compliance with dietary recommendations is comparable in all groups, regardless of age and reproductive status. The frequency of obstetric and gynecological pathologies was significantly higher in younger age groups.

A comparative analysis of anthropometric data showed the presence of significant differences between group 1 and the older groups in the presence of general and abdominal obesity, while there were no significant differences between the groups. More than half of women of groups 2 and 3 are obese or overweight. Half of women of group 3 and more than a third of women of group 2 have an abdominal type of obesity (Table 2).

During analysis of the results of the study of daily monitoring of central aortic pressure and peripheral blood pressure, significant differences were revealed when comparing the parameters of women of group 1 with older groups without a significant difference between the latter. Based on the results presented in Table 3, parameters of vascular stiffness in young women of group 1 are normal, despite the presence of a significant number of CVD RFs. However, an insufficient degree of nighttime decrease in blood pressure was found in a quarter of the patients of group 1, and the rate of morning BP rise was exceeded in 60%. An analysis of the morning changes and daily profile of BP showed the absence of significant differences between group 1 and groups 2 and 3, with the exception of parameters of the degree of nighttime decrease in aortic pressure. Most of the studied parameters

of daily monitoring of central aortic pressure and peripheral BP in women of groups 2 and 3 did not differ significantly, despite the development of menopause in group 3.

At the same time, it seems important to analyze parameters that have a significant difference in groups 2 and 3, as potentially significant initial markers of the development of arterial stiffness. A significant difference was seen between the variability of the double product index (DPI), the pulse pressure amplification index (PPA) and its variability, the subendocardial viability ratio (SEVR), and the length of the left ventricular (LV) ejection duration (ED). An increase in arterial stiffness in group 3 is evidenced by a decrease in SEVR, PPA and PPA variability, as well as an increase in ED, which leads to a decrease in LV systolic function due to a decrease in coronary blood flow and an increase in afterload (Table 3).

When analyzing arterial stiffness in groups 1 and 2, significant differences were revealed for all the studied parameters except for cfPWV and the preejection period (PEP). In groups 2 and 3, significant differences were seen between the cardio-ankle vascular index (CAVI) and the augmentation index (AI), determined by the volume sphygmography method, as well as the average daily rate of the pulse wave velocity in the aorta (PWVao), variability of PWVao, AI, and AI reduced to heart rate = 75 bpm (Aix75). At the same time cfPWV did not show a significant difference in the groups. It is necessary to pay attention to such parameters as the preejection period (PEP), ejection time (ET), the arterial stiffness index (ASI), the reflected wave transit time (RWTT), the maximum rate of increase in blood pressure in the aorta (dp/dt max ao), the variability of these parameters and the variability of CAVI in the aorta (CAVIao), which also showed a significant difference in groups 2 and 3. These indicators reflect the dynamic load on the walls of the great vessels during the passage of the pulse wave, the degree of arterial stiffness and the associated impaired LV function (Table 4).

Discussion

The large number of smoking female medical workers revealed is consistent with the data of various studies, despite the special role of doctors in promoting a healthy lifestyle. According to the extensive Champlain Nurses' Study, smoking is particularly prevalent among nurses [13]. As the age increases, the prevalence of smoking among women decreases, and BMI increases [14]. According to the results of our study, there is no significant difference in BMI between middle-aged and older women, regardless of the reproductive function.

The prevalence of traditional CVD RFs among women and men was estimated in a national multicenter population ESSE-RF study [15]. Compared with the results of that study, we found a higher level of physical activity among the women surveyed, lower consumption of salt, but insufficient consumption of fruits and vegetables.

According to the results of the analysis of the health status of pregnant women in the Russian Federation over 16 years of follow-up, anemia leads among pregnancy pathologies (32.6%), and the frequency of edema, proteinuria, and HDP progressively decreases to 10% [16]. On the contrary, our study revealed the highest frequency of HDP, proteinuria, and edema during pregnancy. The frequency of anemia during pregnancy among the examined women of a younger age was 43%.

The revealed significant differences between postmenopausal women and women with preserved reproductive function in CAVI, aortic pulse wave velocity (PWVao), augmentation index obtained by volume sphygmography and in the analysis of the central pulse wave are consistent with the results of many studies [17–20]. At the same time, cfPWV, the comprehensively studied parameter with the proven predictive ability in our study, was not significant, which may be due to its dependence on BP and heart rate during the study, which corresponded to normal values in our work.

Less studied parameters, which demonstrated significant differences between women with preserved reproductive function and postmenopausal women, are of greater interest. The preejection period and ejection time of the left ventricle, determined by two methods, reflect the systolic function of the left ventricle [21]. An increase in arterial stiffness index (ASI) in the postmenopausal group is associated with a risk of developing subclinical coronary atherosclerosis and has proven prognostic value in the development of coronary heart disease [22]. The reflected wave transit time RWTT

determines the contribution of the reflected wave to the formation of pulse pressure and the creation of LV afterload, decreases with age concurrently with the rise of PWVao, which corresponds to the results of the study [22]. The rate of increase in blood pressure in the aorta (dp/dt max ao) is a complex parameter that depends on the totality of the functions of the main and peripheral arteries, which makes it possible to track changes in LV contractility under inotropic effects [23]. The subendocardial viability ratio (SEVR) reflects the balance between coronary perfusion and LV afterload [24]. A decrease in SEVR in menopausal women indicates an imbalance and the likely development of systolic dysfunction.

In general, the above parameters are of great applied significance for determining the state of the cardiovascular system (CVS) in practically healthy women in relation to CVD identified in said women. These parameters reflect the development of early, preclinical changes and their progression with age, and also determine the beginning of primary and secondary CVD prevention. The objective need to expand these studies primarily in young and middle-aged groups should be noted.

Conclusions

1. High prevalence of CVD RFs among women of various age was revealed. The most common RFs are modifiable: smoking, non-compliance with dietary recommendations and lack of physical activity. Attention should be paid to the high frequency of obstetric and gynecological pathologies, as CVD RFs that are specific to women in younger age groups.

2. In women below the age of 30 with CVD RFs, arterial stiffness, central and peripheral blood pressure correspond to normal values across most parameters.

3. Significant changes in the studied parameters (with the exception of cfPWV and PEP) in the analysis of arterial stiffness, in comparison with women aged under 30, are already observed in group 2, despite their age and preservation of reproductive function, which indicates the need to start implementing preventive measures at this stage.

4. In the group of postmenopausal women, changes in arterial stiffness were detected, which mark the end of the reproductive period and the development of menopausal changes in CVS.

Comprehensive examination, including BPDM with determination of arterial stiffness and daily changes in central aortic pressure, determination of vascular stiffness by volume sphygmography, allows to detect subclinical changes in the vascular wall and evaluate their progression in women of different age groups.

Further studies are needed to determine the relationships between individual CVD RFs and their most frequent combinations with arterial stiffness in women.

Contribution of Authors:

All the authors contributed significantly to the study and the article, read and approved the final version of the article before publication

E. Yu. Maychuk (ORCID ID: https://orcid.org/0000-0002-0866-785X) ,

I. V. Voevodina (ORCID ID: https://orcid.org/0000-0003-2368-0582): concept and design of the research

O. S. Ivanova (ORCID ID: https://orcid.org/0000-0002-1266-9305): collection and processing of the material

O. S. Ivanova (ORCID ID: https://orcid.org/0000-0002-1266-9305): statistical processing

I. V. Voevodina (ORCID ID: https://orcid.org/0000-0003-2368-0582)

O. S. Ivanova (ORCID ID: https://orcid.org/0000-0002-1266-9305): writing text

E. Yu. Maychuk (ORCID ID: https://orcid.org/0000-0002-0866-785X): editing and approval for publication

References:

1. Wenger N. K. Prevention of cardiovascular disease in women: highlights for the clinician of the 2011 American Heart Association Guidelines. Advances in chronic kidney disease. 2013; 20(5): 419–422. https://doi.org/10.1053/j.ackd.2013.02.006
2. Heida K. Y., Bots M. L., Groot K. J. M. et al. Cardiovascular risk management after reproductive and pregnancy-related disorders: A Dutch multidisciplinary evidence-based guideline. European journal of preventive cardiology. 2016; 23(17): 1863–79. https://doi.org/10.1177/2047487316659573
3. Ulubieva E. A., Avtandilov A. G., Timofeeva A. V. and etc. Structural and functional changes in arteries in healthy women under the influence of age and smoking. Women's health issues. 2015; 10(3): 38–44. [in Russian]

4. Caviezel S., Dratva J., Schaffner E. et al. Sex-specific associations of cardiovascular risk factors with carotid stiffness-results from the SAPALDIA cohort study. Atherosclerosis. 2014; 235(2): 578–84. https://doi.org/10.1016/j.atherosclerosis.2014.05.963
5. McEniery C. M., Yasmin, Maki-Petaja K. M. et al. The impact of cardiovascular risk factors on aortic stiffness and wave reflections depends on age: the Anglo-Cardiff Collaborative Trial (ACCT III). Hypertension. 2010; 56(4): 591–7. https://doi.org/10.1161/HYPERTENSIONAHA.110.156950
6. Karimi L., Mattace-Raso F. U., van Rosmalen J. et al. Effects of combined healthy lifestyle factors on functional vascular aging: the Rotterdam Study. Journal of Hypertension. 2016; 34(5): 853–9. https://doi:10.1097/HJH.0000000000000861
7. Sasaki S., Yoshioka E., Saijo Y. et al. Relation between alcohol consumption and arterial stiffness: A cross-sectional study of middle-aged Japanese women and men. Alcohol. 2013;47(8):643–9. https://doi.org/10.1016/j.alcohol.2013.10.003
8. Gu F., Han J., Laden F. et al. Total and cause-specific mortality of U. S. nurses working rotating night shifts. American Journal of Preventive Medicine. 2015; 48(3): 241–52. https://doi:10.1016/j.amepre.2014.10.018
9. Ehrenthal D. B., Goldstein N. D., Wu P. et al. Arterial stiffness and wave reflection 1 year after a pregnancy complicated by hypertension. The *Journal* of *Clinical Hypertension.* 2014; 16(10): 695–9. https://doi:10.1111/jch.12398
10. Abbas S. Z., Sangawan V., Das A. et al. Assessment of Cardiovascular Risk in Natural and Surgical Menopause. Indian Journal of Endocrinology and Metabolism. 2018; 22(2): 223–28. https://doi:10.4103/ijem.IJEM_620_17
11. LeBlanc A. G., Prince S. A., Reid R. D. et al. Smoking behaviour among nurses in Ontario: cross-sectional results from the Champlain Nurses' Study. Canadian Journal of Public Health. 2019. https://doi:10.17269/s41997-019-00259-4
12. Stryuk R. I., Burns C. A., Filippov M. P., et al. Cardiovascular disease and associated comorbid conditions as determinants of adverse perinatal outcomes in pregnancy — an analysis of the results of the register of pregnant BEREG. Therapeutic archive. 2018; 90(1): 9–16. [in Russian] https://doi:10.26442/terarkh20189019-16
13. LeBlanc A. G., Prince S. A., Reid R. D. et al. Smoking behaviour among nurses in Ontario: cross-sectional results from the Champlain Nurses' Study. Canadian Journal of Public Health. 2019. https://doi:10.17269/s41997-019-00259-4
14. Kochergina A. M., Karetnikova V. N., Barabash O. L. Gender specific differences of cardiovascular risk factors in different age groups (according to the ESSE-RF study). Medicine in the Kuzbass . 2016; 15(1): 75–82 [in Russian]
15. Muromtseva G. A., Kontsevaya A. V., Konstantinov V. V. et al. The prevalence of risk factors of noninfectious diseases in the Russian population in 2012-2013. Survey ESSAY-RF. Cardiovascular therapy and prevention . 2014; 13(6): 4–11 [in Russian] https://doi.org/10.15829/1728-8800-2014-6-4-11
16. Kamaev Yu. O., Cherkasov S. N., Cherkasova S. V. et al. Status of pregnancy health in the Russian Federation from 2000 to 2015. Byulleten' nacional'nogo nauchno-issledovatel'skogo instituta obshchestvennogo zdorov'ya imeni N. A. Semashko. 2017; (7): 37–44. [in Russian]
17. Grand'Maison S., Pilote L., Okano M. et al. Markers of vascular dysfunction after hypertensive disorders of pregnancy: a systematic review and meta-analysis. Hypertension. 2016; 68(6): 1447–1458. https://doi.org/10.1161/HYPERTENSIONAHA.116.07907
18. Costa-Hong V. A., Muela H. C. S., Macedo T. A. et al. Gender differences of aortic wave reflection and influence of menopause on central blood pressure in patients with arterial hypertension. BMC Cardiovascular Disorders. 2018; 18(1): 123. https://doi10.1186/s12872-018-0855-8
19. Omboni S., Posokhov I., Parati G. et al. Ambulatory blood pressure and arterial stiffness web-based telemonitoring in patients at cardiovascular risk. First results of the VASOTENS (Vascular Health Assessment of the Hypertensive Patients) Registry. The *Journal* of *Clinical Hypertension.* 2019; 21(8): 1155–68. https://doi10.2196/resprot.5619
20. Kurimoto R., Shiraishi H., Taniguchi T. et al. Brachial-Ankle Pulse Waves Reflect the Hemodynamics of Valvular Heart Disease. The Journal of heart valve disease. 2018; 27(1): 71–77.
21. Kao Y. T., Wang S. T., Shih C. M. et al. Arterial stiffness index and coronary artery plaques in patients with subclinical coronary atherosclerosis. Acta Cardiologica Sinica. 2015; 31(1): 59–65. https://doi10.6515/ACS20140630B
22. Phan T. S., Li J. K., Segers P. et al. Aging is associated with an earlier arrival of reflected waves without a distal shift in reflection sites. Journal of the American Heart Association. 2016; 5(9): 1–10. https://doi10.1161/JAHA.116.003733
23. Monge Garcia M. I., Jian Z., Settels J. J. et al. Performance comparison of ventricular and arterial dP/dtmax for assessing left ventricular systolic function during different experimental loading and contractile conditions. Critical Care. 2018; 22(1): 325. https://doi10.1186/s13054-018-2260-1
24. Aslanger E., Assous B., Bihry N. et al. Baseline subendocardial viability ratio influences left ventricular systolic improvement with cardiac rehabilitation. The Anatolian Journal of Cardiology. 2017; 17(1): 37–43. https://doi10.14744/AnatolJCardiol.2016.7009