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Review Article

THE AORTIC ELASTICITY IN HEARING-IMPAIRED GIRLS AFTER DYNAMIC LOAD.

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Abstract

Persons with hearing impairments are a fairly large group of people whose physiological characteristics are poorly understood. Particular attention should be paid to the state of their cardiovascular system due to the fact that the body of a hearing-impaired person develops in reduced motor activity. When measuring hemodynamic parameters in real-time using an ultrasound monitor in girls with varying degrees of hearing loss, differences were revealed compared with those of normally hearing girls. We analyzed the following hemodynamic parameters at rest and after dynamic loading: aortic compliance (C), mean pressure gradient in aorta (Pmn), pulse arterial pressure (BPp), peak velocity (Vpk), and stroke volume variation (SVV). Higher values of mean pressure gradient in aorta, pulse blood pressure, and peak velocity after dynamic loading were obtained. Differences in the dynamics of aortic compliance indicator values were revealed. An assessment of aortic elasticity in girls with hearing impairment is given. These studies can be used during medical examinations in people with disabilities; when compiling guides for doctors and specialists in cardiology and functional diagnostics; in the preparation of teaching aids for specialists in age and sports physiology, teachers and trainers of specialized boarding schools for hearing-impaired and deaf children.

Keywords: Diagnosis, cardiovascular system, hemodynamics, aortic compliance, aortic elasticity, ultrasound methods.

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INTRODUCTION

Persons with hearing impairment account for more than 5% of the world's population, the physiological characteristics of which are not well understood [1]. The factor of the congenital pathology of the auditory analyzer plays a decisive role in the formation of mechanisms that regulate the functioning of the heart. A person's lifestyle and the prevailing types of loads and their intensity can have a significant impact on these processes. A negative effect on the development of the mechanisms of regulation of the functions of the cardiovascular system (CVS) occurs with reduced motor activity, which is inherent in people with hearing impairment [2]. The physiological characteristics of school-age children with diseases of the auditory analyzer in our country have been studied quite well since there are specialized boarding schools for this category of children. Studies on the physiological characteristics of the regulation of CVS in adults with hearing impairments are not well represented. The literature provides data on the relationship between hearing loss and clinical manifestations of coronary heart disease [3]. Studies have also been conducted to identify the risk of cardiovascular disease in people with various hearing impairments [4]. Earlier, we discovered the influence of severe hearing pathology on the indicators of cardiac output and stroke volume [5,6]. However, it is extremely important to study the contribution of the vascular component to the hemodynamics of the hearing impaired. According to modern authors [7,8,9,10], stiffness of the arterial system is one of the most important factors affecting the level of blood pressure, the fixation of changes, that is necessary to assess the development of the risk of cardiovascular diseases. In this regard, the analysis of aortic elasticity indices gives a more complete description of the hemodynamic state, and it will be possible to draw conclusions about such parameters as preload, afterload, and arterial stiffness.

The aim of our research was to study the hemodynamic parameters in individuals with varying degrees of hearing loss.

MATERIALS AND METHODS

The study of hemodynamic parameters was carried out in 39 girls aged 16-20 years. 21 of them had a hearing pathology of various etiologies and severity, and 18 who had no history of pronounced deviations in the state of the cardiovascular system (CVS) and in the functioning of analyzers made up the control group.

The hemodynamic parameters were measured using an ultrasound cardiac output monitor (USCOM 1-A, Ultrasound Cardiac Output Monitor, Australia) equipped with a 2.2 MHz sensor in AV mode (aortic valve). All measurements were carried out at rest (in the supine position, before the measurements the subjects were in a horizontal position for 5 minutes) and after a functional test under dynamic load. As a dynamic load, the Kushelevsky-modified Martine test was chosen. The test consists of doing 20 squats in 30 seconds. The hemodynamic parameters were fixed at the 1st, 3rd, 5th, and 7th minutes after the dynamic load. To perform hemodynamic measurements in the AV mode, the sensor was positioned in the suprasternal position so that the ultrasound waves emitted by the sensor were precisely directed into the lumen of the ascending aorta towards the aortic valve. The correct positioning of the sensor was determined by the value of the peak blood flow velocity (Vpk), the graphic image of the peak ejection on the monitor screen, the sound tone accompanying the systole (in accordance with the description in the instructions for the device). After adjusting the sensor and obtaining the desired image on the monitor screen, we continued the measurements for the first minute with a choice of practically identical amplitudes of 5 to 8 peaks with an equal interval between them. The average values were selected for further analysis. The values of hemodynamic parameters were obtained and analyzed: pulse blood pressure (BPp); stroke volume (SV); peak velocity (Vpk); stroke volume variation (SVV), pressure gradient in the aorta (Pmn). The aortic compliance (C) value was also calculated, which is the ratio of the increase in blood volume in the vessel to the pressure increase, according to the formula: $C = SV*SVV/100/Pmn$.

Statistical processing of the results was performed by using a Biostat computer program with Student's t-test. All mean values in the text are presented as M±σ. Differences were considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSION

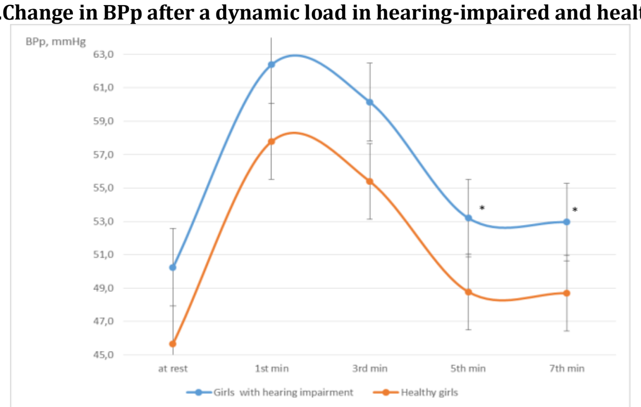
The initial values of pulse blood pressure (BPp) were 50.2±8.14 mm Hg in hearing-impaired girls aged 17-21 and 45.7±7.62 mm Hg in girls with normal hearing. After a dynamic load in the first minute, BPp increased by 24.17% (62.4±7.04 mm Hg) in hearing-impaired girls, BPp increased by 26.52% in normally hearing girls (57.8±10.21 mm Hg). At the 5th minute of observations, BPp in girls with hearing pathology was 5.97% (53.2±6.42 mm Hg) higher than the baseline; for girls without hearing pathology, it was 6.81% higher than the baseline (48.8±4.56 mm Hg). At the 7th minute after the Martinet test, girls with insufficient auditory analyzer function had their BPp 5.40% higher than the initial one (53.0±6.50 mm Hg), girls with normal auditory analyzer function had it 6.57% higher (48.7±4.49 mm Hg). The detected BPp values at the 5th and 7th minutes of the recovery period after dynamic load were higher for hearing-impaired girls than normal-hearing girls (p <0.05) (Table 1, Figure 1).

Table 1. Values of aortic elasticity and peak blood flow velocity in girls aged 16-20 years at rest and after dynamic load (M±σ).

Indicators of hemodynamics	At rest		After dynamic loading							
			In the 1st minute		In the 3rd minute		In the 5th minute		In the 7th minute	
	Girls with hearing impairment	Healthy girls	Girls with hearing impairment	Healthy girls	Girls with hearing impairment	Healthy girls	Girls with hearing impairment	Healthy girls	Girls with hearing impairment	Healthy girls
BPp, mmHg	50,2±8,14	45,7±7,62	62,4±7,04	57,8±10,21	60,1±9,12	55,4±8,93	53,2±6,42*	48,8±4,56	53,0±6,50*	48,7±4,49
Δ			24,17%	26,52%	19,72%	21,29%	5,97%	6,81%	5,40%	6,57%
Vpk, m/s	1,5±0,23	1,4±0,22	1,8±0,20*	1,6±0,30	1,7±0,20	1,6±0,29	1,7±0,19**	1,5±0,24	1,6±0,20**	1,4±0,24
Δ			17,41%	17,53%	14,24%	12,35%	11,08%	9,56%	6,33%	2,75%
Pmn, mmHg	4,2±1,24	3,6±1,06	5,4±1,19	5,0±1,79	5,2±1,21	4,4±1,60	4,9±1,12	4,2±1,31	4,6±1,02*	3,8±1,23
Δ			28,23%	37,93%	22,27%	23,07%	16,31%	16,72%	8,55%	6,35%
SVV, %	19,6±7,57	18,6±6,68	21,9±5,47	22,7±6,02	19,3±7,49	19,7±6,50	17,9±5,35	17,9±4,70	18,9±10,01	17,0±5,14
Δ			11,82%	22,09%	-1,48%	5,85%	-8,71%	-4,00%	-3,79%	-8,66%
C, l/mmHg	4,2±1,84	4,5±2,07	3,8±1,19	4,5±1,75	3,6±1,68	4,5±2,23	3,5±1,27	4,0±1,57	3,8±2,33	3,9±1,26
Δ			-8,33%	1,07%	-13,90%	0,57%	-16,02%	-9,70%	-7,94%	-12,35%

Notes: Δ - dynamics of the values of indicators in % compared with the value at rest;
* - the significance of differences between the average values in girls with and without hearing pathology p≤0.05;
** - the significance of differences between the average values in girls with and without hearing pathology p≤0.01;

Figure 1.Change in BPp after a dynamic load in hearing-impaired and healthy girls.



Note:

* - the significance of differences between the absolute values in girls with and without hearing pathology p≤0.05.

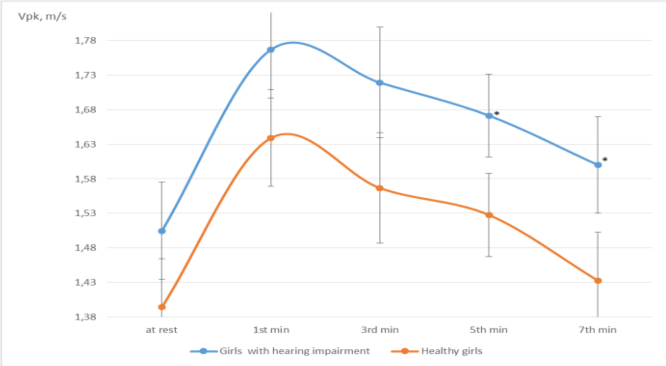
Higher BPp values after dynamic loading indirectly indicated a more pronounced manifestation of arterial stiffness in hearing-impaired girls compared to healthy girls, however, the final conclusion can be made only by analyzing the dynamics of changes in other indicators of central hemodynamics. Differences in BPp values were noted at the end of the recovery period after the dynamic load, which could indicate a reduced adaptive capacity of CVS in girls with a hearing disorder.

Immediately after dynamic load, the value of the peak velocity Vpk in hearing-impaired girls increased by 17.41% (1.8±0.20 m/s), in healthy girls - by 17.53% (1.6±0.30 m/s). At the 5th minute after the Martinet test, the Vpk value for girls with the impaired auditory analyzer was 11.08% higher (1.7±0.19 m/s) than that for the healthy girls - by 9 56% (1.5±0.24 m/s). At the 7th minute after the dynamic load, the Vpk value in girls with hearing pathology was higher than the initial value by 6.33% (1.6±0.20 m/s), in the healthy girls - by 2.75% (1.4 ± 0.24 m/s).

Thus, we recorded higher Vpk values for hearing-impaired girls aged 16–20 years compared with healthy girls of the same age after the Martinet test (dynamic load) on the 5th and 7th (p<0.01) minutes (Table 1, Figure 2). Therefore, a more pronounced reaction of the contractile function of the heart to the dynamic load was observed in girls with impaired activity of the auditory analyzer than in healthy girls at the end of the recovery period after the dynamic load.

Vpk characterizes the maximum speed of blood flow directly in the place of its ejection from the left ventricle to the aorta in a straight section of the vessel from the aortic valve to the ultrasound transducer. Thus, higher Vpk values for hearing-impaired girls aged 16–20 years old than their normally hearing peers indicated a greater intensity of myocardial contractions after performing a dynamic load, and, therefore, a possible sympathetic predominance in the regulation of heart activity in hearing-impaired girls of this age group.

Figure 2. Change in Vpk after a dynamic load in hearing-impaired and healthy girls.



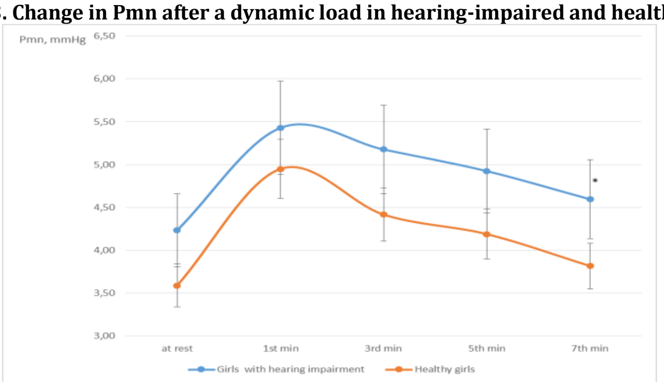
Note:

* - the significance of differences between the absolute values in girls with and without hearing pathology $p \leq 0.05$.

The analysis of the aortic compliance indicator (C) showed approximately equal initial values in girls aged 16-20 years with and without pathology of the auditory analyzer (Table 1). After a dynamic load, starting from the first minute, hearing-impaired girls had a gradual decrease in C by 16.02% than the original (to 3.5±1.27 l/mm Hg) by the 5th minute of observations. In normally hearing girls, up to the 5th minute after the dynamic load, there were no changes in the values of indicator C, but at the 5th minute there was a decrease by 9.70% from the initial one (to 4.0±1.57 l/mm Hg). Despite the absence of significant differences in the values of C both at rest and after a dynamic load in the compared groups of girls, for hearing-impaired girls, we recorded lower values of the indicator C (Table 1).

After the dynamic load, an increase in mean pressure gradient in the aorta (Pmn) was observed, followed by a gradual decrease to 4.6±1.02 mm Hg in girls with hearing impairment and 3.8±1.23 mm Hg in normally hearing girls by the 7th minute of the recovery period. Moreover, Pmn in hearing-impaired girls aged 16–20 years was significantly higher than this indicator than in healthy peers ($p < 0.05$). Consequently, the increased pressure in the aorta, provoked by a dynamic load, returned to its initial values at rest faster in healthy girls than in girls with deviations in the work of the auditory analyzer (table 1). However, these differences are noticeable only at the final stage of the recovery period after the dynamic load (Figure 3).

Figure 3. Change in Pmn after a dynamic load in hearing-impaired and healthy girls.



Note:

* - the significance of differences between the absolute values in girls with and without hearing pathology $p \leq 0.05$.

At the 1st minute after the dynamic load, the initial value of the SVV indicator increased by 11.82% in girls with hearing impairment, and by 22.09% in girls with normal hearing. By the 3rd minute of the recovery period, SVV values were recorded lower than the initial ones by 1.48% in hearing-deprived girls and 5.85% higher in girls with normal hearing. By the 5th minute after the Martinet test, hearing-impaired girls had an SVV value of 8.71% lower than the initial value and 4.00% in healthy girls. Thus, less pronounced changes in the stroke volume of blood were observed in girls aged 16-20 with hearing pathology up to the 5th minute after dynamic load than in their healthy peers.

The obtained values of aortic compliance (C), mean pressure gradient in aorta (Pmn), pulse blood pressure (BPp), peak velocity (Vpk), and stroke volume variation (SVV) testified to manifestations of a decrease in the elastic properties of the arterial system with increasing pressure in aorta in response to dynamic stress in hearing-impaired girls aged 16-20 years compared with healthy girls of the same age. BPp and Pmn indicators, which quantitatively characterize the elastic properties of arteries, had greater values at the end of the recovery period after dynamic loading in hard of hearing girls than normally hearing girls, which may indirectly indicate a more pronounced manifestation of arterial stiffness in girls with hearing pathology than in girls without pathology of hearing. Significant differences in BPp and Pmn in the compared groups of girls observed at the end of the recovery period after a dynamic load can indicate the peculiarities of the compensatory reaction of the arterial system of girls aged 16-20 years with hearing impairment.

It should be noted that increased BPp and Pmn values were recorded against the background of increased Vpk values, which may refute the initial opinion about the predominance of the influence of the sympathetic system on the contractile function of the heart in the final segment of the recovery period after dynamic loading. Increased Vpk could result from the increased pressure in the aorta, due to changes in the morphofunctional state of the arterial wall.

SUMMARY

Thus, we revealed significantly higher values of hemodynamic parameters of Vpk, BPp, and Pmn at low C values in the hearing-impaired girls compared with healthy girls, which indicated signs of arterial stiffness at the final stage of the recovery period after the dynamic load.

CONCLUSION

Based on the data obtained in the course of our study, it can be concluded that persons with hearing impairments need to more thoroughly diagnose hemodynamics, including using functional tests. The data of the study can be used during medical examinations in people with disabilities; when compiling guides for doctors and specialists in the field of cardiology and functional diagnostics; in the preparation of teaching aids for specialists in age and sports physiology, teachers and trainers of specialized boarding schools for hearing-impaired and deaf children; functional diagnostics in athletes, participants in the Deaf Olympic Games.

CONFLICT OF INTERESTS

The author declares that the provided information has no conflicts of interest.

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