Research Article

The use of modern ultrasound methods in the diagnosis of cardiovascular system

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ABSTRACT

Aim: According to the World Health Organization, the diseases of cardiovascular system (CVS) are the main cause of death worldwide, for the past 15 years. In this regard, the importance of precision diagnosis of this type of diseases has significantly increased. **Material and Method:** Noninvasiveness, simplicity, reliability, and informativeness are the main features of modern methods of CVS diagnosing. Ultrasonic methods of diagnosis are of particular interest. They are currently preferred in many cases, due to the compliance with the above principles. One of the most important properties of ultrasound is the Doppler effect, using which it is possible to obtain values of cardiovascular activity in real time, with each heartbeat (beat-to-beat). **Result and Discussion:** Such investigations are especially important for the people with disabilities. When measuring the parameters of CVS, using an ultrasound cardiac output (CO) monitor, deviations from the norm and the parameters of the control group were found in young people with disabilities. We have analyzed a number of different parameters such as blood pressure, stroke volume, CO, cardiac index, and vascular resistance. The dynamics of changes in these indicators, their nature, require a more thorough study, aimed to determine the factors of their occurrence. **Conclusion:** The given researchers can be used for functional diagnostics in sports medicine, during medical examinations of students and sportsmen (professionals, amateurs, and participants of Paralympic games).

KEY WORDS: Cardiac output, Cardiovascular system, Diagnosis, Hemodynamics, Ultrasonic methods of research

INTRODUCTION

At the present time, mass media regularly informs about the cases of athletes death during a match or training process. These incidents occur as in professional sportsmen, as in amateurs. It should be noted that most athletes regularly undergo a medical examination using modern diagnostic tools.

The actual issue is the dosage of physical exertion, which the student receives during the lessons of physical training in higher education institutions, and during training in various sections. Despite the available developed programs, taking into account the state of students' health, there are the cases of excessive physical exertion during the course of sports activities. This is due to the fact, that, most of the time, mainly, the student does not have such physical exertions, contributing to the normal formation of the cardiovascular system (CVS). In this connection, a careful individual approach to assessing the CVS parameters is necessary to prevent the negative consequences of excessive physical exertion in students during sports training. It is also important that in the course of making programs for the lessons of physical training in the higher education institutions, it does not take into account the specificity of concomitant pathology, not related to CVS, especially in students with disabilities. As practice shows, some types of deviations in the state of health lead to mediated influence on the activity of the CVS and the restriction of activity in the period of the organism formation, which cannot but affect the development and formation of the heart.

According to the World Health Organization, diseases of the CVS are the leading cause of death worldwide, for the past 15 years.[1] In nowadays, more and more sophisticated methods of examination come to the rescue to medical workers for solving diagnostic problems. In medical technology, the possibilities of ultrasonic waves and the Doppler effect are used more often. The main ultrasonic method, which makes it possible to appraise the state of CVS, is

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echocardiography (EchoCG). The method has proved itself in medical practice, but the most important factor of widespread use is its noninvasiveness. According to the expert opinion, EchoCG is a conventionally invasive technique (transesophageal access).[2] In addition, the method requires a high qualification of the doctor, because it is necessary to possess the technique of transesophageal placing, accurate positioning the ultrasonic transducer, and differentiation of tissues and organs on the monitor screen. Often, the EchoCG data strongly deviate from the values obtained by invasive monitoring (thermodilution method).[3] In connection with the above-mentioned reasons, an actual noninvasive method of investigation is the ultrasonic measurement of ejection into the aorta by means of an appropriate device that allows to determine the above parameter in real time. While working on this equipment, the precise location of the transducer is important; a human factor is also essential, but there are several well-defined criteria that help to avoid erroneous measurement of parameters. This method of research can be used not only by doctors of functional diagnostics but also by specialists of related disciplines. Over the past decade, studies have been conducted on the basis of medical institutions in Europe, Asia, America, Australia, and Russia, using ultrasound monitoring of stroke volume (SV) output in patients of different profiles. The parameters of CVS were studied during the operations in the field of abdominal surgery,[4] cardiosurgery,[5] liver transplantation,[6] in septic patients,[7] in patients with pulmonary embolism,[8] and in pregnant women.[9,10] Based on the data of these studies, it is possible to note the accuracy of ultrasound monitoring, even in comparison with invasive methods.

The aim of our study is to measure the SV output from the left ventricle to the aorta in young people, 20-23 years old, with disabilities, not associated with the CVS pathology. As a control group, apparently healthy students, who did not have CVS diseases took part in the study.

METHODS

The parameters of blood pressure (BP) were measured by a sphygmomanometer in the experimental group, with further obtaining values for the parameters of ventricular ejection such as SV, cardiac output (CO), heart rate (HR), cardiac index (CI), peak velocity (Vpk), minute distance (MD), systemic vascular resistance (SVR), and other design parameters, using USCOM (Ultrasound Cardiac Output Monitor, Australia). All measurements were carried out at rest. To conduct a correct measurement of the SV, several input data were used, namely: Age (date of birth); gender; and anthropometric parameters (height, body weight). This information is needed to determine the diameter of the aortic valve annulus, on which the calculated parameters depend. After the input of the primary data, the first stage of the study was carried out - measurement of BP. The values of systolic BP (SBP) and diastolic BP (DBP) were also entered into the monitor memory. The next step is the accurate positioning of the ultrasound transducer in the suprasternal position in such a way that the ultrasound beam is precisely directed into the lumen of the ascending aorta at the center of its maximum length. The correct positioning of the transducer was determined, by means of three indicators:

- Vpk (it has definite limits for different age groups, in our case from 1.1 to 1.4);
- Graphic representation of the peak of the output on the monitor screen (it must be of a certain shape and color, it should not have any interference);
- Sound signal (has a certain tone at the time of the output).

After adjusting the transducer, a certain number of output peaks were obtained on the screen (for the primary evaluation, it is enough to have 7-8 graphically verified peaks on the monitor screen, first of all, the absence of a double top). To check the average values, measurements were continued for a minute. For further analysis, peaks, equal in amplitude, were chosen in the amount of 7-8 pieces, with an equal interval between them.

RESULTS AND DISCUSSION

The following CVS parameters were analyzed: HR; BP; SV; CO; CI; SVR; Vpk; and MD.

MD is a complex parameter, which simultaneously characterizes the functions of heart and blood vessels. This parameter of CO is independent of the cross-sectional area of the blood vessel; however, its value is affected by the HR, BP, SV, and vascular resistance. Thus, the deviation from the norm of this parameter indicates the presence of a malfunction in any part of the blood circulatory system, that is, shows the presence of compensatory function of heart with increased vascular resistance or hypertension or indicates a malfunction of the heart itself.

RESULTS

Obtained parameters of CVS functioning in persons with disabilities (experimental group) differed from those in the group of apparently healthy students (control group). Mean values of BP in the experimental group were the following: SBP – 131 ± 25.2 mmHg; DBP – 72 ± 13.7 mmHg; and pulse pressure (PP) – 59 ± 14.1 mmHg. In the control group, the same parameters were, respectively, the following: SBP – 116 ± 12.4 mmHg; DBP – 66 ± 6.4 mmHg; and PP – 50 ± 11.4 mmHg. The values of HR in the experimental group were 89 ± 18.9 beats per minute, whereas in the

control group they were 66 ± 5.7 beats per minute. The flow rate was 1.6 ± 0.2 m/s and 1.3 ± 0.2 m/s, accordingly. In the experimental group, the average MD was 27 ± 3.7 m/min, while in the control group, it was 18 ± 2.3 m/min. Mean values of cardiac activity in the test group were the following: SV – 93 ± 19.5 cm³, SV index – 57 ± 11.3 ml/m²; CO – 8.0 ± 0.8 L/min; CI – 5.0 ± 0.6 L/min/m²; SVR – 921 ± 128.5; and SVR index is 1501 ± 277.5. In the control group, SV – 79 ± 8.4 cm³; SV index – 46 ± 7.4 ml/m²; CO – 5.0 ± 0.6 L/min; CI – 3.0 ± 0.5 L/min/m²; SVR – 1314 ± 195.2; and SVR index is 2268 ± 414.4, respectively. In addition, the mean values and standard deviations of the following parameters were obtained: Pmn – mean pressure gradient (4.6 ± 1.1 mmHg in the experimental group and 27.0 ± 2.6 mmHg in the control group); Vti – velocity time integral (31.0 ± 5.5 cm and 3.1 ± 0.6 cm); ET% – ejection time in percentage (45.0 ± 7.6% and 35.0 ± 3.4%); FT – flow time (308.0 ± 24.2 ms and 321.0 ± 21.4 ms); and SVV – SV variation (change of the ejection volume) (20.0 ± 4.6% and 24.0 ± 4.7%).

DISCUSSION

Significant differences of studied parameters were revealed: MD ($P \leq 0.05$), CO ($P \leq 0.05$), and CI ($P \leq 0.05$). The values of BP, HR, and SV in the experimental group were higher than those obtained in the control group; however, there were no significant differences in the parameters.

CONCLUSION

It should be noted that most of the average values of parameters, characterizing SV output, and differed to the higher side in the experimental group. Values of SVR, respectively, were higher in young people from the control group. At the same time, there was a much larger scatter in the parameter values of the experimental group, which is seen when calculating the value of the standard deviation. However, during the statistical analysis, we did not find significant differences in CVS of both groups. This is primarily the case of BP, SV, and HR values.

Based on the obtained data, the average indices of SBP in the experimental group are higher than in the control group; however, it was not possible to confirm the statistical significance of this difference. As noted above, significant differences were found in the following parameters: MD ($P \leq 0.05$), CO ($P \leq 0.05$), and CI ($P \leq 0.05$). The obtained experimental data clearly demonstrates the significance of such studies in real-time mode, in connection with the fact, that there are no significant differences in such parameters as BP, SV, and HR. Calculated values of the minute and SV of blood circulation, based on the measurement of only BP and HR, did not show a reliable picture. While the CO values obtained with each heartbeat, and in addition to them, the values of the MD complex index more objectively reflect the processes, occurring in CVS. It is important to note that some of the parameters in the experimental group were above the norm, in particular, the MD value, the CO value at the upper limit of the norm, whereas in the control group of students, these parameters were normal. If there are some changes in the identified parameters (an increase of MD, CO, and CI), students need more careful monitoring of the CVS parameters, when dosing physical exertion and having a certain symptomatology, to further diagnosis of abnormalities in the function of heart valves, vascular tone, (possibly clinical, and if necessary, invasive) and examination of students.

Thus, in individuals, whose physical activity has been limited in connection with the underlying disease since birth, it is necessary to perform more thorough diagnosis of cardiovascular functioning, using modern methods such as ultrasonic examination of CO, which is especially important for those, who have dedicated their life for sports and physical culture. Timely implementation of modern diagnostic methods will help in resolving the issue of the causes of abnormalities in the state of the CVS, in choosing the methods of examination, and further correction of the revealed health problems.

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