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CHANGES OF MORPHOFUNCTIONAL STATE OF CARDIOVASCULAR SYSTEM IN ADOLESCENTS WITH METABOLIC SYNDROME MANIFESTATIONS

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The results of investigation of features of morphofunctional state of cardiovascular system in adolescents with manifestations of metabolic syndrome depending on presence of hyperuricemia are presented. In the cardiorheumatology department of the hospital, 34 adolescent patients were observed. Criteria for inclusion in the study: the presence of increased blood pressure levels, increased body mass index values. Depending on serum uric acid levels, patients were divided into two groups: group 1 – patients without hyperuricemia ($n = 18$) and group 2 – patients with hyperuricemia ($n = 16$). Functional diagnostic methods were used: standard 12-channel electrocardiography, transtoral echocardiography, daily Holter monitoring. The main attention was paid to the study of the parameters of the left ventricle. Student's *t*-test was used to determine the significance of the differences, the results at $p < 0.05$ were considered reliable. It was established that adolescents with hyperuricemia were more often diagnosed with primary and secondary arterial hypertension, less often with labile arterial hypertension and autonomic dysfunction syndrome by hypertensive type, and adolescents without hyperuricemia were equally often diagnosed with primary arterial hypertension and labile arterial hypertension, autonomic dysfunction syndrome by hypertensive type. Signs of left ventricular remodeling according to echocardiography were more often noted in boys without hyperuricemia (62.5% of cases) than in girls without hyperuricemia (10%; $p < 0.01$) and in boys with hyperuricemia (26.7%; $p > 0,05$). The findings indicated more significant changes in the morphofunctional state of the cardiovascular system in adolescents with hypertensive conditions and manifestations of metabolic syndrome without hyperuricemia, which requires further study.

Keywords: cardiovascular system; morphofunctional state; adolescents; metabolic syndrome; hyperuricemia.

ИЗМЕНЕНИЯ МОРФОФУНКЦИОНАЛЬНОГО СОСТОЯНИЯ СЕРДЕЧНО-СОСУДИСТОЙ СИСТЕМЫ У ПОДРОСТКОВ С ПРОЯВЛЕНИЯМИ МЕТАБОЛИЧЕСКОГО СИНДРОМА

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Представлены результаты исследования особенностей морфофункционального состояния сердечно-сосудистой системы у подростков с проявлениями метаболического синдрома в зависимости от наличия гиперурикемии. В кардиоревматологическом отделении наблюдали 34 пациента подросткового возраста. Критерии включения

в исследование: наличие повышенных значений уровня артериального давления и индекса массы тела. В зависимости от значений уровня мочевой кислоты в сыворотке крови пациенты были разделены на две группы: группа 1 — пациенты без гиперурикемии ($n = 18$) и группа 2 — пациенты с гиперурикемией ($n = 16$). Использовались функциональные методы диагностики: стандартная 12-канальная электрокардиография, трансторакальная эхокардиография, суточное холтеровское мониторирование. Основное внимание уделяли изучению параметров левого желудочка. Для определения значимости различий использовали *t*-критерий Стьюдента, достоверными считали результаты при $p < 0,05$. Установлено, что у подростков с гиперурикемией чаще диагностировали первичную и вторичную артериальную гипертензию, реже — лабильную артериальную гипертензию и синдром вегетативной дисфункции по гипертоническому типу, а у подростков без гиперурикемии одинаково часто диагностировали первичную артериальную гипертензию и лабильную артериальную гипертензию, синдром вегетативной дисфункции по гипертоническому типу. У мальчиков без гиперурикемии превалировала лабильная артериальная гипертензия, а у девочек — синдром вегетативной дисфункции по гипертоническому типу. Признаки ремоделирования левого желудочка по данным эхокардиографии чаще отмечали у мальчиков без гиперурикемии (62,5 % случаев), чем у девочек без гиперурикемии (10 %; $p < 0,01$) и у мальчиков с гиперурикемией (26,7 %; $p > 0,05$). Полученные данные свидетельствуют о более значимых изменениях морфофункционального состояния сердечно-сосудистой системы у подростков с гипертензивными состояниями и проявлениями метаболического синдрома без гиперурикемии, что требует дальнейшего изучения.

Ключевые слова: сердечно-сосудистая система; морфофункциональное состояние; подростки; метаболический синдром; гиперурикемия.

BACKGROUND

Arterial hypertension is recognized as a component of metabolic syndrome (MS) in the adult population and is considered a significant and independent risk factor for cardiovascular pathology [2]. The urgency of this problem has recently prompted studies of MS-associated comorbid conditions in adolescents, despite numerous disagreements and disputes over the diagnostic criteria for MS and its clinical significance [3, 4, 12]. The concept of MS has not been specified in the ICD-10 and is not subject to statistical accounting. However, in real life, it is constantly discussed by doctors and the population regarding preventing adverse medical consequences, such as atherosclerosis and type 2 diabetes mellitus. MS is considered a "disease of abundance," which clinically presents as obesity with dyslipidemia and arterial hypertension. At the same time, hyperuricemia in adults is recognized as an integral component of MS since it is often combined with insulin resistance and lipid metabolism disorders [13]. Evidence indicates that arterial hypertension and abdominal obesity in adolescents contribute to the deterioration of cardiovascular system functional characteristics. This deterioration manifests as an increase in the frequency of left ventricular myocardial remodeling in the form of concentric hypertrophy with initial manifestations of diastolic dysfunction [14]. The effect of hyperuricemia in adolescents with MS on the cardiovascular system morphofunctional parameters has not been adequately studied.

This study aims to determine the aspects of the cardiovascular system morphofunctional condition in adolescents with manifestations of MS, depending on the presence of hyperuricemia.

PATIENTS AND METHODS

From 2018 to 2019, 34 adolescent patients ($M \pm \sigma = 15.4 \pm 1.9$ years) were under follow to up in the cardio-rheumatology department of St. Petersburg St. Mary Magdalene Children's City Hospital No. 2 (chief physician A.G. Mikava). They were consistently admitted for examination and treatment of increased blood pressure (BP) values.

The criteria for enrolling patients in the study were elevated BP values and increased body mass index (BMI) values.

The decision about the increase in BP was made considering the clinical recommendations "Arterial hypertension in children" of the Ministry of Health of the Russian Federation (2016) [6]. The systolic (SBP, mm Hg) and diastolic blood pressure (DBP, mm Hg) were determined based on the centile distribution of the patient's height. The assessment categories were defined in points, where 0 conditional points indicated normal BP, 1 point meant high normal BP, and 2 points implied arterial hypertension. Body weight was measured and assessed by height (in points according to centile tables). Height was measured and determined by patient age (in points according to centile tables), and BMI (kg/m^2) was calculated. BMI values were considered increased if they were not lower than the 75 centile level, corresponding to assessments of 6, 7, or 8 points.

Depending on the values of uric acid levels in the blood serum (more than 400 μmol/L for boys and more than 300 μmol/L for girls), the patients were distributed into two groups: group 1 consisted of patients without hyperuricemia ($n = 18$; 52.9%) and group 2 included patients with hy-

peruricemia (n = 16; 47.1%). Although the groups were comparable regarding age, they had gender differences, as boys comprised the majority (n = 23; 67.6%).

All patients underwent general clinical blood and urine tests; biochemical blood test with the determination of parameters of fat and carbohydrate metabolism [cholesterol, low-density lipoproteins (LDL) and high-density lipoproteins (HDL), atherogenic index, triglycerides, glucose], with an assessment of the thyroid profile [total T3, free T4, thyroid-stimulating hormone (TSH)]. Additionally, the blood levels of creatinine and cortisol were determined.

The examination protocol included functional and radiation diagnostic methods, namely standard 12-lead electrocardiography (ECG) (Shiller and Fucuda), transthoracic echocardiography (Echo-CG) (Toshiba Aplio500CV and Vivid 7 Pro), 24-hour Holter monitoring (HM), ECG (Kardiotehnika 07 Inkart), ultrasound examination (US) of the thyroid gland and abdominal organs, and examination of the fundus. When analyzing the ECG to determine the signs of left ventricular myocardial hypertrophy (LVMH), the Sokolow–Lyon index was also determined. The percentile distribution of the Echo-CG values was determined depending on body weight according to the tables of Belozerov and Bolbikov [1] and expressed in points. At the same time, the evaluation of echo-CG indicators of 1 point corresponding to values less than 3 percentiles, 2 points corresponding to values from 3 to 10, 3 points corresponding to values from 10 to 25, 4 points corresponding to values from 25 to 50, 5 points corresponding to values from 50 to 75, 6 points corresponding to values from 75 to 90, 7 points corresponding to values from 90 to 97, and 8 points corresponded to values more than 97 percentiles. The mean values of the echo-CG parameters and their percentile distribution were calculated depending on the body weight in the patient groups.

Considering that in adolescents, arterial hypertension and abdominal obesity (as components of MS) contribute to the deterioration of the functional characteristics of the cardiovascular system, which is primarily manifested by remodeling of the left ventricle (LV), most attention was paid to echo-CG parameters of the LV. The end-systolic (ESD, cm) and end-diastolic (EDD, cm) dimensions of the LV were measured and evaluated. The LV myocardium mass (LVMM, g), LV myocardial mass index (LVMMI, g/m^2), the thickness of the interventricular septum (IVS, mm), the thickness of the LV posterior wall (LVPW, mm), and the LV wall relative thickness (LVWRT) were evaluated [9, 16]. The echo-CG criterion for LVMH in boys was considered to be LVMMI at least 47.58 g/m^2, and in girls, these were LVMMI values of at least 44.38 g/m^2, corresponding to the value of the 99th percentile of the population distribution curve of LVMMI. Variants of LV myocardial changes (norm, concentric remodeling, concentric hypertrophy, eccentric hypertrophy with or without dilatation) were assessed according to the echo-CG indicators, namely LVMM (LVMMI), LVWRT, ESD, and EDD of the LV [6].

Based on generally accepted diagnostic criteria, the patients were diagnosed with essential (primary) arterial hypertension (ICD-10 code I10); symptomatic (secondary) arterial hypertension in relation to endocrine disorders (ICD-10 code I15.2); labile arterial hypertension, and autonomic dysfunction syndrome of the hypertensive type (the latter are not defined by ICD-10 as independent nosological units).

Data collection, storage, and primary grouping were performed using MS Office tools. Also, statistical data analysis was performed. The incidence of the attribute, the mean value of the indicator (M), and the standard deviation (σ) were calculated. Considering the normal distribution of the sample (quantitative data were checked for normality of distribution using the Shapiro–Wilk test), Student's t-test was used to determine the significance of differences. The results were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Analysis of the gender composition of patients in groups revealed that in group 1, the quantities of boys and girls did not differ significantly ($p > 0.05$). In contrast, in group 2, boys represented the absolute majority (93.8%; $p < 0.05$), confirming known data on the prevalence of males among patients with hyperuricemia [5]. The average age of boys in the groups did not differ significantly, just as the average age of boys and girls in group 1 did not differ significantly (Table 1).

When studying the absolute and relative values of anthropometric indicators in the patient groups, boys in group 2 were taller without differences in its relative values (Table 2).

An analysis of the established clinical diagnoses showed that primary arterial hypertension was diagnosed more often in group 1 than in group 2. In contrast, secondary arterial hypertension was diagnosed more often in group 2. Labile arterial

Table 1 / Таблица 1

Sex composition and mean age of patients in groups
Половой состав и средний возраст пациентов в группах

Sex composition and average age of patients / Половой состав и средний возраст пациентов		Group 1 / Группа 1 (n = 18)	Group 2 / Группа 2 (n = 16)
Boys / Мальчики, лет		8 (44.4%)	15 (93.8%)
Girls / Девочки, лет		10 (55.6%)	1 (6.2%)
Middle age, years ($M \pm \sigma$) / Средний возраст, лет ($M \pm \sigma$)	boys / мальчики	15.3 ± 1.9	16.2 ± 0.9
	girls / девочки	14.6 ± 2.5	14

Table 2 / Таблица 2

Absolute and relative values of anthropometric measures and blood pressure in boys and girls of observed groups
Абсолютные и относительные значения антропометрических показателей и артериального давления у мальчиков и девочек наблюдаемых групп

Indicators / Показатели	Group 1 / Группа 1		Group 2 / Группа 2	
	boys / мальчики (n = 8)	girls / девочки (n = 10)	boys / мальчики (n = 15)	girls / девочки (n = 1)
Body weight, kg / Масса тела, кг	86.1 ± 13.8	71.1 ± 21.1	92.5 ± 15.2	127
Body weight estimate by height, point / Оценка массы тела по росту, балл	6.6 ± 0.7	6.0 ± 1.2	6.6 ± 1.1	7
Height, cm / Рост, см	171.9 ± 5.9	163.0 ± 11.6	178.6 ± 6.6*	170
Age growth score, point / Оценка роста по возрасту, балл	5.0 ± 2.4	5.7 ± 1.4	5.5 ± 1.6	6
BMI (kg/m^2) / Индекс массы тела, кг/м^2	29.4 ± 5.4	26.0 ± 5.3	29.1 ± 4.1	43.8
BMI assessment, point / Оценка индекса массы тела балл	7.8 ± 0.5	7.3 ± 1.0	7.5 ± 1.0	8
Assessment of systolic blood pressure level, conditional point / Оценка уровня систолического АД, усл. балл	2 ± 0	1.6 ± 0.8	2 ± 0	2
Assessment of diastolic blood pressure level, conditional point / Оценка уровня диастолического АД, усл. балл	1.5 ± 0.8	1.4 ± 0.8	1.7 ± 0.6	2

* t = 2.4; $p < 0.05$ (Student ratio and rate of difference between Group 1 and Group 2 boys).
* t = 2,4; $p < 0,05$ (коэффициент Стьюдента и уровень различий показателя между мальчиками группы 1 и группы 2).

hypertension was detected more often in boys of group 1 than in boys of group 2. The autonomic dysfunction syndrome of the hypertensive type was detected more often in girls of group 1 (Table 3).

The data obtained indicate that among patients of group 2, primary and secondary arterial hypertension prevailed in relation to labile arterial hypertension and autonomic dysfunction syndrome of hypertensive type., Among patients of group 1, there was an equal ratio of primary arterial hypertension (50% of cases) and labile arterial hypertension, autonomic dysfunction syndrome of the hypertensive type (50% of cases in total). In boys of group 1, labile arterial hypertension prevailed, and in girls, the autonomic dysfunction syndrome of the hypertensive type prevailed.

Analysis of complaints presented by boys and girls in group 1 showed a rarer incidence of vertigo, 25% versus 90% in girls (t = –3.39; $p < 0.01$). Vertigo was clinically assessed as a manifestation of autonomic dysfunction syndrome, which was significantly more common in girls of group 1. Differences in the frequency of complaints of headaches, sleep disturbances, and heart failure was not significant. An increase in appetite was noted in 75% of boys and only 30% of girls (t = 2.01; $p > 0.05$). A decrease in physical performance was revealed in 25% of boys and 30% of girls. When compa-

Table 3 / Таблица 3

Clinical diagnosis options in boys and girls in observed groups
Варианты клинического диагноза у мальчиков и девочек в наблюдаемых группах

Clinical diagnosis options / Варианты клинических диагнозов	Group 1 / Группа 1		Group 2 / Группа 2	
	boys / мальчики (n = 8)	girls / девочки (n = 10)	boys / мальчики (n = 15)	girls / девочки (n = 1)
Primary arterial hypertension / Первичная артериальная гипертензия	4 (50%)	5 (50%)	3 (20%)	0
Secondary arterial hypertension / Вторичная артериальная гипертензия	0 (0%)	0 (0%)	7 (46.7%)	1 (100%)
Labile arterial hypertension / Лабильная артериальная гипертензия	3 (37.5%)	1 (10%)	2 (13.3%)	0
Autonomic dysfunction syndrome by hypertensive type / Синдром вегетативной дисфункции по гипертоническому типу	1 (12.5%)	4 (40%)	3 (20%)	0

Table 4 / Таблица 4

Values of biochemical metabolic indices in patients of observed groups
Значения биохимических показателей обмена веществ у пациентов наблюдаемых групп

Indicators of biochemical blood analysis / Показатели биохимического анализа крови	Group 1 / Группа 1		Group, 2 boys / Группа 2, мальчики (n = 15)
	boys / мальчики (n = 8)	girls / девочки (n = 10)	
Cholesterol, mmol/L / Холестерин, ммоль/л	4.4 ± 0.7	4.7 ± 1.0	4.6 ± 1.2
Low density lipoproteins, mmol/L / Липопротеиды низкой плотности, ммоль/л	2.1 ± 0.4	2.3 ± 0.7	2.2 ± 0.6
High density lipoproteins, mmol/L / Липопротеиды высокой плотности, ммоль/л	1.4 ± 0.4	1.3 ± 0.3	1.2 ± 0.4
Atherogenicity factor/ Коэффициент атерогенности	2.3 ± 1.0	2.6 ± 1.2	2.9 ± 1.2
Triglycerides, mmol/L / Триглицериды, ммоль/л	1.8 ± 0.7	1.4 ± 0.9	1.4 ± 0.5
Glucose, mmol/L / Глюкоза, ммоль/л	5.2 ± 0.3	4.5 ± 0.4*	5.0 ± 0.5
Creatinine, μmol/L / Креатинин, мкмоль/л	77.4 ± 15.7	62.0 ± 16.4	88.7 ± 11.5

* t = 2.4; p < 0.001 (Student ratio and rate of difference in group 1 boys and girls)
* t = 2,4; p < 0,001 (коэффициент Стьюдента и уровень различий показателей у мальчиков и девочек группы 1).

ring the frequency of complaints of vertigo, headaches, sleep disturbances, and heart failure in boys of groups 1 and 2, no significant differences were detected. An increase in appetite was registered in 75% of boys of group 1 and 80% of group 2. At the same time, a decrease in physical performance was noted more often in boys of group 2 (60%) than in boys of group 1 (25%; t = –1.9; p > 0.05).

The hereditary burden of cardiovascular pathology was registered equally often in boys of both groups (62.5% of cases each) and exceeded that value in girls of group 1 (40% of cases; p > 0.05).

The average values of lipid metabolism in patients of the groups under study did not differ significantly. However, the atherogenic index was higher in boys of group 2, and the level was higher in boys of group 1 (Table 4). The fasting blood glucose level in boys of group 1 was within the normal range but significantly higher than in girls, indirectly indicating a relative decrease in glucose tolerance. Increased BP values, increased blood glucose levels, and obesity are interrelated components of MS in adolescents [5]. Data analysis of biochemical metabolism parameters revealed more distinct changes in boys, as noted earlier [8].

Table 5 / Таблица 5

Structure and frequency of heart rhythm disorders in patient groups
Структура и частота нарушений ритма сердца в группах пациентов

Types of heart rhythm disorders / Виды нарушений ритма сердца	Group 1 / Группа 1		Group 2 / Группа 2	
	boys / мальчики (n = 8)	girls / девочки (n = 10)	boys / мальчики (n = 15)	girls / девочки (n = 1)
Sinus tachycardia / Синусовая тахикардия	3 (37.5%)	3 (30%)	4 (26.7%)	0
Sinus bradycardia / Синусовая брадикардия	2 (25%)	0	1 (6.7%)	0
Unstable supraventricular tachycardia / Неустойчивая суправентрикулярная тахикардия	0	0	1 (6.7%)	0
Single ventricular extrasystoles / Одиночные желудочковые экстрасистолы	1 (12.5%)	0	1 (6.7%)	1 (100%)
Transient AV blockade of 1 degree / Транзиторная АВ-блокада 1-й степени	0	1 (10%)	1 (6.7%)	0

According to the US, signs of fatty hepatosis were detected in 25% of boys and 10% of girls of group 1, and 53.3% of boys in group 2 ($p > 0.05$). Signs of pancreatic steatosis were revealed in 25% of boys and 30% of girls in group 1, and 60% of boys in group 2 ($p > 0.05$). Signs of hypomotor dysfunction of the biliary tract were seen in 25% of boys in group 1 and 66.7% of boys in group 2 ($t = 2.02$; $p > 0.05$). The data obtained indicated slightly more frequent morphofunctional changes in the hepato-pancreato-biliary system in boys of group 2 than in group 1.

The average values of T3, T4, TSH, and cortisol in the patient groups were within the normal range and did not differ significantly. Autoimmune thyroiditis was diagnosed in one (12.5%) boy of group 1, and secondary (postoperative) hypothyroidism was diagnosed in one (6.7%) boy of group 2.

Evaluation of ECG signs of LVMH revealed no significant differences in the values of the Sokolow–Lyon index in boys and girls of group 1 (27.8 ± 7.0 and 29.2 ± 5.6 mm, respectively), as well as in boys of both groups (27.8 ± 7.0 and 29.0 ± 8.3 mm, respectively). At the same four children (one boy and one girl of group 1, and in two boys of group 2). Moreover, LV myocardial hypertrophy was confirmed by echo-CG data in only one patient.

According to the HM ECG data, the average values of the circadian index in the groups did not differ significantly. However, the enhanced circadian profile of the heart rate (confidence interval (CI) > 1.45), indicated the increased sensitivity of the heart rate to sympathetic influences, was more often detected in girls of group 1 (50%) than in boys of group 1 (12.5%; $p > 0.05$) and group 2 (13.3%; $p > 0.05$). A decrease in CI, which has a prognostically unfavorable value at a level of less than 1.22 [10, 11], the so-called rigid circadian profile of heart rate, was noted in one patient (12.5%) of group 1 with secondary arterial hypertension.

The average values of the minimum heart rate during the day and at night in the groups of patients did not differ significantly. This finding partially coincided with the data of the authors who studied the heart rate variability in adult patients with arterial hypertension [11]. Cardiac arrhythmias were more often registered in boys of group 1 (75% of cases) than in boys of group 2 (53.3%; $p > 0.05$) and in girls of group 1 (40%; $p > 0.05$) (Table 5). The cardiac arrhythmias identified were primarily due to an imbalance of the autonomic nervous system.

Echo-CG study revealed signs of LVMH in five (62.5%) boys of group 1, in one (10%) girl of group 1 ($t = 2.5$; $p < 0.01$), in four (26.7%) boys of group 2 ($p > 0.05$), and in one (100%) girl of group 2. It should be noted that the frequency of diagnosing LVMH according to ECG and echo-CG data does not coincide, which coincides with the data of other authors [7, 15].

Minor heart anomalies (additional LV chord, mitral valve prolapse) in group 1 were detected in 12.5% of boys and 60% of girls ($t = –2.3$; $p < 0.05$), and in 33.3% boys of group 2 ($p > 0.05$). Degree 1 aortic valve (AV) insufficiency of group 1 was di-

agnosed in one (10%) girl. Degree 1 mitral valve (MV) insufficiency was diagnosed in three (30%) girls of group 1 and in six (66.7%) boys of group 2 ($p > 0.05$). Degree 1 pulmonary artery (PA) regurgitation was revealed in one (12.5%) boy and four (40%) girls of group 1 ($p > 0.05$), and in seven (46.7%) boys and one (100%) girl of group 2.

The average values of echo-CG indicators and their percentile distribution depending on body weight (in points) in patients of the groups under study are presented in Table 6.

Evaluation of LV morphological aspects according to echo-CG data in boys of groups 1 and 2 (Table 6) revealed significantly higher values of

Table 6 / Таблица 6

Mean values and percentiles of echocardiographic scores in boys and girls in observed groups
Средние значения и процентили эхокардиографических показателей у мальчиков и девочек в наблюдаемых группах

Indicators and percentiles / Показатели и их процентили	Group 1 / Группа 1		Group 2 / Группа 2	
	boys / мальчики ($n = 8$)	girls / девочки ($n = 10$)	boys / мальчики ($n = 15$)	girls / девочки ($n = 1$)
Left ventricular anterior wall thickness, mm / Толщина передней стенки левого желудочка, мм	3.8 ± 0.5	3.6 ± 0.5	3.8 ± 0.4	5.0
Right ventricular diameter in diastole, mm / Диаметр правого желудочка в диастолу, мм	22 ± 3	24 ± 4	24 ± 4	28
Thickness of the ventricular septum in diastole, mm / Толщина межжелудочковой перегородки в диастолу, мм	10.0 ± 0.7	8.1 ± 0.9**	9.3 ± 0.9	10
Percentile of the thickness of the ventricular septum, point / Процентиль толщины межжелудочковой перегородки, балл	7.6 ± 0.5	6.0 ± 0.9**	7.0 ± 0.7♦	8
Left ventricular posterior wall thickness, mm / Толщина задней стенки левого желудочка, мм	9.9 ± 0.6	8.1 ± 1.1**	9.4 ± 0.9	12
Percentile of left ventricular posterior wall thickness, points / Процентиль толщины задней стенки левого желудочка, балл	7.6 ± 0.5	6.1 ± 1.8*	7.1 ± 0.6	8
Final diastolic diameter of the left ventricle, mm / Конечный диастолический диаметр левого желудочка, мм	50 ± 4	43 ± 3**	48 ± 3	55
Percentile of left ventricular thickness to diastole, point / Процентиль толщины левого желудочка в диастолу, балл	5.8 ± 1.8	3.8 ± 2.5	4.8 ± 1.7	8
Final systolic diameter of the left stomach, mm / Конечный систолический диаметр левого желудочка, мм	33 ± 2	28 ± 2***	31 ± 1♦♦	31
Left ventricular myocardial mass, g / Масса миокарда левого желудочка, г	184.0 ± 28.3	108.5 ± 24.4***	162.8 ± 33.0	247.3
Left ventricular myocardial mass index relative to body area / Индекс массы миокарда левого желудочка относительно площади тела	92.9 ± 15.5	62.5 ± 11.4 ***	77.2 ± 13.0♦	106.1
Relative thickness of left ventricular wall / Относительная толщина стенки левого желудочка	4.0 ± 0.4	3.8 ± 0.5	3.9 ± 0.3	4.4
Thoracic aortic diameter, mm / Диаметр грудной аорты, мм	30 ± 4	27 ± 2*	28 ± 4	29
Percentile of thoracic aortic diameter, points / Процентиль диаметра грудной аорты, баллов	6.6 ± 1.8	5.6 ± 1.2	5.3 ± 2.2	7
Anterior-posterior size of the left atrium, mm / Переднезадний размер левого предсердия, мм	36 ± 2	33 ± 3*	35 ± 3	39
Right atrial anterior-posterior percentile, point/ Процентиль переднезаднего размера левого предсердия, балл	7.9 ± 0.4	7.4 ± 1.3	7.3 ± 1.5	8
Right atrial diameter, mm / Диаметр правого предсердия, мм	40 ± 4	33 ± 5**	36 ± 3♦	32
Pulmonary artery diameter, mm / Диаметр легочной артерии, мм	22 ± 1	20 ± 1***	21 ± 1♦	23

Table 6 (continued) / Продолжение таблицы 6

Indicators and percentiles / Показатели и их процентили	Group 1 / Группа 1		Group 2 / Группа 2	
	boys / мальчики (n = 8)	girls / девочки (n = 10)	boys / мальчики (n = 15)	girls / девочки (n = 1)
Emission fraction, % / Фракция выброса, %	66.0 ± 3.6	68.4 ± 3.9	68.3 ± 4.9	72
Global left ventricular longitudinal deformation, % / Глобальная продольная деформация левого желудочка, %	34.4 ± 1.7	37.2 ± 3.2*	37.4 ± 3.9	41
Maximum aortic blood flow rate, m/s / Максимальная скорость аортального кровотока, м/с	1.2 ± 0.1	1.0 ± 0.1**	1.1 ± 0.1♦	1.1
Pressure gradient on aortic valve, mm Hg / Градиент давления на аортальный кровоток, мм рт. ст.	6.7 ± 1.9	5.6 ± 0.6	5.4 ± 0.6♦	–
Maximum mitral blood flow rate, m/s / Максимальная скорость митрального кровотока, м/с	0.9 ± 0.2	0.9 ± 0.1	0.9 ± 0.1	0.7
Mitral valve pressure gradient, mm Hg / Градиент давления на митральный кровоток, мм рт. ст.	2.9 ± 1.0	2.6 ± 1.1	2.6 ± 0.7	–
Maximum pulmonary artery speed, m/s / Максимальная скорость в легочной артериии, м/с	1.0 ± 0.1	0.9 ± 0.1	1.0 ± 0.1	0.8
Pulmonary artery pressure gradient, mm Hg / Градиент давления в легочной артериии, мм рт. ст.	4.0 ± 0.8	3.3 ± 0.5*	3.7 ± 0.5	–
Maximum tricuspid blood flow rate, m/s / Максимальная скорость трикуспидального кровотока, м/с	0.6 ± 0.1	0.7 ± 0.1	0.7 ± 0.1♦	0.9
Pressure gradient on tricuspid valve, mm Hg / Градиент давления на трикуспидальный клапан, мм рт. ст.	1.4 ± 0.3	2.2 ± 0.4***	1.8 ± 0.5♦	1.0
Systolic pressure in the pulmonary artery, mm Hg / Систолическое давление в легочной артерии, мм рт. ст.	14.8 ± 1.0	14.8 ± 0.8	15.3 ± 1.7	16

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (level of differences in values of indicators for boys and girls of group 1); ♦ $p < 0.05$; ♦♦ $p < 0.01$ (level of difference of values of indicators in boys of group 1 and group 2).
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$ (уровень различий значений показателей у мальчиков и девочек группы 1); ♦ $p < 0,05$; ♦♦ $p < 0,01$ (уровень различий значений показателей у мальчиков группы 1 и группы 2).

the percentile of the IVS thickness, LV end-systolic dimension, LVMM index relative to body area in favor of group 1, which could indicate the course of the LV remodeling process. These changes influenced the parameters of the maximum aortic blood flow velocity and pressure gradient in the AV.

Comparing the average values of echo-CG indicators in boys and girls of group 1 revealed significant differences in most of the studied morphological and functional characteristics caused by sexual factors. At the same time, the absence of signs of systolic dysfunction of the right ventricle was registered, according to significantly higher values of fractional changes in the right ventricle area.

CONCLUSION

As a result of the studies, it was established that adolescents with hyperuricemia were more often diagnosed with primary and secondary arterial hypertension and other manifestations of MS, less often with labile arterial hypertension and the hypertensive type autonomic dysfunction syndrome. In contrast, adolescents without hyperuricemia were equally often diagnosed with primary arterial hypertension and labile arterial hypertension, and autonomic dysfunction syndrome of hypertensive type.

In boys, in the group of patients without hyperuricemia, labile arterial hypertension prevailed, and in girls, the autonomic dysfunction syndrome according to the hypertensive type, was more frequent. The hereditary burden of cardiovascular disease was registered more often in boys (62.5% of cases) than in girls (40% of cases; $p > 0.05$). More pronounced manifestations of metabolic disorders, accompanied by morphofunctional changes in the hepato-pancreato-biliary system, revealed by the US, were detected in boys with hyperuricemia. Cardiac arrhythmias were noted more often in boys of group 1 (75% of cases) than in boys of group 2 (53.3%; $p > 0.05$) and girls of group 1 (40%; $p > 0.05$).

Signs of LV remodeling according to Echo-CG data were registered more often in boys without hyperuricemia (62.5% of cases) than in girls without hyperuricemia (10%; $p < 0.01$) and in boys with hyperuricemia (26.7%; $p > 0.05$). The data obtained indicate more significant changes in the morphofunctional condition of the cardiovascular system in adolescents with hypertensive states and manifestations of MS without hyperuricemia, which requires further study.

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