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ECHOCARDIOGRAPHIC INDICATORS OF CARDIORENAL SYNDROME IN CHRONIC KIDNEY DISEASE IN CHILDREN

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ABSTRACT

When conducting an echocardiographic examination of children with chronic kidney disease, it was found that in children with cardiovascular disorders against the background of chronic kidney disease, characteristic changes in echocardiographic indicators are noted: an increase in the mass of the left ventricular myocardium, the volume of its cavity, and a change in the size of its walls. In all children with cardiovascular changes, signs of myocardial remodeling were found, concentric hypertrophy was noted in 48.4% of observations, the presence of concentric remodeling in 27.9% of cases, and eccentric hypertrophy in 23.8% of cases.

KEYWORDS: *children, chronic kidney disease, myocardium, left ventricular hypertrophy, myocardial remodeling.*

INTRODUCTION

Cardiorenal syndrome refers to the progressive damage to the cardiovascular system caused by the pathological influence of a complex of factors associated with chronic kidney disease. Cardiovascular disorders (CVD) are the main cause of shortening the life expectancy of patients with CKD and are the cause of death in children and adolescents with stage 5 CKD in 20-50% of cases, and the life expectancy in this category of patients is 20-40 years shorter than in the general population [1, 6, 7].

It should be noted that in the structure of diseases of the cardiovascular system, the main cause of death in adult patients is heart failure and coronary artery pathology, mortality in childhood is often associated with sudden cardiac arrest and arrhythmia [2]. Damage to the cardiovascular system in CKD includes changes in blood vessels and myocardial remodeling, which, with the progression of the underlying disease, undergoes certain stages.

Left ventricular myocardial hypertrophy develops already in the early stages of CKD and, according to conducted studies, the frequency of its occurrence in children at stages C2-C4 ranges from 20-30%, while increasing to 85% in patients with disease progression, decreased renal function C2-C4 and those on dialysis. In children with CBP in the pre-dialysis stages, starting from stage C2, a high risk of developing cardiovascular disorders has been established, unlike adult patients with CBP, where such complications are detected in stage C3. A very high risk of developing cardiovascular complications in childhood patients is noted at stages C4-C5 [4].

The most widespread, accessible, and leading visualizing method of diagnostics and dynamic observation of cardiac remodeling processes in patients with CKD at various stages is echocardiography (EchoCG). The use of EchoCG allows for the detection of changes not only in the endocardium, pericardium, valve apparatus, but also in the geometry of the heart itself [3, 5, 8].

MATERIALS AND METHODS

We studied the echocardiographic (EchoCG) examination data of 122 children with chronic kidney disease before the dialysis stage (stages I-IV). The presence of cardiovascular disorders in this category of patients was confirmed by clinical, laboratory, and instrumental diagnostic studies and a complex of special cardiological examinations. The control group consisted of 45 practically healthy children.

Echocardiography (EchoCG) was performed according to the standard method in M- and V-mode using a 5 MHz sensor on the GENERAL ELECTRIC "Vivid S60" device (USA, 2019).

The following indicators were determined in centimeters: end-diastolic size of the left ventricle (EDS); end-systolic size of the left ventricle (ESS); thickness of the posterior wall of the left ventricle (TPWLV); interventricular septum (IVS). According to EchoCG

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data, the following indicators were calculated: left ventricular myocardial mass (LVMM), left ventricular myocardial mass index (LVMMI), relative wall thickness of the left ventricle (RWL), ejection fraction (EF) in %.

To determine the type of heart remodeling, the LVMMI indicators and the relative wall thickness index (RWL) were used. When evaluating the results, we identified the following types of heart geometry: normal geometry - LVMMI within the norm, IOTS = 0.35-0.40; concentric remodeling - LVMMI within the norm, RWL more than 0.40; eccentric hypertrophy - LVMMI above the norm, RWL = 0.35-0.40; concentric hypertrophy - LVMMI above the norm, RWL more than 0.40. The criterion used to evaluate echocardiography indicators was the body surface area (BSA), calculated using the Mostellera formula (1987). Furthermore, the features of the distribution of the studied body surface area ranges, used to assess EchoCG indicators, according to Feigenbaum H. (2005) recommendations, were determined. [3].

RESULTS

At the next stage of the work, we analyzed the clinical course of CKD in children depending on the presence of cardiovascular disorders. As a result, we established that CVI develops in most cases in children with stage III and IV CKD (P=0.002), the obtained data are presented in Table 1.

Table 1
Distribution of examined children with and without cardiovascular disorders depending on the stage of CKD

Number of patients		CKD Stadium			
		Stage I	Stage II	Stage III	Stage IV
Main group, n=122	abs.	6.	18.	55.	43.
	%	4.9	14.7	45.1	35.3

We studied the data of echocardiographic examination of children and adolescents with various stages of CKD depending on the presence of CVI. In this case, taking into account the previously identified differences between the studied groups by age, the body surface area was used as a cofactor, based on the value, which all patients were divided into 3 categories: 0.6-1.0 m2, 1.1-1.5 m2 and 1.5 m2 and higher, according to the recommendations of Feigenbaum N. (2005). This made it possible to eliminate the influence of the heterogeneity of groups by age composition on the comparison results.
When performing EchoCG in children with CKD, it was established (Table 2), which was characteristic of children with cardiovascular disorders with BSA of 0.6-1.0 m2 with a tendency towards an increase in LV EDS indicators compared to the control group (3.6±0.05 cm versus 3.3±0.04 cm, respectively).

Table 2
Comparative analysis of echocardiographic indicators in children with CKD depending on the presence of CVI and BSA indicators

Indicators	Main group (in) n=122			Control group n=45		
	BSA, 0.6-1.0 m^2	BSA, 1.1-1.5 m^2	BSA, 1.5 m^2 and above	BSA, 0.6-1.0 m^2	BSA, 1.1-1.5 m^2	BSA, 1.5 m^2 and above
LV EDS, cm	3.6±0.05*	4.01±0.08*	4.31±0.07	3.3±0.06	3.75±0.05	4.1±0.06
LV ECS, cm	2.33±0.012	2.6±0.03	3.1±0.08	2.2±0.1	2.4±0.05	2.91±0.07
TIVS, cm	0.72±0.01*	0.82±0.03*	0.83±0.03*	0.61±0.02	0.64±0.01	0.74±0.02
TPWLV, cm	0.73±0.01*	0.84±0.02*	0.87±0.02*	0.6±0.02	0.67±0.01	0.75±0.01
EDV, ml	55.3±0.5*	71.0±3.9*	90.9±0.4*	48.4±5.0	62.9±1.3	81.94±2.3
ESV, ml	28.3±0.9*	32.5±0.3*	37.0±0.36*	23.9±1.1	28.1±0.9	31.26±1.2
LVMM, g	74.4±3.3*	114.2±8.02*	130.2±7.1*	48.7±1.1	67.2±2.4	90.3±7.4
LVMMI, g/2	86.34±3.4*	86.6±5.8*	79.3±4.6*	53.2±3.8	56.8±2.1	55.6±4.3
EF, %	65.0±0.5	63.0±1.1	65.3±0.65	64.8±0.9	65.7±0.7	64.4±0.3
RWL	0.41±0.008*	0.42±0.01*	0.41±0.01*	0.35±0.01	0.36±0.01	0.36±0.02

Note: * - reliability of the data to the indicators of the control group (* - P<0.05; P<0.01; P<0.001).

Also, in this group, an increase in LV EDS indicators was established depending on the increase in BSA. The ECS values in children of the main group did not differ significantly from the indicators in the control group (P>0.05). TIVS and TPWLV indicators in children of the main group significantly increased compared to the control group (P<0.05-0.01). In this case, the dependence of the increase in TIVS on BSA was established. The values of EDV and ESV significantly increased in the main group with all BSA

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indicators compared to the control group (P<0.05). We also conducted a comparison of indicators that allow us to assess the presence of heart hypertrophy.

The analysis showed that LVMM and LVMMI statistically significantly increased with the development of BSA (p<0.001). LVMM in patients with cardiovascular disorders against the background of CBP was significantly increased - by 1.4 - 1.7 times compared to the control group (p<0.001). The median LVMMI in the control group was minimal among all the studied values, constituting 53.2±3.8, 56.8±2.1 and 55.6±4.3 g/^{2}, while in the main group these indicators reliably increased almost 1.6 times and amounted to - 86.3±3.4, 86.6±5.8 and 79.3±4.5 g/^{2} depending on the level of BSA.

The EF indicators in children of the main group practically did not differ from the indicators of the control group.
A reliably significant increase in RWL indicators in children of the main group by 16.7% was established, depending on the indicators of the control group, especially pronounced changes were registered in children with BSA 0.6-1.0 m^2.

After which the patients were classified into one of 4 phenotypes:
1. Norm (normal left ventricular mass and relative wall thickness),
2. Concentric hypertrophy (increased left ventricular myocardial mass and relative wall thickness),
3. Eccentric hypertrophy (increased left ventricular myocardial mass, but normal relative wall thickness),
4. Concentric remodeling (normal left ventricular mass, but increased relative wall thickness).

When distributing children with CKD depending on myocardial remodeling, it was established that in children of the main group with CVI against the background of CKD, concentric hypertrophy was noted in 48.4% (59 out of 122 patients), in 27.9% (34 out of 122 patients) cases, the presence of concentric remodeling and in 23.8% (29 out of 122 patients) the presence of eccentric hypertrophy were characteristic.

Concentric remodeling is characterized by a decrease in the volume of the left ventricular cavity, as well as a decrease in the ratio of volume to mass of the left ventricular cavity (EDV/ LVMM), which leads to an increase in the rigidity of the left ventricular cavity. EDV was 61.6±3.6 ml; LVMM - 115.3±6.3 g; Concentric thickening of the left ventricle walls in the first stages is of a compensatory nature, serves to maintain systolic function, when normal cardiac output is provided by an increase in the mass of the contractile myocardium. The thickened heart wall acquires greater rigidity, which reduces the relaxation properties and ventricular expansion. The thickness of the interventricular septum and the posterior wall of the left ventricle (TIVS and TPWLV) was 0.75±0.02 cm and 0.74±0.02 cm, respectively.

Concentric hypertrophy is characterized by a uniform thickening of the interventricular septum and the free wall of the left ventricle with a normal or insignificant increase in the size of its cavity: TPWLV and TIVS - 0.81±0.02 cm and 0.79±0.02 cm, respectively, EDV and ESV - 69.1±3.9 ml and 24.3±2.01 ml, respectively. This variant of LV hypertrophy is usually associated with hemodynamic LV overload and pressure.

Eccentric hypertrophy of the left ventricle is characterized by insignificant or moderate thickening of the walls of the left ventricle in combination with significant or moderate dilation of its lumen: TPWLV and TIVS - 0.79±0.02 cm and 0.71±0.02 cm, respectively. EDV and ESV - 81.6±4.6 ml and 29.4±2.5 ml, respectively, EDS and ESS - 4.3±0.08 cm and 2.9±0.07 cm, respectively. Its development is associated with volumetric overload of the heart.

According to the value of Pearson's $\chi 2$ criterion, statistically significant differences in the distribution of the examined patients by different types of myocardial geometry were noted between the studied groups (r=0.001). At the same time, a decrease in the proportion of patients with normal geometry in the development of CVI in children with CKD was noted. It should also be noted that with the development of CVI in CKD, an increase in the frequency of all pathological geometry types occurred. The observed picture corresponded to the ideas about the pathogenesis of cardiac geometry disorders in the development of CKD, initially associated with myocardial hypertrophy, and in the late stages of the disease - with dilation of cardiac chambers.

CONCLUSION

Thus, the obtained data indicate significant structural and functional changes in the heart in the occurrence and progression of CKD in children. In children with CVI against the background of CKD, characteristic changes in echocardiographic parameters are noted: an increase in the mass of the myocardium of the left ventricle, the volume of its cavity, and a change in the size of its walls. In 48.4% of patients, concentric hypertrophy was noted, in 27.9% of cases - the presence of concentric remodeling, and in 23.8% - eccentric hypertrophy.

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