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Structure of minor heart anomalies in children based on echocardiographic data

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Abstract: Over the past decade, the structure of cardiovascular pathology in childhood has undergone significant changes. The proportion of heart rhythm disorders, cardiomyopathies, and congenital heart defects has increased [1,3,9]. Currently, conditions associated with heart changes in connective tissue dysplasia (CTD) are gaining increasing importance [2,4,6].

Keywords: Minor Heart Anomalies, connective tissue dysplasia (CTD).

Introduction: Over the past decade, the structure of cardiovascular pathology in childhood has undergone significant changes. The proportion of heart rhythm disorders, cardiomyopathies, and congenital heart defects has increased [1,3,9]. Currently, conditions associated with heart changes in connective tissue dysplasia (CTD) are gaining increasing importance [2,4,6].

This phenomenon is due to the introduction of echocardiographic (EchoCG) examination into clinical practice, which has made it possible to diagnose numerous diseases at early stages, detect subtle deviations from the norm, and expand the capabilities of cardiologists overall. The non-invasiveness of the method, broad indications for examination, the possibility of continuous monitoring, and the high resolution of diagnostic equipment allow for the detection of microstructural changes in the heart. These changes have been later defined as "minor heart anomalies" (MHA) [1,5,8].

MHA refers to hemodynamically insignificant anatomical changes in the architecture of the heart and major vessels, which do not lead to severe dysfunction of the cardiovascular system [2,3,7]. These structures (abnormally positioned chords and trabeculae, valve prolapse, small septal aneurysms, prolapsing pectinate muscles, an elongated Eustachian valve in the right atrium, patent foramen ovale, borderline dilation of the aorta and pulmonary artery, and functionally narrow aorta) have attracted significant interest from specialists in various medical fields [1,3,5].

In some cases, MHA form the basis of cardiovascular pathology in children. At the same time, some researchers consider them to be variations of the norm or borderline conditions. However, MHA can, over the years, independently become a cause of various complications or exacerbate other pathological conditions or diseases [6].

An excess of the established threshold level of cardiac stigmatization in healthy children (more than three minor heart anomalies) may indicate potential health risks related to factors affecting health formation and parameters characterizing it [2]. The frequency of detection of MHA by echocardiographic examination (EchoCG) among children and adolescents varies between 39% and 68.9%, according to different studies [2,6].

Objective of the Study

To determine the prevalence and structure of minor heart anomalies in children and adolescents based on echocardiographic examination data.

METHODS

Echocardiographic (EchoCG) results of 52 children and adolescents aged 3 to 15 years who were receiving treatment at the regional children's medical center in the cardiorheumatology department were analyzed. Data on the examined children were collected using clinical-anamnestic-functional methods. The study included an analysis of the nature of antenatal,

intranatal, and postnatal periods, past and concurrent diseases, and the presence of cardiovascular complaints.

The examinations were conducted using ultrasound scanners in B-mode, as well as pulsed-wave and continuous-wave Doppler imaging (Toshiba Capasee 2 device). Statistical processing of the obtained results was carried out using variation statistical methods, and all result values were processed using Microsoft Excel 2010 standard computer programs. Heart structure assessments were performed from standard positions, using parasternal, apical, subcostal, and suprasternal approaches.

RESULTS AND DISCUSSION

Ultrasound examination of the heart in children revealed various minor heart anomalies (MHA) differing in localization and combination. The most prevalent anomalies involved the left ventricle and mitral valve. The identified minor heart anomalies included:

- Mitral valve prolapse (MVP) – detected in 23 (42.2%) children
- Abnormally located chords of the left ventricle (ALCLV) – found in 19 (36.5%) patients
- Combined MHA (MVP + intraventricular formations) – observed in 10 (19.2%) patients

Furthermore, in 10 children (19.2% of all detected MHA), various combinations of anomalies were identified. These included:

- MVP + additional left ventricular chords – 6 cases (11.5%)
- Additional left ventricular chords + patent foramen ovale (PFO) – 2 cases (3.8%)

Table 1

Structure and Frequency of Identified Minor Heart Anomalies (MHA)

Type of MHA	Number of Cases (n = 52)	Percentage (%)
Mitral valve prolapse (MVP)	23	42.2%
Abnormally located chords of the left ventricle (ALCLV)	19	36.5%
Combined MHA (MVP + intraventricular formations)	10	19.2%
MVP + additional left ventricular chords	6	11.5%
Additional left ventricular chords + patent foramen ovale (PFO)	2	3.8%

Analysis of the Frequency of Minor Heart Anomalies (MHA) in Children

The conducted analysis of the frequency of minor heart anomalies (MHA) has shown that abnormally located left ventricular chords, additional chords, and mitral valve prolapse (MVP) are the most commonly detected anomalies. It has been established that clinically and functionally significant MHA in children include:

- Multiple abnormally located chords in the left ventricle combined with cardiac rhythm disturbances
- Valve prolapse with structural changes in valve leaflets (myxomatous type)
- Hemodynamically significant regurgitation

Prevalence of Mitral Valve Prolapse (MVP) in Children

MVP was detected twice as often ($p<0.05$) in the main study group (42.2%). Among these cases:

- 63.8% of children had MVP of the anterior leaflet
- 20.9% had MVP of the posterior leaflet
- 15.3% had MVP of both leaflets

In most children with MVP, the depth of leaflet prolapse ranged from 3.0 to 5.8 mm, and regurgitation at the valve annulus did not exceed grade I. The latter was significantly more common in children (34.4%, $p<0.002$).

In one patient (4.3% of the studied group), grade II MVP was noted, with prolapse of the anterior leaflet reaching 7.0 mm and the posterior leaflet at 3.0 mm,

accompanied by regurgitation at the level of the valve annulus, within physiological norms.

Topographic Variants of Abnormally Located Left Ventricular Chords (ALCLV)

According to the classification of minor heart anomalies, the topographic distribution of abnormally located left ventricular chords (ALCLV) was as follows:

- Transverse chords – 9 cases (47.4%)
- Diagonal chords – 5 cases (26.3%)
- Longitudinal chords – 3 cases (15.8%)
- Multiple chords – 2 cases (10.5%)

Systolic Function of the Left Ventricle in Children

The analysis of left ventricular systolic function showed that older children had a consistently higher cardiac pump function than younger school-age children.

A comparative analysis of systolic function parameters revealed a trend towards increased stroke volume (SV), ejection fraction (EF), fractional shortening (FS), cardiac output (CO), and cardiac index (CI) in children with ALCLV aged 11-13 years. A statistically significant increase ($p<0.05$) was observed in children aged 14-15 years, indicating enhanced pump and contractile function of the left ventricle.

Similarly, 15 children (12.6%) aged 7-10 years with MVP demonstrated an increase in volumetric parameters (end-diastolic volume [EDV], end-systolic volume [ESV], and stroke volume [SV]) compared to other MHA types.

Adequate diastolic filling of the ventricles is crucial for effective cardiac pump function. High values of EDV, SV, and the presence of bradycardia, which prolongs diastolic filling time, suggest that enhanced cardiac pump function in the setting of vagotonia can be considered a compensatory response.

Table 2

Central Hemodynamics in Children with Minor Heart Anomalies

Parameter	MVP (n=23)	ALCLV (n=19)	Combined MHA (n=10)
End-diastolic volume (EDV) (ml)	XX ± X.X	XX ± X.X	XX ± X.X
End-systolic volume (ESV) (ml)	XX ± X.X	XX ± X.X	XX ± X.X
Stroke volume (SV) (ml)	XX ± X.X	XX ± X.X	XX ± X.X
Ejection fraction (EF) (%)	XX ± X.X	XX ± X.X	XX ± X.X
Fractional shortening (FS) (%)	XX ± X.X	XX ± X.X	XX ± X.X
Cardiac output (CO) (L/min)	XX ± X.X	XX ± X.X	XX ± X.X
Cardiac index (CI) (L/min/m^2)	XX ± X.X	XX ± X.X	XX ± X.X

Conclusions

1. The most common minor heart anomalies in children include:

o Abnormally located left ventricular chords (ALCLV)

o Additional chords

o Mitral valve prolapse (MVP)

2. Clinically and functionally significant MHAs include:

o Multiple ALCLV associated with rhythm disturbances

o Valve prolapses with myxomatous changes and hemodynamically significant regurgitation

3. The left ventricular systolic function showed an age-related increase, particularly in children aged 11-

15 years, indicating an enhanced contractile function of the left ventricle.

4. Children with MVP aged 7-10 years exhibited higher volumetric parameters (EDV, SV) compared to other MHA types, suggesting a compensatory mechanism in response to vagotonia.

These findings highlight the importance of echocardiographic monitoring in children with minor heart anomalies, particularly those with multiple anomalies and rhythm disturbances.

Table 2. Central Hemodynamics Characteristics in Children with Minor Heart Anomalies (MHA)

Parameter	MVP (n=23)	ALCLV (n=19)	Combined MHA (n=10)
End-diastolic diameter of the left ventricle (EDD LV) (mm)	46.25 ± 0.8	45.4 ± 0.6	45.7 ± 1.0
End-systolic diameter of the left ventricle (ESD LV) (mm)	28.8 ± 0.7	28.4 ± 0.4	28.9 ± 0.7
End-diastolic volume of the left ventricle (EDV LV) (ml)	97.9 ± 4.5	93.1 ± 2.8	97.61 ± 5.1
End-systolic volume of the left ventricle (ESV LV) (ml)	33.9 ± 2.0	31.0 ± 1.2	32.4 ± 1.9
Cardiac output (ml/min)	64.9 ± 2.8	64.4 ± 0.2	65.3 ± 3.5
Stroke volume (ml)	64.4 ± 0.2	63.9 ± 2.1	64.8 ± 0.4
Ejection fraction (EF) (%)	66.9 ± 0.87	67.1 ± 0.8	66.9 ± 0.8
Fractional shortening (FS) (%)	36.8 ± 0.6	37.3 ± 0.6	37.3 ± 0.6

Interpretation of Results:

- Left ventricular end-diastolic and end-systolic diameters (EDD and ESD LV) were similar across all groups, indicating no significant structural enlargement.
- End-diastolic volume (EDV) and end-systolic volume (ESV) values were slightly higher in MVP and Combined MHA groups than in the ALCLV group, which suggests mild variations in left ventricular filling.
- Cardiac output and stroke volume remained within normal physiological limits across all groups, confirming the absence of major hemodynamic impairments.
- Ejection fraction (EF) and fractional shortening (FS) were consistent among all groups, indicating preserved systolic function of the left ventricle.

Overall, these findings suggest that while MVP and ALCLV may cause minor variations in left ventricular structure and function, hemodynamic stability is largely maintained in children with these minor heart anomalies.

Table 3. Analysis of the Frequency of Minor Heart Anomalies (MHA) in 2013-2015

Year	Number of Diagnosed Cases	Percentage of Total Cases (%)
2013	18	34.6%
2014	15	28.8%
2015	18	34.6%

Key Findings from the Study:

- In 47.8% of children with MVP, the end-diastolic diameter of the left ventricle (EDD LV) exceeded the 75th percentile, which was significantly higher than in children with additional structures in the left ventricular cavity ($p < 0.05$) and substantially higher compared to the control group ($p < 0.001$).
- Among children with ALCLV, 34.8% had an EDD LV greater than the 75th percentile, which was significantly higher ($p < 0.05$) than in the control group, where only 7.7% of children showed similar values.
- In 40% of children with combined MHA, the diastolic diameter of the left ventricle was above the 75th percentile, which was statistically significant ($p < 0.05$) compared to the control group.
- The frequency of diagnosed MHA cases remained relatively stable over the three years of study, with cases ranging between 28.8% and 34.6% annually.

These findings indicate that children with MVP, ALCLV, and combined MHA exhibit notable structural deviations in left ventricular size, which may contribute to altered central hemodynamics. Additionally, the prevalence of MHA remained relatively consistent from 2013 to 2015.

Table 3. Analysis of the Frequency of Minor Heart Anomalies (MHA) in 2013-2015

Year	Number of MHA Cases	Percentage of Total Examined (%)
2013	18	34.6%
2014	15	28.8%
2015	18	34.6%

CONCLUSION

Thus, it has been established that clinically and functionally significant minor heart anomalies (MHA) in children include abnormally located chords (ALC) in the left ventricle in combination with heart rhythm disorders, prolapse of heart valves with altered leaflets (of the myxomatous type), and hemodynamically significant regurgitation.

The frequency of minor heart anomalies remains stable over the past three years. The most commonly identified anomalies are those of the left ventricle, including abnormally positioned chords, additional chords, and mitral valve prolapse (MVP).

Therefore, it has been demonstrated that intracardiac hemodynamics in children with MHA is characterized by persistent changes in systolic and diastolic functions of the left ventricle, which may be caused by adaptive restructuring of intracardiac hemodynamics.

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