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ORIGINAL PAPER

Evaluation of Diagnostic Methods in the Differentiation of Heart Murmurs in Children

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ABSTRACT

Introduction: The most common clinical sign in pediatric cardiology is a heart murmur (organic and inorganic). Organic are sign of heart disease, while inorganic (basically divided into accidental and functional) murmurs occur on anatomically healthy heart. **Aim:** To determine the justification of the application of the methods of cardiac treatment. **Patients and methods:** Study included 116 children aged from 1 to 15 years, who were referred due to cardiac treatment to Pediatric Clinic, of Sarajevo University Clinical Center. **Results:** The first group consisted of children with innocent heart murmur, 97 (53 males). The second group consisted of patients with organic murmur, 19 (13 males). The average age of the first group was 7.69 (1.01–15.01) years old, and of the second group 3.15 (1.01- 8.06) years old, and there is a significant difference between these two groups ($p < 0.001$). Medical history questions about potentially harmful habits of mother in pregnancy, found significant differences in the frequency of the existence of habits between the first and second groups of subjects (14.44% vs. 85.1%, $p = 0.013$). The values of the pulse of patients showed statistically significant difference ($p = 0.012$). The most common place of the murmurs' appearance is the second left intercostal space. In the first group, the most common were vibratory (32.3%) and ejection (31.9%) and in the second the most common were holosystolic (73.7%) murmur. Analyzing the R/S ratio of V1, a significant difference among the two groups was found (mean 0.78 vs. the values for 1.45, $p = 0.003$). There is a significance in terms of developed hypertrophy of the heart cavities (BVH) between the two groups. The most common accidental murmur was classic vibratory Still's murmurs (55.43%) and the most common congenital heart defects was ASD (36.8%). **Conclusions:** A heart murmur itself, should not be the purpose of auscultation. One of the tasks of pediatricians, pediatric cardiologists in particular would be to improve auscultation, as a sovereign method of heart murmurs assessment. Heart murmur assessment should be adapted to recognize whether heart murmur is innocent, or there is suspected or probable congenital heart defect.

Key words: pediatric cardiology, heart murmurs, cardiac treatment of heart murmurs.

1. INTRODUCTION

Pediatric cardiology was always the basis of pediatrics, at the same time making its integration and affecting significantly the reduction of perinatal mortality, which is the basis of assessment of the development of medicine in a country (1). Modern pediatric cardiology today deals mainly with congenital heart defects (CHD), whose incidence is from 0.8% to 1% (1). The most common congenital anomalies are CHD (30%). The most common clinical sign in pediatric cardiology is a heart murmur, which can often be uncharacteristic (2). Heart murmurs are common in healthy infants, children, and adolescents (3). Heart murmurs in the highest percentage can be a cause for specialized cardiac treatment (4, 5). Evaluation of heart murmur represents the exclusion or the existence of congenital heart anomalies. Normal anatomic and functional findings of heart must be proven by clinical examination, electrocardiography (ECG), X-ray diagnostics, laboratory diagnostics, less often echocardiography, and other non-invasive and invasive methods. Heart murmurs occur due to turbulent movement of blood through the heart chambers and blood vessels, when there are anatomical changes to the valves and heart muscle, or narrowing of blood vessels. Heart murmurs are in most cases caused by turbulence due to imbalance in blood flow velocity and the size of the opening through which it flows. Mur-

murs depend directly on the diameter of the blood cavities and speed of blood flow, and they are inversely proportional to the viscosity of blood. Heart murmurs can be organic and inorganic. Organic are sign of heart disease, and inorganic murmurs occur on anatomically healthy heart (6). Inorganic murmurs, which are usually called innocent, are basically divided into accidental and functional. Many authors classify murmurs into a joint group. In relation to the duration, murmurs are divided into systolic, diastolic and continuous. Systolic murmurs can be ejection and regurgitant, diastolic can be regurgitant, fluctuate and atrial contraction, and continuous murmurs can be venous and arterial (7, 8, 9). Heart murmurs are by auscultation revealed in over 50% of children and adolescents, with a peak incidence between 8 to 12 years (10). Given the frequency of murmurs, doctors should know its characteristics (11, 12, 13). The clinical significance of heart murmurs is that unrecognized or misinterpreted murmurs can start unnecessarily complicated and time consuming diagnostic procedure and burden parents and children by fear of heart disease. In most cases, medical history, clinical examination, ECG, laboratory diagnosis and eventual X-ray is sufficient for differentiation of these murmurs. Echocardiography should not be a routine method for every murmur. The organic murmurs are sign of heart disease and occur due to vibration of anatomically damaged valve either in the period of its formation (congenital heart anomalies) or later due to the inflammatory process (acquired heart anomalies). In addition to the aforementioned cardiac etiology, organic murmurs can be extracardial when they occur as a result of vibrations caused outside of heart (pleuro-pericardial adhesions). Functional murmurs (Graham Steel murmur, Austin Flint murmur, Carey Coombs murmur, functional murmur of mitral regurgitation, tricuspid stenosis functional murmur, functional murmurs in states with high protruding volume - elevated temperature, anemia, anxiety, exercise, thyroid disorders, agitation, pregnancy, hypoproteinemia) in children occur primarily in diseases where the heart is increasingly burdened. Functional murmurs constitute a group of transition murmurs between organic and accidental, and have common characteristics like that they are soft, mild and relatively of constant intensity due to uniform vibration of preserved valve, with its clear punctum peak at a lower level of propagation. Accidental murmurs (Still's murmur, pulmonary flow murmur, carotid bruit, systolic murmur of pulmonary flow in the newborn, venous hum, benign cephalic murmur, Potain murmur, Mammari souffle) occur on anatomically and functionally normal heart. Some authors distinguish them from functional (murmurs that occur in diseases that secondarily affect the heart), also they are often considered to be a common group of innocent murmurs.

2. AIM

The aim is to determine the justification of the application of the methods of cardiac treatment, and to determine the correlation of murmurs on the heart and their frequency.

3. PATIENTS AND METHODS

Study included 116 children aged from 1 to 15 years, from the Federation of Bosnia and Herzegovina, who were referred due to cardiac treatment to Pediatric Clinic, UCC Sarajevo (clinical type of research was conducted, of manipulative-prospective character (a three-year period, starting from January 2012), using a questionnaire which consisted of nine parts (general information, medical history, data from the cardiological status, data of auscultation, murmur characteristics, echophonocardiograph records of murmurs, laboratory diagnostics, X-ray diagnostics and electrocardiographic diagnostic)). Descriptive statistics of the data obtained was done.

4. RESULTS

The first group consisted of children with innocent heart murmur, 97 (53 males). The second group consisted of patients with organic murmur, 19 (13 males). The average age of the first group was 7.69 (1.01–15.01) years old, and of the second group 3.15 (1.01- 8.06) years old, and there is a significant difference between these two groups ($p < 0.001$). There is no significant difference between sexes in the groups. The average age of the father of a child in the first group was 29.29 (19-43) years old, and of the mother 25.08 (16-40), in the second group father's average age was 26,57 (21-34), and mother's 22.42 (18-32), with no significant difference between groups. Medical history did not find significant differences between groups when talking about the presence of chronic diseases in mothers ($p=0.064$), the presence of infection in pregnancy ($p = 0.276$) and positive family history of cardiac diseases ($p=0.391$). Medical history questions about potentially harmful habits of mother in pregnancy, found significant differences in the frequency of the existence of habits between the first and second groups of subjects (14.44% vs. 85.1%, $p = 0.013$). On physical examination of the subjects, a significant difference in body weight between the groups was identified, but not in body height of the subjects ($p = 0.067$). The physical examination of the patient showed a significant difference, in frequency of signs of heart diseases, such as cyanosis, dyspnea and edemas by comparing the first and the second group of patients. Physical examination found significant differences by comparing two groups of patients based on the occurrence of pulsations, thrill and heart apex position (Table 1).

	Pulsations		Thrill		Heart apex	
	Yes	No	Yes	No	Normal	Abnormal
I. group	12 (12.4%)	85 (87.6%)	6 (6.2%)	91 (93.8%)	88 (90.7%)	9 (9.3%)
II. group	11 (57.9%)	8 (42.1%)	8 (42.1%)	11 (57.9%)	10 (52.6%)	9 (47.4%)
	$p < 0.001$		$p < 0.001$		$p < 0.001$	

Table 1. Clinical examination of patients (n=116) in a sample

	Rhytm		Sounds		Extrasound	
	Regular	Irregular	Normal	Pathological	Yes	No
I. group	94 (96.9%)	3 (3.1%)	82 (84.5%)	15 (15.5%)	10 (10.3%)	87 (89.7%)
II. group	13 (68.4%)	6 (31.6%)	10 (52.6%)	9 (47.4%)	8 (8.2%)	11 (91.8%)
	$p < 0.001$		$p = 0.005$		$p = 0.002$	

Table 2. Auscultatory findings (n=116) in a sample

Comparing the values of systolic and diastolic blood pressure compared to the patients height, a significant difference between groups has not been proved (systolic $p = 0.327$ and $p = 0.504$ diastolic). The values of the pulse of patients showed statistically significant difference (on average, 98.72 vs. 111.52, $p = 0.012$). Auscultation findings showed a signif-

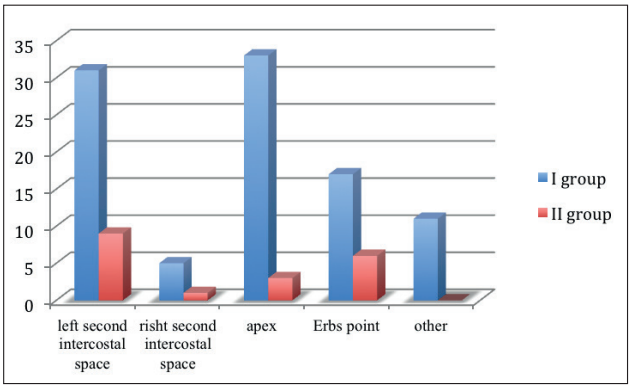

Figure 1. Localisation of murmurs in a sample

	Normal [1]	Rightward [2]	Leftward [3]
I. group	74 (76.3%)	17 (17.5%)	6 (6.2%)
II. group	11 (57.8%)	4 (21.1%)	4 (21.1%)
1 vs 2	p = 0.712		
2 vs 3		p = 0.381	
1 vs 3		p = 0.049	

Table 3. Axis of ECG (n=116) in a sample

	RVH		LVH		BVH	
	Yes	No	Yes	No	Yes	No
I. group	8 (8.3%)	89 (91.7%)	0	97 (100%)	1 (1.3%)	96 (98.7%)
II. group	3 (15.8%)	16 (84.2%)	1 (5.3%)	18 (94.7%)	4 (21.1%)	15 (78.9%)
	p = 0.550		p = 0.362		p < 0.001	

Table 4. Ventricular hypertrophy (n=116) in a sample

icant difference in the rhythm of the heart, heart tones, and appearing of extra sound (Table 2). There were no significant differences between the two groups compared to the duration of the murmur.

The most common place of the murmurs' appearance is the second left intercostal space (in the first group in 31.9% of cases, and in second in 47.6% of cases) (Figure 1).

Peak of the murmur as well as its expansion, dependence of the respiration and the change in body position, show a significant difference between the two groups of patients. In the first group, the most common were vibratory (32.3%) and ejection (31.9%) murmurs, and in the second the most common were holosystolic (73.7%). By phonocardiographic analyzing variability of the first and second heart sound of the respondents, there is a significant difference in the second heart tone (prominent second tone, 17.5% vs 78,9%, p <0.001). The difference in the amplitude of murmurs is significant (average values (0.916vs1.221, p <0.001), as well as the duration of the heart murmur of the respondents (0,386 By X-ray analysis, cardiothoracic index was normal in 82.5% of cases in the first group of patients, and in 31.6% of cases in the second (p <0.001), and pulmonary vascular drawing was normal in 80.4% of the first group, and in 10.5% of the other groups (p <0.001). There were no significant differences between groups in the size of the great arteries. ECG showed no significant difference by comparing heart rate, and the length of the P wave, the duration of the PR interval, QRS complex and QT interval. By analyzing high electric shaft a significant difference in the incidence of sinistrogram compared to normogram was found (6.2 vs. 21.1%, p = o.o49) (Table 3)

Analyzing the R/S ratio of V1, a significant difference among the two groups was found (mean 0.78 vs. the values for 1.45, p = 0.003). There is a significance in terms of developed hypertrophy of the heart cavities (BVH) between the two groups (Table 4).

In laboratory, there was no significant difference between the two groups by analyzing the regularity of blood counts and the oximetry of respondents. In the first group, all patients had an innocent murmur (an accidental (94.84%, 5.15% functional), while in the second group all had an organic murmur, or cardiac anomalies. The most common accidental murmur was classic vibratory Still's murmurs (55.43%) (Figure 2 and the most common congenital heart defects was atrial septal defect (ASD), 36.8% (Figure 2).

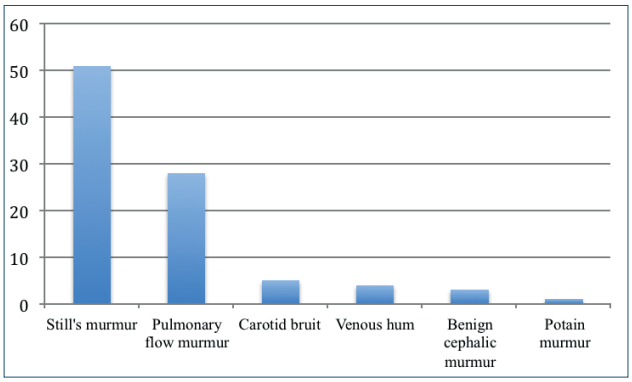

Figure 2. Distribution of accidental murmurs in a sample

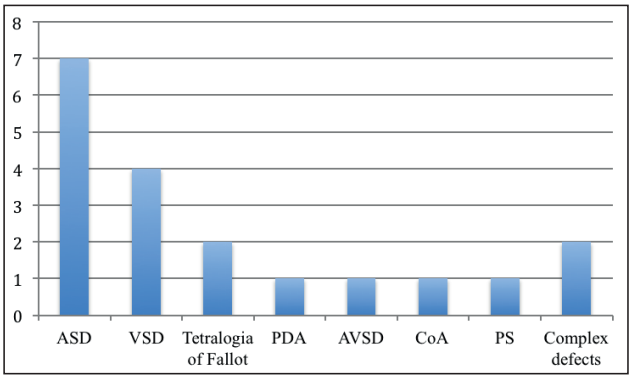

Figure 3. Causes of organic murmurs in a sample

5. DISCUSSION

There is no data that shows a higher incidence of innocent murmurs in one or the other sex which is not the case with some CHD (organic murmurs). For example nine common congenital heart abnormalities, which account for over 80% of all CHD have unequal gender representation (1) (1 in every 100 children has defects in their heart due to genetic or chromosomal abnormalities, such as Down syndrome; for CHD, genes in chromosome 1 show some defects in nucleotide sequence) (14). There is a 2-3 times higher incidence of patent ductus arteriosus (PDA), ASD type II and atrioventricular septal defect (AVSD) in female children and a significantly higher incidence of coarctation of the aorta (CoA), aortic stenosis (AS) and transposition of great arteries (TGA) in male children (as a rule, anomalies that develop in the aorta are more frequent in boys with an approximately equal represen-

tation of ventricular septal defect (VSD), Tetralogy of Fallot (ToF) and pulmonis stenosis (PS). At the same time, the child's age shows a higher incidence of some accidental murmurs (neonatal - sistolic pulmonary flow, pre-school period-Still's murmur, school period-pulmonary ejection murmur, adolescents - mammary souffle). With this study, we could not prove that the age of mothers and fathers was important in the emergence of organic murmurs at the time of birth of the subjects, which could be explained by a relatively small group of respondents with organic murmurs, but also by the exclusion of patients with visible stigma, or syndromes, from the study. Data related to the positivity of family cardiac history and status of pregnant women with records of diseases, infections, habits have in practice been proved credible although indirect. Direct medical history in didactic terms are hardly separable from a dose of suggestibility and personality that in itself is hard to turn off. It takes experiential skills to detect.

As a rule, medical history should be placed from perinatal age, including gestational and prenatal history, that involve cyanosis, prematurity and respiratory distress. Questions about taking medications during pregnancy as well as about maternal diseases should be asked. Extracardiac anomalies exist in 20-45% CHD, and 5-10% have distinctive chromosome defects. Family history must be directed to diseases that could be prevented such as atherosclerosis and cerebrovascular accidents (hypercholesteremia and thrombophilia) or muscle diseases (muscular dystrophy, dermatomyositis, family metabolic cardiomyopathy), and other measures of preventive pediatric cardiology especially prenatal. These days prenatal (preventive) cardiology is mentioned a lot and it actually consists of fetal echocardiography, and fetal interventional cardiology. The basic need for fetal echocardiography is determined by factors that increase the risk of prenatal heart disease and they are actually indications for fetal echocardiography.

Physical examination should first determine if the child is sick or not, and if yes, whether the child has heart failure or not. The order of individual tests in the classical approach is: inspection, palpation, auscultation, percussion, measurement of arterial blood pressure. Inspection includes observation of jugular veins, edema, pathological pulsations, chest deformity, the existence of cardiac hump, assessment of dyspnea, cyanosis, and hypoxemic crisis. With inspection we visualize the stigmata on the basis of which a syndrome associated with possible heart disease can be recognized. In the area of inspection we also include recognition of other systemic diseases (diseases of the CNS, respiratory, gastrointestinal, genitourinary, hematological, collagen and similar). Cyanosis is a result of reduced oxygen concentration in the peripheral blood and is not entirely a reliable sign of hypoxia (i.e. It will be difficult for it to develop in anemic patients and easier in patients with polycythemia). In practice, excluding pulmonary disease as a source of cyanosis, underlying cyanosis certainly stands next to the right-left shunt. Regardless of whether the cyanosis is visible on inspection or not, in every child in which CHD is suspected, measuring of blood oxygen saturation percutaneously (pulse oximetry) should be done so the cyanosis could be confirmed or excluded on the basis of objective laboratory parameters (low partial pressure of oxygen, low blood oxygen saturation). This is particularly important to do in newborns in which cyanosis is difficult to spot due to the fact that they have a lot of fetal hemoglobin, which binds oxygen better, but in darker pigmented children also. In newborn children the cyanosis is even more difficult to evaluate because they have not only lung and heart diseases, but also a depression of the central nervous system.

Measuring of blood pressure that must be done at every cardiac examination, given the subject and only one spotted CHD with hypertension (CoA) had no significance between our groups. Auscultation, as undoubtedly the most important part of the cardiology examination, was used to assess the heart rhythm, tones, clicks and noise with all of its characteristics in different positions. The auscultation by itself has to estimate a minimum of 3-6 consecutive cardiac cycles, while staying at each auscultation site at least 30-45 seconds. Auscultation of the heart should always be done systematically. The goal of auscultation is the assessment of heart rate and rhythm, tone quality, especially the definition of a second tone, the presence of additional tones, and the detection and analysis of heart murmurs (15, 16, 17). A murmur does not represent the purpose of auscultation. It is one of the parameters that is complementary to other parameters. In the group of patients with organic murmurs, there was significantly more signs of pathologic auscultatory findings.

The presence of clicking should be listened specifically towards these states, especially if we have present high heart frequency (in newborns and infants) when it is impossible to say whether there is extra tone or not, and sometimes it is not possible to say for diastolic murmur. Characteristics of innocent murmurs are likely to occur in early systole, happen after the first tone, have small intensity, they are poor in transmission, they are best audible along the left systolic edge, when lying down, they have growing-decreasing shape (crescendo-decrescendo), they become gentler when inspiring, when the patient sits and stands, their intensity increases with the Valsalva maneuver (attempted exhalation against a closed airway), they are not associated with an ejection click and other abnormal tone, and are not associated with cardiovascular abnormalities. Some of the specifics related to these murmurs are different, regardless of the unexplained cause of them. The incidence of accidental murmurs is from 24 to 97.5% (24% Bluementhol, 41% Castellotti, 50% Ebstein, 61.3% Keith, 70% Dunford, 80% Carl, 97.5% Lyuxwiller). Differential diagnosis of innocent murmurs can be difficult. It is hard because there are very few complementary methods that can help. Correlation of higher voltage in the left precordial leads, lower heart rate, smaller diameter of ascending aorta, increasing flow and acceleration in the output section of the aorta and output of the left ventricle, vibration of aortic valve of 1 and more than 1 mm and frequency greater than or equal to 100Hz (11). Technical validity of radiography of children is difficult to achieve. Assessment of cardiomegaly and its existence should be based on pathognomonic configuration of hearth shadow on image. Cardiomegaly can be a result of CHD with heart failure or without heart failure (VSD, TGA, Botalli ductus, Ebstein anomaly), myocarditis or cardiomyopathy, pericardial effusion, excessive hydration or blood transfusion, and can also be found in hypoglycemia, acidosis and severe hypoxemia. Cardiothoracic ratio is enlarged significantly in the group of children

with organic murmur. X-ray is very significant in differentiation of suspected and probable CHD. X ray is very important in CHD monitoring, but has no significant role in the differentiation of heart murmur. Electrocardiography (ECG) is one of the oldest diagnostic methods in cardiology, which not only that has not lost its importance until today (regardless of the new methods that have appeared during time), but it became more widespread and practically irreplaceable in the diagnosis of many heart (but also other) diseases. It is one of the most simple and cheapest methods, especially important for rhythm disorders, and also for monitoring of CHD patients (18, 19). It has an important role in initial differentiation of heart murmurs (18). ECG is still the method of priceless importance in diagnosis and follow up of CHD evolution (19). Fonocardiography can not replace auscultation in no circumstances. There is no specific laboratory test for heart murmur.

Echocardiography provides a definitive diagnosis of heart disease but is not required in case of innocent murmur-inappropriate pediatric cardiologist and echocardiographic referral leads to useless and expensive examinations, resulting in a work overload for pediatric cardiologists (20).

6. CONCLUSIONS

Anamnestic data should be carefully taken considering prenatal, perinatal, postnatal period, family medical history has to have special reference to the habits during pregnancy, association with other diseases, preferences to respiratory infections, poor tolerance to the stress as well as the subjective feeling of the general situation, particularly on the main symptoms of heart disease (heart failure, signs of heart failure, cyanosis, and syncope).

Physical examination has to be done to determine whether the child is sick, whether the child has signs of heart disease (cyanosis, dyspnea, edema), with the measurement of body weight, pulse oximetry, measurement of pressure, and palpation pulsation, thrill and changes of ictus.

Auscultation as a reliable method in differentiation of murmurs should be conducted systematically by evaluating the frequency and rhythm of heart, the quality of tone, especially defining second tone, presence of additional tones, and detection and analysis of heart murmur, with accurate records of all the characteristics of murmurs.

X-ray diagnosis should not be a part of the routine diagnostic differentiation of heart murmurs.

Electrocardiography is a routine method in pediatric cardiology that has its place in the differentiation of murmurs, through which more information regarding the differentiation of murmurs can be obtained, as well as the evolution of CHD. Phonocardiography is a standard, complementary method. It serves to document the analysis and to confirm auscultation of doctor. There is no specific laboratory test for murmur. Echocardiography should be a routine initial method for each heart murmur in children. Doctors, family doctors, specialists in school medicine, pediatricians, should be trained in recognizing heart murmurs. A heart murmur itself, should not be the purpose of auscultation. It is necessary to know the characteristics and differentiation of heart murmurs. One of the tasks of pediatricians, pediatric cardiologists in particular would be to improve auscultation, as a sovereign method of heart murmurs assessment.

Heart murmur assessment should be adapted to recognize whether the heart murmur is innocent, or there is suspected CHD or probable CHD.

• Conflict of interest: none declared.

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