

Assessment of the patients referred to the pediatric cardiology clinic due to murmur

Children with murmur

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Abstract

Aim: Heart murmur is one of the most common reasons for evaluation in the pediatric cardiology clinic. The aim of this study is to evaluate the physical examination and echocardiographic findings of patients referred due to murmur.

Material and Methods: Patients admitted to the pediatric cardiology clinic due to murmur were evaluated retrospectively. The intensity of the murmurs was graded as 1-2/6, 3/6, and >3/6. The type of murmur was classified as innocent or pathological. Echocardiographic findings were classified as normal, normal for age, or pathological.

Results: Two hundred patients were included in the study. Murmur was graded 1-2/6 in 72.5% of patients, 3/6 in 7%, and >3/6 in 1%. Innocent murmur was detected in 54.5%, pathological murmur in 26% of the patients. Echocardiographic findings were normal in 54% of the presenting cases, normal for age in 15.5%, and pathological in 30.5%. Patients without murmur had normal echocardiographic findings in 64.1%, pathologic findings in 7.69%. Echocardiography was normal in the majority of the patients with a grade of 1-2/6, but was pathological in those with a grade of $\geq 3/6$. Echocardiography was pathological in 7.69% of the patients without murmur, in 10.09% with an innocent murmur, and in 90.38% with a pathological murmur. The intensity of murmur was observed as significant ($p=0.001$), but the characteristics of the murmur was not observed as significant determinant in distinguishing echocardiographic findings ($p=0.115$).

Discussion: Echocardiographic findings are not always related to physical examination findings of murmur, therefore we suggest that auscultation alone may not be sufficient in the evaluation, and a detailed assessment with echocardiography may be more appropriate.

Keywords

Child, Echocardiography, Auscultation, Murmur

DOI: 10.4328/ACAM.21831 Received: 2023-07-24 Accepted: 2023-08-25 Published Online: 2023-08-29 Printed: 2023-09-01 Ann Clin Anal Med 2023;14(9):849-853

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This study was approved by the Ethics Committee of Health Sciences University, Bakırköy Dr. Sadi Konuk Training and Research Hospital (Date: 2023-03-20, No: 2023-06-13)

Introduction

Murmurs are sounds that are produced by turbulent blood flows in the heart and vascular structures and are transmitted to the chest wall. They have frequencies between 20 Hz and 2000 Hz [1-3]. Murmurs may be heard in approximately one-third of routine physical examinations [1]. Murmur is a cause of anxiety for parents and physicians, therefore it is one of the most frequent reasons for admission to pediatric cardiology clinics. While 75-80% of murmurs are innocent, it may sometimes be the only finding to raise suspicion of congenital heart disease. Differentiations and diagnoses of the conditions are easily made with echocardiography [4-7]. The purpose of this study is to evaluate the physical examination and echocardiographic findings of the patients referred to the pediatric cardiology clinic due to murmur.

Material and Methods

Patients presenting to the pediatric cardiology clinic due to murmur during January 2023 and February 2023 were evaluated retrospectively. Anamnesis, physical examination and echocardiographic data were obtained from records of the hospital system. Murmur intensity was classified as 1-2/6, 3/6, and >3/6. The type of murmur was classified as innocent or pathological.

Echocardiographic findings were classified as normal, normal for age, or pathological. Normal for age echocardiographic findings included physiologically normal findings, including patent foramen ovale (PFO), peripheral pulmonary stenosis (PPS), and patent ductus arteriosus (PDA).

Ethical Approval

The study was approved by the Ethics Committee of the Health Sciences University, Bakırköy Dr. Sadi Konuk Training and Research Hospital (decision number: 2023-06-13, date: 20.03.2023). Informed consent was obtained from all the patients and their parents.

Statistical Analysis

Statistical analyses and graphics were performed using SPSS 29 Statistical Software. Categorical data were presented with frequency and percentage. Continuous variables were evaluated with mean, Standard deviation, median, minimum and maximum values. The results of the evaluation with physical examination and echocardiography were compared with the McNemar test. In order to evaluate the physical examination results according to the echocardiographic findings, the rates of sensitivity, specificity, positive and negative predictive values and accuracy were calculated.

Results

Two hundred patients were included in the study. Boys represented 51% of the cases. The majority of patients consisted of children older than 49 months, the second most common group consisted of the patients aged up to three months. No murmur was detected in 19.5% of the patients referred for this reason, while 1-2/6 murmur was present in 72.5%, 3/6 in 7%, and >3/6 in 1% of the patients. Innocent murmur was detected in 54.5% and pathological murmur was detected in 26% of the patients. Echocardiographic findings were normal in 54% of the presenting cases, normal for age in

15.5%, and pathological in 30.5% of them (Table 1).

Patients without murmur had normal echocardiographic findings in 64.1%, pathological findings in 7.69%, normal for age findings in 28.21% of the patients. Patients with grade 1-2/6 murmurs had normal echocardiographic findings in 57.24%, normal for age findings in 12.41% of the patients, while 30.35% of the patients had pathological findings. Patients with grade 3/6 murmur had mostly (85.72%) pathological findings with a small percentage (14.28%) of normal for age findings. All of the patients with murmurs greater than 3/6 had pathological echocardiographic findings. Patients that are classified to have innocent murmur had normal echocardiographic findings mostly (76.15%). Further, 13.76% of the patients had echocardiographic findings that were normal for age, while 10.09% of the patients had pathological findings. Patients with pathological murmur had mostly pathological findings (90.38%), with a small percentage (9.62%) of echocardiographic findings that were normal for age (Table 2).

None of the patients with pathological murmur had normal echocardiographic findings. Pathological echocardiographic findings were present in 3 patients without murmur, in 11 patients with innocent murmur and in 47 patients with pathological murmur. Echocardiographic findings normal for age were detected in 11 patients without murmur, 15 patients with innocent murmur and 5 patients with pathological murmur (Table 2).

Pathological echocardiographic findings included mostly atrial septal defect (ASD), ventricular septal defect (VSD), PDA, mitral valve prolapse, mitral and aortic insufficiency, bicuspid aortic valve, tetralogy of Fallot and operated congenital heart diseases.

Aortic stenosis, aortic coarctation, subaortic membrane, interventricular septal hypertrophy, pulmonary insufficiency, non-compaction cardiomyopathy were also present among the patients with pathologic echocardiographic findings. It was determined that there was a significant difference between echocardiography results and physical examination results involving the intensity of murmur. The two diagnostic methods do not give similar results ($p=0.001$) (Table 3). When murmur intensity was used as a determinant for distinguishing echocardiographic findings, the sensitivity of the physical examination was 21.67%, the specificity was 97.86%, the positive predictive value was 81.25%, the negative predictive value was 74.46%, and the accuracy rate was 75%, odds ratio 12.63%, 95% confidence interval was 3.448-46.272. Murmur intensity was observed as a significant determinant for distinguishing echocardiographic findings.

It was determined that there were no significant differences between echocardiographic results and physical examination results in terms of characteristics of the murmur. The two diagnostic methods give similar results ($p=0.115$) (Table 3). When murmur characteristics were used as determinants for distinguishing echocardiographic findings, the sensitivity of the physical examination was 76.67%, specificity was 95.71%, the positive predictive value was 88.46%, the negative predictive value was 90.54%, and the accuracy rate was 90%, the odds ratio was 73.38%, 95% confidence interval was 26.638-202.144. The characteristics of murmur were not observed as

Table 1. Sociodemographic Features and Clinical Findings of the Patients.

Gender	n%	Age (months)	n(%)	Presence of Murmur	n(%)	Characteristics of Murmur	n (%)	Echocardiographic evaluation	n (%)
Male	102(51)	0-3	30 (15)	None	39 (19.5)	None	39 (19.5)	Normal	108 (54)
	98 (49)	4-6	13 (6.5)	1-2/6	145(72.5)	Innocent	109 (54.5)	Pathological	61 (30.5)
Female		7-24	27 (13.5)	3/6	14 (7)	Pathological	52 (26)	Normal for age	31 (15.5)
		25-48	23 (11.5)	>3/6	2 (1)				
		≥49	107 (53.5)						

Table 2. Distribution of Echocardiographic Findings According to Auscultation Findings.

Evaluation of murmur with auscultation	Normal echocardiographic findings n (%)	Pathological echocardiographic findings n (%)	Echocardiographic findings normal for age n (%)	
Presence of murmur	No murmur	25 (64.1)	3 (7.69)	11 (28.21)
	1-2/6	83 (57.24)	44 (30.35)	18 (12.41)
	3/6	0	12 (85.72)	2 (14.28)
	>3/6	0	2 (100)	0 (0)
Characteristics of murmur	No murmur	25 (64.1)	3 (7.69)	11 (28.21)
	Innocent	83 (76.15)	11(10.09)	15 (13.76)
	Pathological	0 (0)	47 (90.38)	5 (9.62)

Table 3. Diagnostic value of murmur intensity and murmur characteristics to determine echocardiographic findings.

	Pathological echocardiographic findings (-)	Pathological echocardiographic findings (+)	TOTAL	p
Intensity grade	n	n		
No murmur + 1-2/6	137	47	184	0.001
≥3/6	2	14	16	
Characteristics of murmur	n	n		
No murmur+ Innocent	134	14	148	0.115
Pathological	5	47	52	
TOTAL	139	61	200	

significant determinants in distinguishing echocardiographic findings (p=0.115).

Discussion

Innocent murmurs develop as a result of increased flow velocity caused by regions of different widths between the chambers of the heart and vessels or between two vessels due to tissue vibrations [1]. Heart murmur is one of the main causes of evaluation in pediatric cardiology clinics. The majority of murmurs are innocent, without accompanying structural heart disease, and can generally be differentiated from pathological murmurs through accurate history and physical examination. However, murmur differentiation requires gradual skill development [3]. Studies have described various characteristics of innocent heart murmurs. Accordingly, innocent murmurs are soft musical sounds on the left of the sternum that do not spread to other regions. They are short, systolic murmurs that show differences in characteristics with respiration or position [8]. Studies have declared that pansystolic murmurs greater than grade 3/6, accompanied with an early or mid-systolic click, the presence of abnormal S2, all diastolic murmurs

should be accepted as pathological [9,10]. Consistent with this knowledge, murmur grade was 1-2/6 in the majority of the patients in our study, most of the murmurs were innocent, and echocardiography was normal in the majority of these patients. In our study, murmurs with low grade were also detected in the patients with echocardiographic findings normal for age. Echocardiographic evaluation was normal in the majority of the cases classified as innocent murmur. Patients with murmurs >3/6 do not have normal echocardiographic findings. We can suggest that in our study, echocardiographic findings were not pathologic in 92.31% of the patients without murmur, in 89.91% of the patients with innocent murmur, while it was pathological in 90.38% of the patients in the study. Pathological murmurs can be missed with auscultation, particularly because children may be irritable during examination, and the diagnosis depends on the clinical experience of the physician [7,11]. Murmurs may not be heard exactly if conditions during examination are not appropriate for physical examination or if the physician lacks adequate clinical experience. As a result, intensity and type of murmurs that are heard may not be accurately evaluated [7]. Yildiz et al.

[7] detected innocent murmurs in 92.1% of their patients, and Karacan et al. [12] in 80% of their patients. In the present study, no murmur was detected in 19.5% of the patients who were referred for this reason, while innocent murmur was present in 54.5% the participants.

Pathological murmur was present in 26% of all the patients. Pathological echocardiographic findings were detected in 30% of all the patients in our study. The American Heart Association does not recommend echocardiography in cases of murmurs of with grade 2/6 or lower intensity, which are interpreted as innocent by an experienced physician [13]. However, patients with murmurs that are thought to be innocent were examined with echocardiography in Yıldız et al.'s study [7], and different cardiac pathologies were detected. Some of these pathologies include conditions that were not expected to cause murmur and do not require follow-up, but some of them include valvular pathologies that necessitate follow-up and small atrial and ventricular septal defects and pulmonary stenosis [7]. Therefore, they suggested that murmurs that are described as innocent should also be evaluated with echocardiography. We stated 14 patients without murmur and with innocent murmur who had pathologic echocardiographic findings. These echocardiographic findings were in concordance with the previous study.

Atrial and ventricular septal defects are more commonly detected under two years of age, for this reason physical examination should be performed more carefully in these ages [7]. Children under two years of age constituted 35% of all the patients in the present study. ASD and VSD, Tetralogy of Fallot, operated congenital heart diseases were present in patients under 2 years of age. Children under 3 months of age consisted of 30 patients and pathologic findings included VSD, ASD, interventricular septal hypertrophy.

Only half of the congenital heart diseases can be detected in the first weeks of life during routine examinations of healthy newborns. Diagnosis via physical examination is difficult since hemodynamic changes are not yet complete during this period [14]. Studies in the literature, have also reported that echocardiography definitely should be performed for the diagnosis of murmurs detected in the neonatal period [7]. Cardiac murmurs detected in patients over 12 years of age are also important because the prevalence of valvular diseases increases with age. Valve problems have been shown to be more common in patients over 5 years of age. Therefore, such problems are not expected to produce physical examination findings in the first weeks of life. Patients older than four years of age constituted 53.5% of the children in this study. Pathologic echocardiographic findings included valvular diseases in 21 patients. They were mitral insufficiency, mitral valve prolapses with mitral insufficiency, bicuspid aortic valve with aortic insufficiency and aortic stenosis and pulmonary stenosis.

Some pathological murmurs are highly determinant for some cardiac diseases, especially for VSD. Kocabaş et al. [3] detected VSD with a high incidence, according to the characteristics of the murmur. Similarly in the present study, VSD, pulmonary stenosis, and mitral valve pathologies were suspected with a high probability of pathological murmur.

Correct identification of cardiac murmurs characteristics is

of very great importance. Correct recognition of innocent murmurs is important in terms of avoiding anxiety, unnecessary drug therapy, and restriction of physical activity. If pathological murmurs are misidentified as innocent, the diagnosis and management of the present congenital heart disease will be delayed. Besides, the delay in prophylaxis of infective endocarditis or surgical treatment will cause a very important problem [7]. Mahnke et al. [15] reported that 40% of research assistants identified innocent murmurs as 'pathological' and 21% diagnosed pathological murmurs as 'innocent' and concluded that auscultation experience levels were below than those required. Yıldız et al. [7] reported that echocardiographic examinations revealed pathological findings in 17.75% of patients initially regarded as having innocent murmurs, while echocardiography was normal in 7.54% of patients initially regarded as having pathological murmurs. In our study, we determined pathological echocardiographic findings in 30.35% of the patients with grade 1-2/6 murmurs and in 7.69% of the patients without murmurs. Besides, there were echocardiographic findings that were normal for age in 14.28% of the patients with grade \geq 3/6. In addition, pathological echocardiographic findings were stated in 10.09% of the patients regarded as having innocent murmurs, while echocardiographic findings normal for age were detected in 9.62% of the patients with pathological murmurs. Yıldız et al. [7] demonstrated that physical examination is a significant determinant of echocardiographic findings with a high specificity, positive and negative predictive values and accuracy suggesting that murmurs should be also evaluated with echocardiography for evaluating possible insignificant cardiac defect that has been dismissed and should be followed up in the future. McCrindle et al. [9] did not suggest evaluating with echocardiography if the physical examination was performed by experienced physicians. But Çimen et al. [11] declared that patients without significant murmur may have minor cardiac defects that should be evaluated during follow ups, so they suggested the necessity of echocardiography for evaluation of cardiac murmurs. We demonstrated in our study that characteristics of murmur is a not a significant determinant for echocardiographic findings. Therefore, the presence of murmur independent from its characteristics should be evaluated with echocardiography.

To our knowledge, this is the first study in the literature that examines the relation of the intensity of murmur with echocardiographic findings. We showed that murmur intensity was observed as a significant determinant for distinguishing echocardiographic findings, suggesting that high grades of murmur shows a high probability of echocardiographic findings. This finding if supported by other studies, would decrease the necessity of echocardiographic findings in lower grades of murmur and in the absence of murmur, and also will increase the requirement of echocardiographic evaluation with the presence of high grades of murmur.

Conclusion

Although the majority of murmurs were innocent and cardiac findings were normal, pathological findings were also detected in patients without murmurs or initially regarded as innocent murmurs. Pathological echocardiographic findings were

detected in the majority of pathological murmurs, but findings normal for age were also observed. The intensity of murmurs is valuable in determining the need for further evaluation with echocardiography, while murmur characteristics are an independent factor to make a decision for the necessity of echocardiographic evaluation. In light of these knowledge, these findings suggest that auscultation alone may not be sufficient for the evaluation of the patients with murmur, therefore echocardiographic evaluation may be more appropriate for evaluation.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Funding: None

Conflict of interest

The authors declare no conflict of interest.

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How to cite this article:

Ajda Mutlu Mihçioğlu. Assessment of the patients referred to the pediatric cardiology clinic due to murmur. *Ann Clin Anal Med* 2023;14(9):849-853

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