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Doppler Phonolyser in Comparison to Conventional Statoscope in Detecting and Interpreting Abnormal heart Murmurs in Congenital and Structural Heart Defects

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Abstract

Background: Echocardiography currently represents a significant proportion of cardiac medical expenditure, while many researchers believe that it would be wise to limit the use of this technique, through the enhancement of diagnosis techniques contributing to clinical auscultation. Hence, this study was conducted to evaluate the efficiency of detection of the newly invented Doppler Phonolyser Machine (DPM) compared to the findings by the conventional stethoscope in detecting heart murmurs.

Methods: In a cross-sectional study, a total of 112 patients referred to the pediatric cardiology clinic were enrolled between Jan. 2017 and Jan. 2018. In step one, the patients were initially examined by a pediatric cardiologist, and then in step two, they were randomly divided into two groups (A and B) and were blindly re-examined by a 2nd-year pediatric resident. In Group A (Statoscope group), heart auscultation was performed using only a conventional Statoscope whereas, in Group B (Statoscope + DPM), heart sounds were detected and analyzed using a stethoscope and DPM. In the third step, the diagnostic results made by the pediatric cardiologist and the pediatric resident in groups A and B were compared with the final diagnostic echocardiography made by a pediatric cardiologist.

Results: Heart murmurs as one of the most common reasons for cardiologist referrals comprise about 65% of referrals to pediatric cardiologists. There was only a moderate correlation between a stethoscope and echocardiography to identify cardiac abnormality based on heart murmurs (56%), while there was a significant correlation between the diagnoses made by Doppler Phonolyser accompanied with the conventional statoscope when compared with the echocardiography results (٪85).

Conclusion: Doppler Phonolyser is an innovative smart machine that could efficiently detect and analyze abnormal heart sounds and might play a key role in more accurate and earlier diagnosis of congenital and structural heart defects by general physicians and non-cardiologist specialists, and may potentially reduce the cost of treatment as well as anxiety of the patient's family.

Keywords: Congenital Heart Defect, Heart, Murmur.

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1- INTRODUCTION

Heart murmurs are physical findings related to the flow across the cardiac structures and most often are identified as a pathologic sound and the signal of an underlying cardiac abnormality. The heart murmurs might occur transiently in children, according to their size, age, and hemodynamic state at the time of the examination (1). Researchers reported that the heart murmur is one of the most common reasons for children's referral to cardiologists; with a prevalence of about 65% to 80% among the referred schoolchildren (2). Many forms of congenital heart disease are often first recognized by the presence of a heart murmur (3). Nevertheless, it could be difficult to distinguish during a physical examination, and it is necessary to focus on some different features like the timing, location, quality, and loudness (1).

Examining the normal and abnormal sounds of the heart with a stethoscope is one of the most critical tools made in the medical sciences, which allows the doctor to hear the normal heart sounds and control the rhythm of beats. Moreover, it helps to hear additional and abnormal sounds and possible murmurs in systolic or diastolic stages. Furthermore, some structural and functional heart disorders can be specified by analyzing the sounds' intensity, location, and flow. However, using a stethoscope also has problems, including lack of hearing low gradient flows and the effect of environmental noise on its performance. In this regard, a device has been designed for displaying and recording heart sounds using the Doppler Effect called Doppler Phonolyser, which makes it possible for the user to examine heart sounds with more precision and use visual analysis in addition to the hearing. Many researchers believe that echocardiography currently represents a significant proportion of cardiac medical expenditure, and it would be wise to limit the use of this technique. Well-trained cardiologists can identify the vast majority of functional murmurs on auscultation. However, better training of non-specialist physicians in cardiac auscultation may help in decreasing medical expenses (7).

Cardiac auscultation is still widely used to diagnose heart murmurs, and the enhancement of diagnosis techniques would contribute significantly to clinical auscultation (8). Therefore, this study was conducted to evaluate the accuracy of diagnosing congenital and structural heart diseases using Doppler Phonolyser compared to that of the diagnoses made by the conventional stethoscope.

2- METHODS & MATERIALS

2-1. Study Population

The present study was financially supported by Mashhad University of Medical Sciences, Mashhad, Iran (grant number: 961188) and approved with the ethical approval number: IR.MUMS.fm.REC.1396.745. In a cross-sectional study, all patients referred to the pediatric cardiology clinic at Imam Reza educational Hospital of Mashhad University of medical sciences in Mashhad-Iran, between Jan. 2017 and Jan. 2018 were included. One hundred twelve children, including 63 males and 49 females with a mean age of 35.58 (0.03-288) months, were enrolled.

At the first step, all patients were examined by a pediatric cardiologist. A checklist was completed by the pediatric cardiologist based on the presence of normal and abnormal heart sounds heard using the stethoscope, and a possible diagnosis was performed based on the audiological heart findings. At the second stage, all patients were randomly divided into two groups. The participants in group "A" were blindly referred to the 2nd-year pediatric residents for re-examination using a stethoscope; and the findings and the possible diagnosis were recorded in a

second checklist. The participants in group "B" were blindly referred for re-examination to the other 2nd-year pediatric residents trained to work with the Doppler Phonolyser device and checked by stethoscope and Doppler Phonolyser at the same time. The patients' auditory findings and possible diagnosis were recorded in a third checklist. At the third step, the patients underwent an echocardiography test, and the final diagnosis was recorded in the checklist. Finally, the findings of the two groups were compared to the results of the echocardiography test.

2-2. Doppler Phonolyser

The Doppler Phonolyser is a diagnostic and educational machine to identify heart sounds. The device uses the Doppler phenomenon to make heart sounds audible and visible and shows the data by graph analysis. **Fig. 1** represents an example of the Doppler Phonolyser output. The graph illustrates the time of the onset and duration of the murmurs in the systolic and diastolic heart phases with different colors. The typical signal and the turbulent blood flow are represented by green and red color tones, respectively, in the graph. The structural heart diseases can be predicted depending on the maximum sound intensity location and the time of murmur occurrence. Therefore, medical students can acquire a visual mentality of sounds heard on a stethoscope, and also improve their recognition of heart murmur parameters by the Doppler phenomenon.

Doppler Phonolyser is a smart machine that is used in this study. The probe of the device was placed on different zones of the chest, and the corresponding graphs were recorded in four zones; right second intercostal space (R 2nd ICS), left second intercostal space (L 2nd ICS), left lower sternal border (LLSB), and fifth intercostal space at the midclavicular line (5th ICS MCL). The machine has 3-leads to detect the murmur duration. By comparing the simultaneous ECG signals and the Doppler graph, the duration of the murmur can be determined.

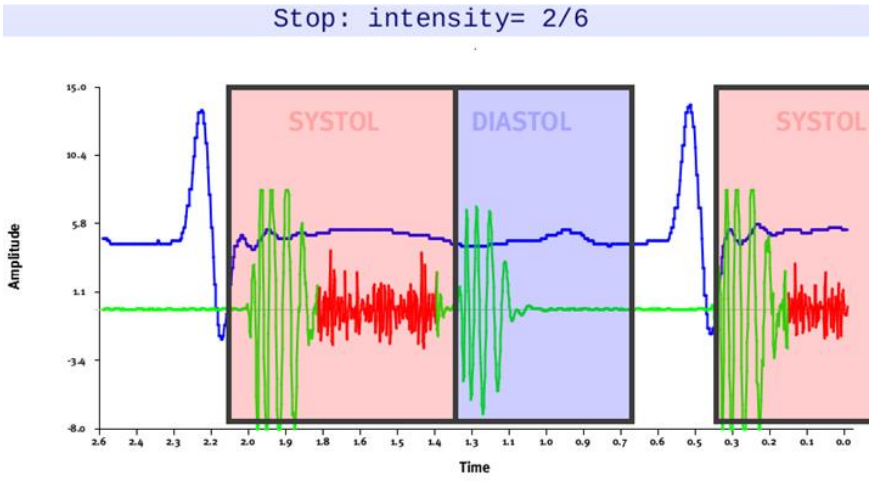

Fig. 1: Output of Doppler Phonolyser device

2-3. Statistical analysis

All analyses were conducted using the SPSS software version 11.5. To statistically evaluate the performance of the methodology, Student's T-test and Pearson correlation were used. Moreover, the sensitivity and specificity of the method were considered.

3- RESULTS

The characteristics of the study population have been summarized in **Table 1**. The mean age and weight of

subjects were 35 months and 12 kg, respectively.

The reasons for referral to a cardiologist were classified into seven categories, including heart murmur, cyanosis, tachypnea, tachycardia, syndromic facies, cardiomegaly in chest X-ray, and FTT. The frequency of the referral causes are shown in **Fig. 2**.

Table-1: Mean age and weight of patients

Characteristics	Mean	Variance	Standard deviation	Minimum	Maximum
Weight (Kg)	12.0637	183	13.5	1.2	80
Age (month)	35.577	3471	59	0.03	288

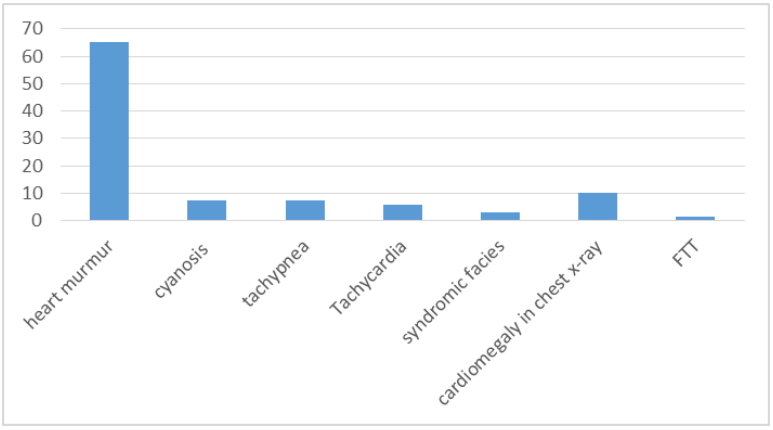

Fig. 2: The frequency of referral reasons to the pediatric cardiologist clinic

The results demonstrated that Heart murmur was the most significant cause of referrals, and more than 60% of referrals were due to hearing extra sound in the heart.

The correlation between the conventional stethoscope and echocardiography in diagnosing typical heart sound was 62% which is only a moderate correlation. The correlation between Doppler Phonolyser and echocardiogram in diagnosing healthy subjects was 90% (p<0.001). The Pearson ratio was calculated to explain the correlation factor. A ratio between 0.30 and 0.69 indicates a moderate correlation, and 0.70 to 1 shows a strong correlation. Spearman correlation between echocardiography and stethoscope was 0.68 (p<0.001), and between echocardiogram and Phonolyser was 0.80.

The sensitivity and specificity parameters were also examined. **Table 2** indicated the calculated PPV and NPV parameters for the stethoscope and the Doppler Phonolyser (Echocardiography was considered as the gold standard). PPV indicates how likely a person is to be ill if the test is positive, and NPV indicates how likely a person is to be healthy if the test is positive.

Table-2: Evaluation of sensitivity, features, PPV and NPV

Device	Sensitivity	Specificity	PPV	NPV
Doppler Phonolyser	98%	89%	95%	96%
Stethoscope	77%	93%	96%	63%

4- DISCUSSION

Despite the use of Dr. Lannec's invention; stethoscope (10, 11), which has been used in patient examinations for more than 180 years, and stethoscope with variable amplification, which has been used for more than 80 years, the auditory recognition of the heart murmurs is still difficult (12). The Phonocardiogram, developed in 1894 (9, 13), can image auditory signals; however, since 1980, research activities have decreased in this field due to the advancement of echocardiography. On the other hand, as pathological murmurs have high frequencies, Phonocardiography can improve the diagnostic accuracy of heart murmurs (14). In 2006, the main parameters of Doppler and the applications of continuous and discrete Doppler were described (15). In 2007, the shape of various murmurs in structural heart diseases such as ASD, VSD, MR, and PS and their characteristics were specified (16). Then, researchers worked on a Doppler signal to create a model for closer examination of the heart, especially the fetal heart. The accuracy of the procedure was the same as direct electrocardiography of the heart (17). Also, another study was conducted to monitor the heart, especially the fetal heart, using Doppler signals in 2013 (18). In this research line, a new method for analyzing the sound of the heart was introduced in 2013 (19). Finally, In 2014, central heart health parameters were examined based on the Doppler signal (20). In this regard, the present study was conducted to evaluate the effectiveness of using a Doppler Phonolyser alongside a stethoscope for more accurate diagnoses of patients. Results indicated that the most common reason for referrals to a cardiologist was hearing heart murmurs, and the cause of almost 65% of referrals was an abnormal sound in the heart. Moreover, considering the diagnosis of health issues, the stethoscope alone and Doppler Phonolyser alongside a stethoscope indicated moderate (62%) and high (90%) correlations, respectively, with an echocardiogram.

A previous study reported a weak correlation between a stethoscope and Doppler to determine an ankle-brachial index. Results revealed the higher accuracy of Doppler ultrasound compared to a stethoscope to assess systolic pressure and ABI calculation {Chesbro, 2011 #1}. In evaluating intrapartum fetal heart rate using a handheld Doppler compared to Pinard stethoscope, researchers have reported an increased ability to detect abnormal FHR using the Doppler {Kamala, 2018 #2}. These findings indicated the preference of the Doppler technique in heart disease diagnosis.

In the early clinical practices for detecting heart murmurs in children, due to limited cardiac auscultation skills, doctors usually could not distinguish innocent from pathological murmurs. Also, the ability of pediatric residents to recognize heart murmur was less than expected, which led to referring children to pediatric cardiologists for echocardiography.

5- CONCLUSION

In this study, the efficiency of the Doppler Phonolyser in the diagnosis of heart murmurs was compared to that of the stethoscope. The results showed that the Doppler Phonolyser might play an essential role in the more accurate diagnosis of heart murmurs. Doppler Phonolyser, alongside the stethoscope, introduces an efficient and worthwhile device for diagnosing heart murmurs and early detection of diseases. Also, it would preserve the golden time for the treatment of the acute disease and reduce the stress and anxiety of the patient's family and the cost of treatment. However, there were some limitations in using Doppler Phonolyser, including lack of audio playback and no recognition of S1 and S2

sounds which needs more improvement for a suitable solution in future efforts.

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7- Conflict of interest: None.

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