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Accuracy of Cardiac Auscultation for Diagnosing Congenital Heart Diseases in Newborns

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Abstract

Introduction: Congenital Heart Disease (CHD) is defined as a gross structural abnormality of the heart or intrathoracic great vessels that is actually or potentially of functional significance. Auscultation is one of the basic tools for evaluation of a patient with a suspected heart disease. The ability of cardiac auscultation for diagnosing a CHD in an asymptomatic neonate is limited and dependent on the physician's experience and level of clinical confidence. Although, echocardiography is the gold standard, auscultation is the primary screening tool for the diagnosis of a suspected CHD in resource limited settings. This study was undertaken to assess whether auscultation is effective as a screening tool in neonates.

Methods: A cross sectional study was conducted over one year. Healthy term neonates who were born in the hospital were included. Physical examination of cardiovascular system was done by a pediatric resident. A pediatric cardiologist performed 2D echocardiography for all babies. The accuracy of the physical examination was assessed.

Results: The sensitivity of physical examination was 37.8%, the specificity was 99.1%. The positive predictive value was 85% and the negative predictive value was 92.2%. Out of 377 term neonates 45 were diagnosed with a CHD out of which VSD was the most frequently found lesion. The prevalence of CHD was found to be 10.12 per 1000 live births.

Conclusion: Physical examination is not sufficient to identify CHDs in neonates with murmur. Early 2D echocardiography is beneficial in delineating structural heart defects.

Introduction

Congenital Heart Disease (CHD) is defined as a gross structural abnormality of the heart or intrathoracic great vessels that is actually or potentially of functional significance. (1) CHD accounts for almost one third of all major congenital anomalies. The prevalence is 6-8 per 1000 live births. Out of these 25% constitute critical CHD requiring early intervention (2).

An estimated 85% of children diagnosed with CHD will survive into adulthood (3), yielding between 1.0 and 2.9 million adult survivors with CHD (4). Although, the exact aetiology of CHD is unknown, numerous theories have been put forward to explain the pathogenesis of CHD, the most commonly accepted one is Nora's multifactorial inheritance hypothesis (5).

Making diagnosis of CHDs, the foremost plan while initiating measures to control morbidity and mortality related to the disease. Heart murmur although, not the most common manifestation of a CHD is the most common reason for a visit to the cardiologist. Auscultation for assessment of heart murmur is one of basic tools used for initial evaluation of a child suspected with cardiac abnormalities. It still remains the first step of cardiac examination and the advantage lies in the fact that it is non-invasive, relatively quick and inexpensive. The ability of cardiac auscultation for diagnosing a CHD in an asymptomatic neonate is limited and dependent on the physician's experience and level of clinical confidence. There have been multiple studies which still support auscultation as a diagnostic modality for CHDs.

Our study prospectively assessed the diagnostic accuracy of cardiac auscultation in newborn term babies, using echocardiography as the gold standard. The present study

also helped determine the prevalence of CHDs in a tertiary care rural hospital in India.

Methods

A cross sectional, diagnostic study was conducted in the pediatric department of a rural tertiary care hospital, AVBRH, Sawangi, Wardha. The study duration was one year. All term live births occurring in the hospital between September 2017 and September 2018 were selected for the study.

The study was initiated after obtaining appropriate permission from the Institutional Ethics Committee (*Reference number: DMIMS (DU)/IEC /2017-18/6704*).

All the relevant data was collected in predesigned proformas. A paediatric resident was selected for examining the cases throughout the study period. Relevant history including antenatal, perinatal and significant medical and obstetric history of the mother was asked and details of the delivery were ascertained. Anthropometry, vital monitoring and systemic examination was done in all cases. Physical examination of CVS for detecting congenital heart disease included detection of any murmur. Echocardiography (Reference standard) was performed by a cardiologist on the same day who was blinded to the observations of the observer. Echocardiography machine (Philips) Color Doppler system with a multi frequency 3.5 to 5 MHz probe was used. 377 babies were included in the study.

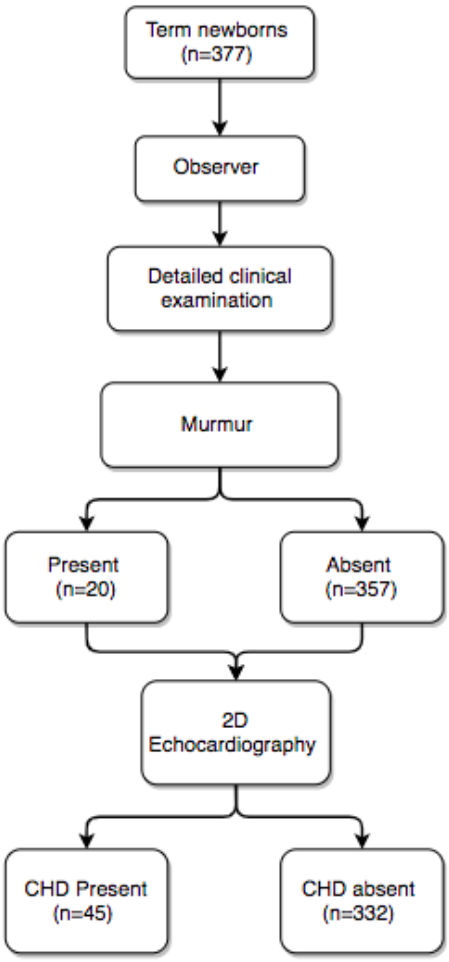

Figure 1: Flow chart of the study design

Statistical analysis

All data was entered in the Microsoft excel spreadsheets and stata software (stata 10, stata corporation Texas, USA) was used for data analysis. Distribution of data was studied by Kolmogorov Smirnov test. Quantitative data was analyzed using mean, median and standard deviation. To know the accuracy of the physical examination (Murmur & Abnormal second heart sound) for CHD the Sensitivity, Specificity, positive predictive value, negative predictive value, Positive Likelihood ratio, and Negative Likelihood ratio for each physical sign was calculated. Cohen's kappa coefficient for measurement of inter-rater reliability for qualitative items was used to determine the diagnostic accuracy of the observers.

Results

377 healthy, term newborn babies were included in the study. 183 were males and 194 were females. Out of 377 babies, 45 were diagnosed with a CHD on 2D echo.

The prevalence of congenital heart disease in the present study was found to be 10.12 per 1000 live births. 21 males were found to have a CHD while 24 females were diagnosed with a CHD. The presence of CHD was not affected by the gender of the neonate. (p value>0.05)

A murmur was found on physical examination in case of 20 babies while 357 babies had no murmur. When echocardiography was performed, out of the 20 babies with a murmur, 17 had a congenital heart disease, while in 357 babies with no murmur, 28 had a significant finding on echocardiography.

When data from for detection of murmur was analyzed, the sensitivity of murmur for detecting presence of CHD was found to be 37.8%, specificity was 99.1%. The positive predictive value was 85% and negative predictive value was 92.2%. The positive likelihood ratio was 41.8 and negative likelihood ratio was 0.62 **(Table 1).**

	Echocardiography (Gold standard)		Total	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Positive LR	Negative LR
Murmur	**CHD Present**	**CHD Absent**							
Present	17	3	20	37.8 %	99.1 %	85 %	92.2 %	41.8	0.62
Absent	28	329	357						
Total	45	332	377						

Table 1: Diagnostic accuracy of auscultation

Ventricular septal defect was the most common lesion found on 2D echo in the present study which was observed in 16 patients (4.24%) followed by 15 neonates who had a Atrial septal defect (3.97%), 5 had a patent ductus arteriosus (1.32%), and 9 had other congenital heart disease (2.38%) which included pulmonary stenosis in 5 patients (1.32%) and tricuspid regurgitation in 4 (1.06%).

Discussion

When compared to cardiovascular examination of children; neonatal auscultation is often dissatisfying. Frought with conditions it is also made arduous by the baby's crying and other confounding factors such as the rapidly changing nature of the neonatal circulation and presence of innocent murmurs and tachycardia.

Despite these problems, a thorough clinical examination and an accurate cardiac auscultation remain the first tool in the screening for congenital heart diseases in newborns. This makes it imperative to determine the accuracy of auscultation as a screening tool when better and newer modalities like echocardiography are available.

The objective of this study was to determine the accuracy of auscultation when compared to echocardiography in neonates. Despite the advantages of echocardiography, the lack of availability and high cost in low and middle income countries makes Echocardiography a confirmatory test and physical examination is the primary screening tool. The present study also determined the prevalence of CHDs in a rural tertiary care hospital in newborn babies.

Present study employed a pediatric resident as the primary observer. Sensitivity of cardiac auscultation for recognizing a cardiac murmur was 37.8%, while the specificity was 99.1%. The positive predictive value was 85% whereas the negative predictive value was 92.2%. The positive likelihood ratio was 41.8 and negative likelihood ratio was 0.62. This showed that if a murmur was not recognized by the paediatric resident, it effectively ruled out the possibility of an underlying CHD. The positive likelihood ratio of 41.8 showed that presence of a murmur in case of observer had a large effect on increasing the chances of the baby having a congenital heart disease. Similar findings were observed in studies conducted by Zhao Q et al and Sackey AH et al.

Zhao Q et al(6) studied cardiac auscultation by general pediatricians and assessed the accuracy based on grades of murmur. They found a relatively higher sensitivity than the present study with the sensitivity of grade 1 and 2 murmurs being 89.58% while for grade 3 being 83.33%. The specificity in both studies was found to be similar, Zhao Q et al noted an increasing specificity with the increasing grade of murmur. Grade 1 murmur had a specificity of 94%, Grade 2 had 97.3 while, grade 3 had 99.69% specificity.

Sackey AH et al studied auscultation performed by general pediatricians and found that clinical assessment had a sensitivity of 93% (much higher than the current study), specificity of 59%, positive predictive value of 35%, and negative predictive value of 97% for detection of CHD.(7) When a pathological murmur was present, the positive likelihood ratio was 2.3, and the negative likelihood ratio was 0.1. Although, it should be considered that the sample size in the said study included pediatric patients as well.

Zuppa AA et al(8) found physical examination to be more sensitive (89.2%) but less specific (40%). They attributed the low specificity to changing nature of neonatal circulation and the presence of PDA and PFO. PPV was 25% and NPV was 94%. Castello-Herbreteau B et al(9) noticed a high sensitivity of 90.3% with a high specificity of 93.8%. PPV and NPV were 95.6% and 86.5% respectively. Azhar AS et al (10) found no significant difference in the findings of the two study groups but concluded that echocardiogram was still needed to reach the accurate diagnosis of congenital heart disease in neonates even if a pediatric cardiologist is consulted. Ageliki KA et al (11) noted that the overall ability of pediatric trainees in identifying congenital heart disease (CHD) was moderate and significantly lower compared to neonatologists. However, at ''lower'' levels of clinical confidence (i.e., clinical diagnosis of possibly pathologic murmurs), pediatric trainees had good ability in excluding CHD (sensitivity 94.6%;). They further concluded that the ability of cardiac auscultation for in asymptomatic neonates is limited and dependent on the physician's experience and level of clinical confidence. They too, advised echocardiography for confirmation of CHD for all neonates with a possibly pathologic murmur.

The most common lesion found in our study was Ventricular septal defect followed by followed by atrial septal defect and patent ductus arteriosus. These findings have been corroborated by multiple other studies as well (12–15).

Lastly, the prevalence of CHDs in neonates at birth is on the ascent due to better diagnostic modalities which help to detect even milder forms of disease, resulting in increased survival rates and better healthcare facilities. The prevalence of CHDs observed in other studies varied from 8.1 to 9.96 per 1000 live births (16–18). Our study reports a slightly higher prevalence of CHDs in healthy term babies at around 10.12 per 1000 live births. The higher prevalence in the present study can be attributed to the fact that it is a hospital based study and not a population based one.

Author	Year	Observer	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Positive LR	Negative LR
Castello-Herbreteau et al[9]	2000		90.3	93.8	95.6	86.5		
Azhar et al[10]	2006	Neonatologists	78	33	77	37		
		Cardiologists	83	25	80	29		
Ageliki KA et al[11]	2011	Pediatricians	94.6	64	-	-	2.6	0
		Neonatologists	98.3	71.1	-	-	3.4	0
Zuppa AA et al [8]	2014		89.2	40	25	94		
Sackey et al [7]	2016		93	59	34	97	2.3	0.1
Zhao et al [6]	2019	Grade 3 murmur	83.3	99.89	65.57	99.98	26.6	0.17
Present study	2019	Observer	37.8	99.1	85	92.2	41.8	0.62

Table 2: Diagnostic accuracy of clinical examination among various studies in detecting congenital heart diseases.

Conclusion

The ability of cardiac auscultation for diagnosing CHD in asymptomatic neonates is limited and dependent on the experience and level of clinical confidence of the clinician. The care available for children in Low and middle income (LMIC) countries, such as India differs from that in high income countries. Majority of the CHDs still go undiagnosed due to paucity of resources. Although a huge progress has been made it is still inadequate. Hence, Echocardiography should remain an option for all neonates with a possibly pathologic murmur. In a newborn, the potential benefits of early diagnosis, in the context of physical examination findings, should be considered in determining whether an echocardiogram should be performed in the neonatal period.

What is already know on this topic

1) Echocardiography is a useful tool in neonatal screening for CHDs
2) The neonatal prevalence of CHDs was similar to other hospital based studies

What this study adds

1) Skills in clinical assessment of heart murmurs in neonates can be improved among pediatric resident in training.
2) The current level of cardiac care leaves a lot to be desired and such a study will bring forth the changes in the CHD trends and allow for better targeted approach.

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