

Original Research Article

Clinical screening tool for early detection of congenital heart disease in children living at high altitude

Abhinav Gautam¹, Parveen Bhardwaj², Vipin Roach^{2*}, Amit Sachdeva³, Drishti Rana⁴

¹Department of Pediatrics, Dr RPGMC, Tanda, Himachal Pradesh, India

²Department of Pediatrics, IGM, Shimla, Himachal Pradesh, India

³Department of Community Medicine, IGM, Shimla, Himachal Pradesh, India

⁴Department of Obstetrics and gynaecology, Dr RPGMC, Tanda, Himachal Pradesh, India

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*Correspondence:

Dr. Vipin Roach,

E-mail: roach9797@gmail.com

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ABSTRACT

Background: Congenital heart diseases (CHD) have a high morbidity and mortality and its early detection is critical. The aim of the study is to develop a clinical screening tool for early detection of children with congenital heart disease at high altitude.

Methods: This was a hospital based cross sectional study. All children between age 0 to 1 year visiting the OPD and admitted in indoor services of pediatrics with suspected heart disease based on pre-defined clinical criteria were evaluated for development of clinical screening tool for prediction of presence of CHD using parameters; heart rate (HR), respiratory rate (RR), ratio of HR/RR, pulse oximetry, presence of precordial pulsations and murmurs. Then diagnostic performance of these tools was calculated by using ECHO as a gold standard test.

Results: A total of 102 study participants were included in our study. Among the total, 79 (77.5%) had underlying CHD. Result was considered positive if any of them was present. In children age less than one year living at high altitude suspected to have high risk for presence of CHD and/or arterial oxygen saturation of less than 87.2%, this screening tool has sensitivity of 78.79% and specificity of 66.67%.

Conclusions: This study concluded that combination of screening tools along with pulse oximetry in the community settings of developing countries are better in early detection and timely management of CHD than using these tests/parameters alone.

Keywords: CHD, Clinical screening tool, Early detection

INTRODUCTION

Congenital heart disease (CHD) is defined as an anatomic malformation of the heart or great vessels which occurs during intrauterine development, irrespective of the age at presentation.^{1,2} The worldwide incidence is around 2-8 per 1000 live births but the burden in India is huge due to very high birth rate.³

Approximately 10% of present infant mortality in India may be accounted for by congenital heart disease.⁴

CHD have a high morbidity and if not detected early carry a high mortality rate.³ About 25% of CHDs are life-threatening and may manifest before the first routine clinical examination.^{5,6} Early detection is critical to preventing infant morbidity and mortality. Combined with advances in therapeutic interventions, early detection can enable the majority of children born with CHD to lead normal productive lives.⁷⁻⁹

Rapid advancements have taken place in the diagnosis and treatment of CHD.¹⁰ The detection of CHD can be done by various modalities like history, physical

examination, Imaging studies like echocardiography, cardiac magnetic resonance imaging, CT scan and diagnostic cardiac catheterization.¹

The present study, conducted in a tertiary care center, attempted to identify a strategy based on clinical signs/symptoms and pulse oximetry that best predicts CHD in newborns/infants. Therefore, this study was conducted with the objective to develop clinical screening tool for early detection of children with congenital heart disease at high altitude between 0–1-year age group which can be used by doctors, paramedical staff and other health care providers.

METHODS

Type of study

It was hospital based cross-sectional observational study.

Study population

Children age between 0 to 1 year with suspected heart disease were selected.

Study period

Study conducted for one year from July 2018 to June 2019.

Setup for study

It was tertiary care hospital.

Source

Study conducted at outdoor and indoor services of department of pediatrics IGM, Shimla.

Inclusion criteria

Children age 0 to 1 year of with suspected heart disease based on presence of any one of the following features: Excessive forehead sweating, suck rest suck cycle, increased precordial pulsations, cyanosis, fast breathing, recurrent chest infections, failure to gain weight with age, murmur, persistence of oxygen requirement to maintain normal oxygen saturation were included.¹¹⁻¹⁶

Exclusion criteria

Patients on respiratory support (CPAP, mechanical ventilation), already diagnosed with CHD were excluded from study.

Ethical approval

This study was conducted after approval from protocol review committee of IGM, Shimla.

Data collection and screening for CHD

After taking the informed consent from parents or guardians, the data related to age, gender, altitude of residence was collected. The altitude of residence of mother was ascertained from the "design and production of the Himachal Pradesh topographic overview map."¹⁷ Weight and length were recorded to detect failure to thrive.¹⁸

Stage 1 screening

Then on the basis of presence of any one of parameters listed in ground of suspicion, patient got enrolled in study and also looked for presence of any other previously mentioned parameters. On this basis, we enlisted a high-risk population, in whom we can suspect underlying CHD.

Stage 2 screening

Clinical screening tool tested for detection of CHD: Following clinical tool were tested to assess their diagnostic performance for detection of CHD: HR, RR, pulse oxygen saturation, ratio of HR/RR and presence of heart murmurs.

Confirmation of CHD

Presence of CHD was confirmed based on echocardiographic evidence of CHD. All children suspected to have CHD based on initial symptoms-based screening criteria stated above underwent echocardiography examination using echo machine model I E 33 of Philips medical system pvt. ltd. using pediatric and neonatal probe by consultant cardiologist. The 2D echo images were obtained and reviewed real time from sub costal, apical 4 chamber, parasternal long and short axis and suprasternal views supplemented with color flow imaging. The presence of CHD on echocardiography was taken as the CHD present.

Operational definitions

Recurrent pneumonia: ≥ 2 episodes in a single year with radiographic clearing between occurrences.

Tachycardia: The cutoff values taken for labeling tachycardia was different for different age groups and the values taken are as follows. ≤ 3 months, HR ranging 110-160/minute, 3-6 months, HR ranging 100-150/minute and 6-12 months, HR ranging 90-130/minute.

Tachypnea: Any value exceeding this range was considered as tachypnea ≤ 3 months, RR ranging 30-60/minute, 3-6 months, RR ranging 30-45/minute and 6-12 months, RR ranging 25-40/minute.

Failure to thrive: weight consistently below the 3rd percentile for age and sex, progressive decrease in weight

to below the 3rd to 5th percentile, or a decrease in the percentile rank of 2 major growth parameters in a short period.

Data analysis

The data was analyzed using Epi Info version 7. Statistical software. The data was reported as frequency and percentages for categorical variables and mean $\pm$ SD for continuous variable with normal distribution. The diagnostic performances of the initial screening tools were tested by calculating sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) using two by two table. The discriminating ability of HR, RR, ratio of HR to RR, pulse oxygen saturation was estimated AUC with ROC. The cutoff values obtained from ROC was used to test the performance of the parameter by calculating sensitivity, specificity, PPV and NPVs. The clinical parameters under study having significant diagnostic ability were used to develop the predictive ability of these parameters used as the diagnostic parameter to assess any incremental value in predicting presence of CHD by calculating sensitivity, specificity, PPV and NPV. Two sided $p < 0.05$ was taken as the statistically significant.

RESULTS

In our study there were 102 participants in total. Out of them 57 participants were ≤ 1 month of age i.e. 55.9% of total, 29 (28.4%) between 2-6 months, 16 (15.7%) between 7-12 months. There were 55 males and 47 females. Most of the participants i.e. 41 (40.2%) were residents of altitude ranging between 2000-3000 meters. Out of 102 study participants, 4 had history of GDM and only 3 participants had underlying CHD. None of our study participants had history of antenatal fever and heart disease in family (Table 1).

Out of 102 study participants, there were maximum 57 (55.9% of total) participants in ≤ 1 month age group and 44 (55.7%) out of them underlying congenital heart disease. Between 2-6 months there were 29 (28.4%) patients, out of them 21 (26.6%) had underlying CHD. Between 7-12 months age group there were 16 patients (15.7%), out of them 14 (17.7%) had underlying CHD and $p = 0.509$ i.e., not significant. Out of all those study participants having underlying congenital heart disease i.e. 79 patients, 46 (58.2%) were male and 33 (41.8%) were females. Odd ratio was 0.54 (95% CI=0.26-1.15) and $p = 0.11$ which is not significant. Out of 79 study participants having underlying congenital heart disease, maximum i.e. 31 (39.2%) were residents of altitude ranging between 1000-2000 meters and $p = 0.139$ which is not significant (Table 2).

In the present study, tachycardia was present in 55 (53.9%) out of 102 study participants and out of these 55 patients, 48 were diagnosed with underlying CHD. Odds ratio was 2.7 with CI (1.2-5.94), with $p = 0.019$, which is

significant. Failure to thrive was seen in 16 patients among all 79 diagnosed patients with CHD. Odd ratio was 0.22 with CI (0.03-1.57), with $p = 0.14$, which is not significant. The 66 (74.5%) patients had murmur on examination. Odd ratio was 0.26 with CI (0.13-0.53) with $p = 0.000$ which is highly significant. The 31 (39.2%) patients had history of forehead sweating. Odd ratio was 0.19 with CI (0.05-0.79) with a $p = 0.005$ which is highly significant. In 30 (31.4%) patients, there was history of suck rest suck cycle while feeding. Odd ratio was 0.21 with CI (0.05-0.83) with a $p = 0.010$, which is significant. 18 had history of recurrent chest infections and all of them were diagnosed with underlying congenital heart disease. $P = 0.010$ which was significant. The 27 (34.2%) had history of cyanosis with a $p = 0.003$ which is significant. The 26 (32.9%) had increased precordial pulsations with a $p = 0.001$ which is highly significant. The 69 (87.3%) had persistence of oxygen requirement. Odd ratio was 0.4 with CI (0.20-0.80) with a $p = 0.026$ which is highly significant (Table 3).

Diagnostic performance of clinical screening tools tested for predicting CHD

HR: Ability of HR of >151 /minute for predicting probability of presence of CHD was 0.67 (95% CI=0.560-0.788) by AUC using ROC. The area under curve for HR was 0.674 (95% CI=0.560-0.788). So, we take the corresponding cut off HR of 151.00 for estimation of sensitivity came out to be 64.6%.

RR: Ability of RR of >51 /minute for predicting probability of presence of CHD was 0.533 (95% CI=0.397-0.699) by AUC using ROC. The area under curve for RR was 0.533 (95% CI=0.397-0.699). So, we take the corresponding cut off 51.00 and value of our sensitivity came out to be 57%.

HR/RR ratio: Ability of HR/ RR of >2.97 for predicting probability of presence of CHD was 0.542 (95% CI=0.408-0.676) by AUC using ROC. The area under curve for HR/RR ratio was 0.542 (95% CI=0.408-0.676). So, we take the corresponding cut off 2.97 and value of our sensitivity came out to be 55.7%.

Oxygen saturation at room air: Ability of oxygen saturation at room air $<88\%$ for predicting probability of presence of was 0.792 (95% CI=0.695-0.889) by AUC using ROC. The area under curve for the oxygen saturation in room air was 0.792 (95% CI=0.695-0.889). So, we take the corresponding cut off value of 88. Our sensitivity came out to be 79.7% and specificity came out to be 52.2%.

On the basis of sensitivity and significant p value, we included 7 parameters for making two different tools (one for doctors and second for paramedics and health workers). The parameters included are tachycardia, forehead sweating, suck rest suck cycle, murmur, increased precordial pulsations, recurrent chest infections

and SpO₂. Then sensitivity, specificity, PPV and NPVs of individual tool were calculated. We considered the tool as a positive test if any one of the parameters of tool were present and congenital heart disease was present.

In the screening tool for doctors, we included all the 7 parameters (tachycardia, forehead sweating, suck rest suck cycle, murmur, increased precordial pulsations, recurrent chest infections and SpO₂) and the result was considered positive when any of the 7 parameters was present. For the screening tool for paramedics, we

included 5 parameters (tachycardia, forehead sweating, suck rest suck cycle, recurrent chest infections and SpO₂) and the result was considered positive when any of them was present.

The sensitivity, specificity, PPV, NPV and accuracy of this tool for doctors in diagnosing CHD is 98.73%, 8.7%, 78.79%, 66.67% and 78.43% respectively. The sensitivity, specificity, PPV, NPV and accuracy of this tool for staff in diagnosing CHD is 97.47%, 30.43%, 82.80%, 77.78% and 82.35% respectively.

Table 1: Socio-demographic and risk factor characteristics of the study participants.

Characteristics	Category	Male, N (%)	Female, N (%)	Total, N (%)
Age (in months)	≤1	29 (28.4)	28 (27.4)	57 (55.9)
	2-6	16 (15.6)	13 (12.7)	29 (28.4)
	7-12	10 (9.8)	6 (5.8)	16 (15.7)
Mean age	2.86±3.53			
Altitude (m)	≤1000	14 (13.7)	10 (9.8)	24 (23.5)
	1000-2000	22 (21.5)	19 (18.6)	41 (40.2)
	>2000	19 (18.6)	18 (17.6)	37 (36.3)
Risk factors for CHD	H/O GDM	2 (1.9)	2 (1.9)	4 (4)
	Fever with rash during pregnancy	0	0	0 (0)
	Family H/O CHD	0	0	0 (0)
Reasons for suspecting CHD	Failure to thrive	13 (12.7)	4 (3.9)	17 (16.7)
	Recurrent chest infection	14 (13.7)	4 (3.9)	18 (17.6)
	Suck rest suck cycle	22 (21.5)	10 (9.8)	32 (31.4)
	Forehead sweating	22 (21.5)	11 (10.7)	33 (32.4)
	Failure to maintain the oxygen saturation	49 (48.03)	35 (34.3)	84 (82.4)
	Increased precordial pulsations	16 (15.6)	10 (9.8)	26 (25.5)
	Murmur	45 (44.1)	31 (30.3)	76 (74.5)
	Tachycardia	34 (23.5)	21 (20.5)	55 (53.9)
	Cyanosis	19 (18.6)	9 (8.8)	28 (27.5)

Table 2: Age, gender and altitude wise distribution of congenital heart disease.

Variables			CHD		Total	P value
			No	Yes		
Age (in months)	≤1	Count	13	44	57	0.509
		% within CHD	56.5	55.7	55.9	
	>1 to ≤6	Count	8	21	29	
		% within CHD	34.8	26.6	28.4	
	>6 to ≤12	Count	2	14	16	
		% within CHD	8.7	17.7	15.7	
Sex	Male	Count	9	46	55	0.11
		% within CHD	39.1	58.2	53.9	
	Female	Count	14	33	47	
		% within CHD	60.9	41.8	46.1	
Altitude (in meters)	≤1000	Count	2	22	24	0.139
		% within CHD	8.7	27.8	23.5	
	1000-2000	Count	10	31	41	
		% within CHD	43.5	39.2	40.2	
	>2000	Count	11	26	37	
		% within CHD	47.8	32.9	36.3	
Total	Count		23	79	102	
	% within total		22.5	77.5	100	

Table 3: Diagnostic performance of screening criteria used in stage 1 screening.

Variables		CHD, N (%)		Total, N (%)	OR (95% CI)	P	Sensitivity	Specificity	PPV	NPV
		Absent	Present							
Tachycardia	Yes	7 (30.4)	48 (60.8)	55 (53.9)	2.7 (1.2-5.94)	0.019	83.54	56.52	86.84	50.00
	No	16 (69.6)	31 (39.2)	47 (46.1)						
Failure to thrive	Yes	1 (4.3)	16 (20.3)	17 (16.7)	0.22 (0.03-1.57)	0.14	20.2	95.6	94.1	25.88
	No	22 (95.7)	63 (79.7)	85 (83.3)						
Murmur	Yes	10 (43.5)	66 (83.5)	76 (74.5)	3.8 (1.89-7.6)	0.000	83.54	56.52	86.84	50.00
	No	13 (56.5)	13 (16.5)	26 (25.5)						
Forehead Sweating	Yes	2 (8.7)	31 (39.2)	33 (32.4)	5.01 (1.25-20.16)	0.005	39.24	91.3	93.94	30.43
	No	21 (91.3)	48 (60.8)	69 (67.6)						
Suck rest cycle	Yes	2 (8.7)	30 (38.0)	32 (31.4)	4.8 (1.9-19.5)	0.010	37.97	91.30	93.75	30.00
	No	21 (91.3)	49 (62.0)	70 (68.6)						
Cyanosis	Yes	1 (4.3)	27 (34.2)	28 (27.5)	8.3 (1.17-58.87)	0.003	34.1	95.6	96.4	29.7
	No	22 (95.7)	52 (65.8)	74 (72.5)						
Recurrent chest infection	Yes	0 (0.0)	18 (22.8)	18 (17.6)	NA	0.010	22.78	100	100	27.38
	No	23 (100)	61 (77.2)	84 (82.4)						
Increased precordial pulsation	Yes	0 (0.0)	26 (32.9)	26 (25.5)	NA	0.001	32.91	100	100	30.26
	No	23 (100)	53 (67.1)	76 (74.5)						
Persistent oxygen requirement at room air	Yes	15 (65.2)	69 (87.3)	84 (82.4)	2.4 (1.24-4.96)	0.026	87	34.7	82.1	44.4
	No	8 (34.8)	10 (12.7)	18 (17.6)						

Table 4: Comparison of diagnostic performance of clinical screening parameters tested in predicting CHD in children with suspected CHD, used in tool making sensitivity, specificity, PPV and NPV of stage 1 screening criteria used for suspecting CHD.

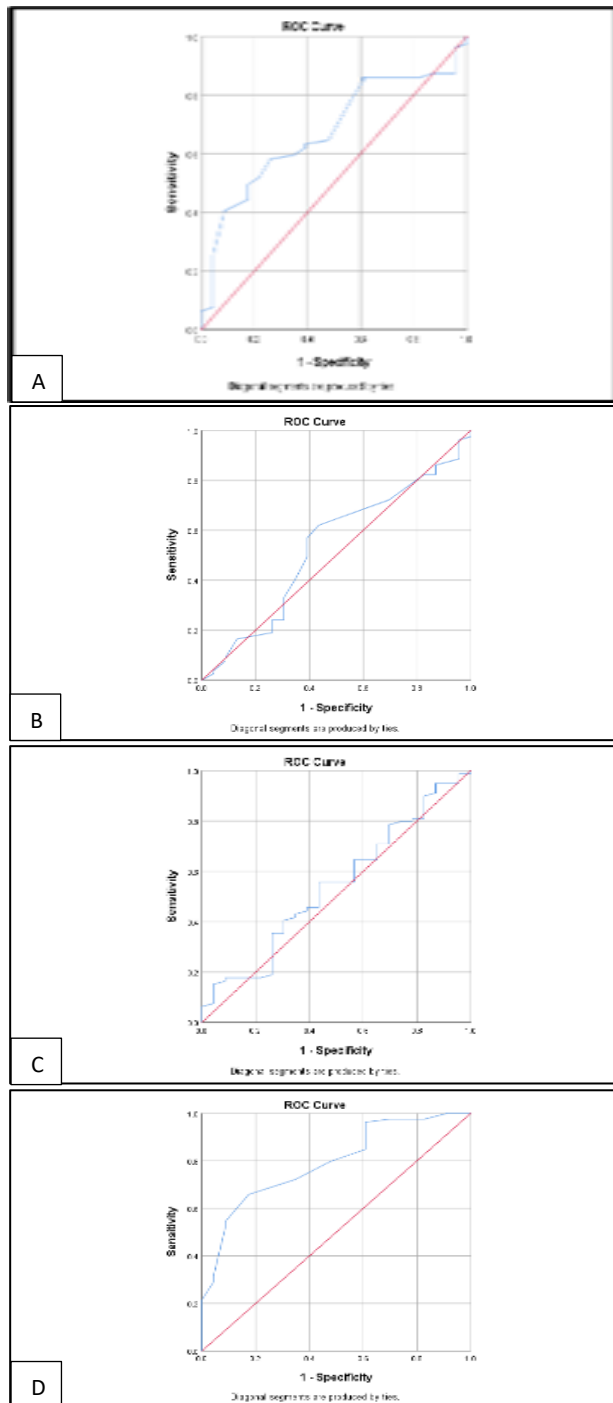
Statistics	Murmur		Forehead sweating		Suck rest suck cycle		Recurrent chest infection		Increased precordial pulsations	
	Value	95% CI	Value	95% CI	Value	95% CI	Value	95% CI	Value	95% CI
Sensitivity	83.54	73.51-90.94	39.24	28.44-50.87	37.97	27.28-49.59	22.78	14.10-33.60	32.91	22.75
Specificity	56.52	34.49-76.81	91.3	71.96-98.93	91.30	71.96-98.93	100.00	85.18-100.00	100.00	85.18
PPV	86.84	80.39-91.40	93.94	80.03-35.22	93.75	79.48-98.31	100.00	NA	100.00	NA
NPV	50.00	35.15-64.85	30.43	26.03-35.22	30.00	25.71-34.67	27.38	25.06-29.83	30.26	27.11
Accuracy	77.45	68.11-85.14	50.98	40.89-61.01	50.00	39.93-60.07	40.20	30.61-50.37	48.04	38.04

Table 5: Comparison of diagnostic performance of clinical screening parameters tested in predicting CHD in children with suspected CHD, used in tool making sensitivity, specificity, PPV and NPV of stage 2 screening criteria used for suspecting CHD.

Statistics	HR		RR		SpO ₂	
	Value	95% CI	Value	95% CI	Value	95% CI
Sensitivity	60.76	49.13-71.56	44.30	33.12-55.92	79.75	69.20-87.96
Specificity	69.57	47.08-86.79	69.57	47.08-86.79	56.52	34.49-76.81
PPV	87.27	78.29-92.88	83.33	71.99-90.68	86.30	79.60-91.05
NPV	34.04	25.99-43.14	26.67	20.65-33.69	44.83	31.58-58.86
Accuracy	62.75	52.61-72.12	50.00	39.93-60.07	74.51	64.92-82.62

Table 6: Diagnostic performance of composite clinical screening tool for doctors and paramedics.

Variables	Screening tool for doctors		Screening tool for paramedics	
Statistic	Value	95% CI	Value	95% CI
Sensitivity	98.73%	93.15% to 99.97%	97.47%	91.15% to 99.69%
Specificity	8.70%	1.07% to 28.04%	30.43%	13.21% to 52.92%
PPV	78.79%	76.56% to 80.86%	82.80%	78.56% to 86.34%
NPV	66.67%	15.95% to 95.47%	77.78%	43.82% to 94.01%
Accuracy	78.43%	69.19% to 85.96%	82.35%	73.55% to 89.19%

**Figure 1 (A-D): ROC curve of HR, RR, HR/RR Ratio and Oxygen saturation at room air.**

DISCUSSION

In the present study, 79 (77.5%) patients (46 male and 33 female) were detected to have underlying congenital heart disease out of total 102 patients. Maximum 57 (55.9%) patients were of ≤ 1 month of age group and among them 44 (77.19%) had underlying congenital heart disease. So, it is essential to recognize congenital heart disease in the early stages as the deterioration is sudden and, most of the children with complex heart disease die at presentation or before any surgical intervention is made.¹⁹

Vaidyanathan et al in their study, screened 5487 newborns and CHD was detected in 425 neonates (7.75%).² The low detection of CHD in their study was due to the fact that, they included all newborns born between February 2006-2009 prospectively, on the basis of many baseline characteristics of study population. In another study done by Mohsin et al 25 (1.5%) newborns were detected to have congenital heart disease out of total 1,650 screened cases.²⁰ Study conducted by Mathur et al detected 72 (7.57%) cases with congenital heart disease out of 950 screened cases.²¹ Our study has included participants between 0-1 year of age group, while most of the studies done on CHD screening included only neonates. Also in the present study, we used various clinical symptoms and parameters as a criterion for suspicion of CHD, which lead to higher detection rate of CHD.

In our study, out of 102 study participants, 4 had history of GDM and among them 3 participants had underlying congenital heart disease. Odd ratio was found to be 1.11 with 95% CI (0.19-6.32) with a $p=1.000$, which is not statistically significant. Similar to our study results, in another study done by Skim et al gestational diabetes was present in 6 (3.7%) out of 258 included patients with a $p=0.272$. So, in both of these studies there was no significant correlation between GDM and CHD.²²

In the present study, 31 (39.2%) had history of forehead sweating, with a $p=0.005$ which is highly statistically significant and 30 (31.4%) had history of suck. It means that both forehead sweating and suck rest suck cycle are significant predictors of underlying CHD. In the present study, 18 (22.78%) had history of recurrent chest infections and all of them were diagnosed with underlying congenital heart disease with $p=0.010$ which

was statistically significant. So, recurrent chest infection is a significant predictor of CHD as per our study.

In the current study, 27 (34.2%) had history of cyanosis with a $p=0.003$ which was statistically significant. Similar to our study, Mathur et al and Vaidyanathan et al also concluded that the central cyanosis was highly significant in diagnosing underlying CHD.^{2,21} It signified that cyanosis is a significant predictor of underlying CHD. In our study, 26 (32.9%) had increased precordial pulsations with a $p=0.001$ which was statistically highly significant. Similar trends were seen in a study done by Vaidyanathan et al which also shown that abnormal precordial pulsation was significant to detect underlying CHD having $p=0.005$.² So, both these studies add up to that increased precordial pulsation is a significant predictor in detecting CHD.

In present study, only 16 participants were diagnosed with failure to thrive. There was no statistically significant relation between failure to thrive and CHD in our study as most of participants were ≤ 1 month of age.

The 48 (60.8%) were those having tachycardia and 31 (39.2%) had normal HR. Odd ratio was 2.7 with 95% CI=1.2-5.94, with a statistically significant $p=0.019$. The area under ROC curve for HR was 0.674 (95% CI=0.560-0.788). So, we had taken the corresponding cut off 151 and value of our sensitivity came out to be 64.6%. So, tachycardia can be considered as an important tool in screening of CHD.

In our study, 73 (71.5%) participants out of 102 were found to have abnormal pulse oximetry. The area under curve for the oxygen saturation in room air was 0.792 (95% CI=0.695-0.889). So, we had taken corresponding cut off value of 87.50 and then the sensitivity and specificity came out to be 79.7% and 56.52% respectively. Similar results were seen in the study done by Vaidyanathan et al where abnormal pulse oximetry was found abnormal in 549 (10%) patients.² Our study had a high sensitivity but low specificity when compared to other studies. The reason for this difference in overall sensitivity and specificity of SpO₂ in all these studies was that, our study enrolled 0-1-year age group while in other studies, they included all neonates and we selected study participants only on meeting the criteria of suspicion, thus making a high-risk population in stage 1.

In the screening tool for doctors, we included all the 7 parameters (tachycardia, forehead sweating, suck rest suck cycle, murmur, increased precordial pulsations, recurrent chest infections and SpO₂) and the result was considered positive when any of the 7 parameters was present. For the screening tool for paramedics, we included 5 parameters (tachycardia, forehead sweating, suck rest suck cycle, recurrent chest infections and SpO₂) and the result was considered positive if anyone of them was present.

The sensitivity, specificity, PPV, NPV and accuracy of the tool made for doctors in diagnosing CHD came 98.73%, 8.7%, 78.79%, 66.67% and 78.43% respectively. Sensitivity, specificity, PPV, NPV and accuracy of tool for paramedical staff in diagnosing CHD and 97.47%, 30.43%, 82.80%, 77.78% and 82.35% respectively.

In study done by Mohsin et al the sensitivity, specificity, PPV, and NPV of clinical screening were 92%, 98.6%, 51.1%, and 99.9% respectively.²⁰ The difference in sensitivity, specificity, PPV and NPV in both these studies was due to different inclusion criteria.

Limitations

Since HR varies significantly with age thus cutoff value of 151 beats/minute recorded in ROC in overall population may not hold true for children in different age groups. The number of children in different age groups were small for meaningful analysis with respect to different age groups. The validation of the clinical screening tool developed was not done.

CONCLUSION

This tool will help to screen CHD'S early in the disease course as most of the children with complex heart disease die at presentation or before any surgical intervention is made. We concluded that sensitivity, specificity, PPV, NPV and accuracy of this tool for doctors (included all 7 parameters) in diagnosing CHD was 98.73%, 8.7%, 78.79%, 66.67% and 78.43% respectively. sensitivity, specificity, PPV, NPV and accuracy of this tool for paramedical staff (included all 7 parameters except murmur and precordial pulsations) in diagnosing CHD was 97.47%, 30.43%, 82.80%, 77.78% and 82.35% respectively. In children age less than one year living at high altitude suspected to have high risk for presence of CHD based on history of forehead sweating, suck rest suck cycle, murmur, increased precordial pulsations, recurrent chest infections, presence of HR >151 beat/minute and or arterial oxygen saturation of less than 87.2% has ability to predict presence of CHD is 78.79% and ability to rule out presence of CHD is 66.67%.

Recommendations

We recommend that forehead sweating, suck rest suck cycle, tachycardia, murmur, increased precordial pulsations, recurrent chest infections and hypoxemia can be considered as a significant parameter in screening of CHD. This tool has a significantly higher yield in detecting underlying CHD. Using this composite tool for doctors and paramedics will be beneficial in early detection of CHD, leading to early intervention and decreasing mortality in ≤ 1 age group. We recommend that cut-off levels of SpO₂, lower than those used at sea level, should be adopted when dealing with newborns living at high altitudes. Recording of HR and pulse oximeter in quiet and eutermic state in children age ≤ 1

year of age residing at high altitude has high sensitivity and specificity in detecting presence of CHD. Thus, these clinical screening tools could be used for screening of CHD even at primary health care setting among high-risk children. We also recommend that this tool should be validated in primary health centers and sub centers.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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