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Research Article

Accuracy of pulse oximetry versus arterial blood gas in screening cyanotic heart

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ABSTRACT

Background: A study was planned To determine the performance and accuracy of pulse oximetry in children with cyanotic heart diseases compared with arterial oxygen saturation measurements from arterial blood gas analysis and to use transcutaneous pulse oximeter as the first line of non-invasive investigation to diagnose cyanotic heart diseases in peripheral and rural health facilities where echocardiography may not be readily available.
Methods: This was a prospective observational study conducted in Safdarjung Hospital. Children with cyanotic congenital heart disease were enrolled the data was analyzed by using PASW Statistics version 19.0 (SPSS Inc., Chicago, IL, US). Frequency and percentage was calculated for categorical variables. Mean and standard deviation was calculated for continuous variables. Chi-square test and Fisher's exact test was used to compare categorical variables. Correlation was assessed between ABG and SpO2.
Results: A total number of 40 children were enrolled. There was a significant correlation between transcutaneous oxygen saturations and arterial oxygen saturation statistically.
Conclusions: The pulse oximeter detected oxygen saturation comparable to arterial oxygen saturation in all the patients with cyanotic heart diseases, even though most of them did not present with clinically significant cyanosis.

Keywords: Transcutaneous pulse oximeter, Arterial blood oxygen saturation, Cyanotic heart disease, Children

INTRODUCTION

Congenital heart diseases are a common structural defects occurring in new-borns with a prevalence ranging from 3.7 to 17.5 per 1000 live births.[1] Most of these new-borns are asymptomatic at birth, but the duct dependent lesions need to be identified, as early surgery remains the mainstay in preventing morbidity in such cases. However in resource limited countries it becomes difficult to do an echocardiography on all suspected cases of congenital heart defects at the earliest due to the large number of patients, and also due the non-availability of the same in the peripheral or rural health centers. Several strategies have been suggested worldwide like prenatal ultrasound screening, post discharge follow up examination beyond one week of life and training clinicians to detect silent heart diseases in children, but no one method has been successful and were rather cumbersome.[2,3]

Pulse oximetry is a non-invasive non-cumbersome method, which can indirectly measure arterial oxygen saturations. Owing to its small size, portability, relative accuracy and wide use in tertiary centers to measure arterial oxygen saturations for screening cardiac and respiratory diseases in children.[4] This study was planned to determine the performance of pulse oximetry in children with diagnosed cyanotic heart diseases compared with arterial oxygen saturation measurements from arterial blood gas analysis and to assess the feasibility of recommending pulse oximetry as the first line of non-invasive investigation for screening cyanotic heart diseases in peripheral and rural healthcare facilities.

The primary objective of the study:

- To determine the performance and accuracy of pulse oximetry in children with cyanotic heart diseases

compared with arterial oxygen saturation measurements from arterial blood gas analysis.
- To use transcutaneous pulse oximeter as the first line of non-invasive investigation to diagnose cyanotic heart diseases in peripheral and rural health facilities where echocardiography may not be readily available.

METHODS

This was a prospective observational study conducted in the Pediatric ward of Safdarjung Hospital, a tertiary care center in northern India during the period of October 2014 till July 2015.

Inclusion criteria

Children aged between day 1 of life to 12 years with diagnosed cyanotic heart disease on echocardiography presenting to the pediatric wing.

Exclusion criteria

- Children on inotropic support
- Children with diseases known to alter pulse oximetry values like methhemoglobinemia, sickle cell disease.

All the children admitted in pediatric ward with cyanotic heart disease confirmed on echocardiography were enrolled in the study.

Statistical analysis

The transcutaneous pulse oximeter used was Schiller model P201.

Patient demographics were recorded including age, sex, chief complaints, time of diagnosis and echocardiography findings.

Pulse oximetry was done at the time of admission and an arterial blood gas sample was drawn at the same time.

The data was analysed by using PASW Statistics version 19.0 (SPSS Inc., Chicago, IL, US). Frequency and percentage was calculated for categorical variables. Mean and standard deviation was calculated for continuous variables. Chi-square test and Fisher's exact test was used to compare categorical variables. Correlation was assessed between ABG and SpO2.

RESULTS

Demographic data

A total of 40 children with congenital cyanotic heart disease proven on echocardiography were enrolled in the study, patients with shock, on ionotropes, sickle cell disease, meth-hemoglobinemia were excluded. All the data pertaining to the age, sex, address, age of presentation, chief complaints of presentation, previous hospital admissions were obtained.

Table 1: Age of children with CHD at first diagnosis (n=40).

	Frequency	Percentage
<1 month	14	35.0
1-6 month	16	40.0
6-12 months	7	17.5
>1 year	3	7.5
Total	40	100.0

The children were in the age group between the age group of day1 of life to 14months of age. Maximum numbers of infants were between 1-6 months of age constituting 40% of the study population followed by less than 1 month accounting for 35%.

Table 2: Frequency of different diagnoses among children with CHD (n=40).

	Frequency	Percentage
TOF	16	40.0
TGA	8	20.0
TAPVC	7	17.5
DORV	5	12.5
Tricuspid atresia	4	10.0

Male babies were 29 (72.5%) and the remaining 11 (26.5%) were female babies. Only 47.5% of the patients were from Delhi the rest were from Uttar Pradesh (32.5%), Bihar (12.5%) and the remaining from Rajasthan.

Table 3: Frequency of different clinical features among children with CHD (n=40).

	Frequency	Percentage
Asymptomatic	15	37.5
Fast breathing	19	47.5
Cough	15	37.5
Cyanosis	11	27.5
Decreased oral acceptance	3	7.5
Total	40	100.0

*Multiple responses

Structural defects

The most common congenital defect was tetralogy of fallot (TOF) (40%), followed by transposition of the great arteries (TGA), total anomalous pulmonary venous connection (TAPVC), double outlet right ventricle (DORV), tricuspid atresia (TA).

It was noted that 45% of the children had no history of any previous admissions and less than 20% had 2 or more previous hospital admissions, 37% children had history of

one previous hospital admissions.

Clinical presentations

Cough and fast breathing was the common complaint in 35-45% of the patients enrolled, while 37% of the children were asymptomatic and were diagnosed incidentally during routine check-ups. Cyanosis was present only in 27% of the infants.

In the children with TOF 11 had cough and fast breathing at the time of presentation and only 5 had complains of cyanosis at the time of presentation.

Table 4: Different clinical features according to diagnosis among children with CHD.

	Fast breathing	Cough	Cyanosis	Com5	Asymtomatic
TOF	11*	10*	5	0	2*
TGA	4	2	4	1	3
TAPVC	1	0*	1	1	5
DORV					
Tricuspid atresia					

Table 5: Different parameters among children with CHD (n=40).

	Mean	SD
SpO_2	73.33	8.67
ABG	63.31	10.06
Hb	16.0425	1.96
Platelet count	270275	114091

Arterial saturations

The mean oxygen saturation by transcutaneous pulse oximeter was 73% and 63mm of Hg in arterial oxygen saturation. There was a significant correlation between the pulse oximeter saturation and arterial saturation statistically. The mean oximeter saturation was 78% in TOF, 73% in TGA, 70% in TAPVC, 66% in DORV, 65% in tricuspid atresia.

The pulse oximeter detected oxygen saturation comparable to arterial oxygen saturation in all the patients with cyanotic heart diseases, even though most of them did not present with clinically significant cyanosis. The oxygen saturations were less than 80% in all the patients detected by pulse oximeter.

Table 6: Different parameters according to diagnosis among children with CHD.

	SpO2	ABG	Hb	Platelets
TOF	78.3±4.78	66.24±8.28	15.58±1.59	267375±97856
TGA	73.9±11.66	66.04±15.26	15.94±1.72	213375±67379
TAPVC	70.4±6.27	61.66±6.03	17.51±2.82	392714±167956
DORV	66.8±3.03	55.4±4.11	16.0±2.39	244000±52053
Tricuspid atresia	65.5±12.12	58.9±11.57	15.6±0.76	214250±41460

DISCUSSION

Asian data

There is a high prevalence of congenital heart diseases in Asia but the exact antenatal prevalence cannot be assessed due to limited availability of echocardiography especially in the rural health facilities.[5]

The most common cyanotic heart disease in our study was TOF, which was similar to other Indian studies, followed by TGA, TAPVC and DORV.[6,7] However DORV and TAPVC was more commonly seen in another Indian study as compared to TGA as compared to our study.[7]

Gold standard

Echocardiography is the gold standard for diagnosing congenital heart diseases but due to non-availability in

resource limited developing countries alternate investigations need to develop to mandate early diagnosis.[8-10]

Pulse oximetry has been evaluated in several studies as a screening tool for diagnoses of congenital heart diseases in children and has had positive results in measuring oxygen saturations below 95%.[11-13]

Studies have shown increased rate of diagnosis of congenital heart diseases when pulse oximetry was combined with clinical examination, however these studies were done in urban tertiary care centers where the examination was conducted by trained pediatric cardiologists.[14] In this study despite being examined by trained cardiologist 40% of patients would have been missed and discharged if not coupled with pulse oximetry.

Timing

Timing of the pulse oximetry is important, as it is likely to diagnose more false positives if evaluated within the first 24hours of life due to transition from fetal to neonatal circulation.[15,16]

However few studies have reported low sensitivity of pulse oximetry in diagnosing cyanotic heart disease and have advocated clinical diagnosis over pulse oximetry.[15-19] A study by Schimtt et al further reported poor sensitivity of pulse oximeter in detecting cyanotic diseases with oxygen saturations less than 80%.[11]

In our study pulse oximetry accurately detected all cyanotic heart diseases even in children with oxygen saturation below 80% and had a significant correlation with the arterial saturation statistically.

Other studies

In this study more than 50% patients were from rural health care centers with only 27% having history of cyanosis and most of them were not diagnosed with cyanotic heart diseases prior despite previous hospital visits. The working group has recommended pulse oximeter saturation below 90% as abnormal for well infants and advocated further evaluation of such babies, so children diagnosed with oxygen saturation below 90% by pulse oximeter in the peripheral health center can be referred to tertiary care centers thereby reducing the critical time from diagnosis to interventions and thus improving the eventual outcome in such children.[16]

CONCLUSION

Hence pulse oximetry can used as preliminary mode of investigation to detect cyanotic heart diseases in children with repeated respiratory symptoms or cyanosis in the peripheral and rural healthcare facilities in a resource limited country like India, it however needs to be followed up with echocardiography to confirm the diagnosis.

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