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Original Article

Association between oxygen saturation and critical congenital heart disease in newborns

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Abstract

Background Critical congenital heart disease (CCHD) is relatively common, with a prevalence of 6-8 in every 1,000 live births. This congenital anomaly is a newborn condition that would be ideally suited for a screening program, if simple and reliable methods were available. Pulse oximetry (PO) has been proposed as a screening method to detect CCHD.

Objective To assess for a possible association between decreased oxygen saturation and CCHD in newborns.

Methods We conducted a cross-sectional study from March 2014 to February 2015 in several hospitals in North Sumatra. Healthy, full term and post-term newborns aged 2 to 72 hours underwent pulse oximetry measurements on the right hand and one of the lower extremities. If oxygen saturation (SpO2) was ≤ 95%, the measurement was repeated 2 more times. Subjects also underwent echocardiography.

Results A total of 386 newborns underwent SpO_2 measurements: 377 newborns had $SpO_2 > 95\%$ and 9 newborns had $SpO_2 \leq 95\%$. Of the infants with $SpO_2 > 95\%$, 297 were excluded because their parents refused echocardiography examination. Thus, 80 newborns with $SpO_2 > 95\%$ and 9 newborns with $SpO_2 \leq 95\%$ underwent echocardiography. Echocardiography revealed that 5 of 9 newborns with $SpO_2 \leq 95\%$ suffered from Tetralogy of Fallot (ToF) (3 subjects) and transposition of the great arteries (TGA) (2 subjects). One infant with $SpO_2 > 95\%$ had ventricular septal defect (VSD), as detected by echocardiography. Oxygen saturation ≤ 95% had significant association with CCHD ($P<0.001$).

Conclusion Decreased oxygen saturation has a significant association with critical congenital heart disease in newborns. **[Paediatr Indones. 2018;58:90-4; doi: http://dx.doi.org/10.14238/pi58.1.2018.90-4]**.

Keywords: *: pulse oximetry; oxygen saturation; critical congenital heart disease; newborn*

Congenital heart disease (CHD) is the most common group of significant congenital abnormalities. It may present with an asymptomatic murmur detected on routine neonatal examination.[1] Among all congenital malformations, cardiac lesions are the most common, with a prevalence of approximately 6 to 8 per 1,000 live births. Early diagnosis of CHD is important because delayed treatment of severe CHD can lead to cardiac failure, cardiovascular collapse, and even death. However, such early diagnosis of CHD in the first few days of life is difficult.[2]

Congenital heart disease accounts for about 10% of infant deaths due to congenital malformations.[3] Early detection of ductal-dependent CHD is important in newborns prior to ductal closure,[2] thus, screening for these abnormalities in newborns should be done prior to hospital discharge. For this purpose, pulse

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oximetry (PO) can be a sensitive method to detect these abnormalities.[4]

Pulse oximetry has been proposed as one such strategy to be an effective, noninvasive, and inexpensive tool, allowing earlier diagnosis of CCHD.[5,6] Screening with PO has been suggested as a useful strategy for detecting defects with decreased arterial oxygen saturation (SpO_2), before heart failure and circulatory collapse develops.[7] Several studies have documented the lack of sensitivity of routine neonatal examination in detecting CHD. The aim of this study was to assess for a possible association between decreased oxygen saturation and detecting CCHD in newborns.

Methods

This cross-sectional study was conducted from March 2014 to February 2015 in Medan, North Sumatera, Indonesia in four hospitals, one maternity and three general hospitals. All newborn infants >36 weeks gestational age and birth weight ≥2,500 grams born during the one-year study period underwent pre-ductal (finger probe) and post-ductal (foot probe) PO measurements. Premature infants below 36 weeks gestation and infants with respiratory disorders were excluded from the study. Subjects were selected by consecutive sampling. Pulse oximetry was performed on asymptomatic newborns using a *Tuffsa*t pulse oximeter (GE Ohmeda, Finlandia) with a reusable probe.

Measurements were performed by doctors and nurses at the Post-natal Ward on infants aged 2 to 72 hours, on either the right or left foot while the infant was quiet. Infants with $SpO_2 \leq 95\%$ on the lower extremities had the readings repeated twice after 1 hour. Infants whose SpO_2 remained ≤ 95% after the repeated measurement underwent echocardiography.

The study was approved by the Research Ethics Committee of the University of Sumatera Utara Medical School. Informed consent was obtained from subjects' parents. Basic characteristics of subjects were obtained from interviews, questionnaires, and physical examinations. Gestational age was assessed using the new Ballard score.[8] Birth weight was categorized as between 2,500 to 2,999g, 3,000 to 3,499g, 3500 to 3999 g, and >4,000g. Infant age at the time of screening was categorized as <24 hours, 24 to 36 hours, 37 to 48 hours, and >48 hours.

Analyses were performed with *SPSS statistical software version 17.0.* The association between oxygen saturation and CCHD was analyzed by Chi-square test. P values <0.05 were considered to be statistically significant.

Results

Our study subjects were predominantly male (49 newborns). The majority of subjects had birth weights in the 3,000g to 3,499g category (58 newborns), and were 37 to 48 hours of age (**Table 1**).

During the study period, 386 newborns underwent PO measurements. Of these, 297 infants were excluded because their parents refused echocardiography examination. The remaining 89 newborns underwent echocardiography, 80 of whom had SpO_2>95% and 9 of whom had $SpO_2 \leq 95\%$. Echocardiography revealed that 5 of 9 newborns suffered from either ToF (3 subjects) or TGA (2 subjects). One infant with SpO_2>95% had a VSD, detected on echocardiography. Oxygen saturation ≤ 95% had a significant association with CCHD (P<0.001).

Table 1. Demographic characteristics of subjects

Subject characteristics	(N = 89)
Sex, n	
Male	49
Female	40
Age, n	
< 24 h	18
24-36 h	28
37-48 h	34
> 48 h	9
Birth weight, n	
2,500 – 2,999 g	13
3,000 – 3,499 g	58
3,500 – 3,999 g	17
≥ 4,000 g	1

Table 2 shows the echocardiographic findings in our 89 subjects. In infants with cyanotic CHD (SpO2 ≤ 95%), 3 newborns had ToF and 2 newborns had TGA. In newborns with SpO2 > 95%, 1 infant had a VSD.

Table 2. Echocardiography findings after SpO_2 measurement

	Age, hours	Pre-ductal/ post-ductal $SpO_2 \leq 95\%$	Pre-ductal/ post-ductal $SpO_2 > 95\%$
TGA	7-22	71-80 / 65-84 (n=2)	None
ToF	5-26	88-89 / 86-90 (n=3)	None
VSD	28	None	98/96 (n=1)
Normal	<24 - >48	87-94 / 89-92 (n=4)	96-100 / 96-100 (n=79)

ToF=tetralogy of Fallot, TGA=transposition of the great arteries, VSD=ventricular septal defect

Of the 9 infants with SpO2 ≤95%, five were diagnosed with CCHD by echocardiography, while 4 infants had normal echocardiograms. None of the subjects with SpO2 > 95% had VSD, as evaluated by echocardiography. Chi-square analysis revealed a significant correlation between ≤ 95% oxygen saturation and CCHD in newborns (P=0.001) (**Table 3**).

Table 3. Association between CCHD and SpO_2 values

	CCHD	Normal	Total	P value
$SpO_2 \leq 95\%$	5	4	9	0.001
$SpO_2 > 95\%$	1	79	80	
Total	6	83	89	

Discussion

This study was conducted from March 2014 to February 2015 in several hospitals in Medan and Lubuk Pakam: H. Adam Malik Hospital, Stella Maris Hospital, Sundari Hospital, and Grand Medistra Hospital. Of 89 newborns who underwent screening for SpO_2 followed by echocardiography, 9 had SpO_2 <95%, while the rest had SpO_2 > 95%.

Congenital heart diseases are the most common group of congenital malformations and a leading cause of infant death in developing countries.[9] The clinical manifestations of this disorder vary from mild to severe. In the mild form, patients may have no symptoms or abnormalities on clinical examination. However, those with severe CHD may have clear symptoms since birth that require emergency procedures. Globally, congenital heart disease affects more than one million of live births per year, due to structural cardiac and major blood vessels disorders appearing shortly after birth.[10]

Early detection in asymptomatic newborns can prevent severe consequences of illness caused by delayed diagnosis.[11] Screening of asymptomatic newborns with PO is a promising strategy for early detection of critical congenital heart disease (CCHD), because it manifests only as a decrease in SpO_2.[12] According to the *American Academy of Pediatrics* (AAP) and *American Heart Association* (AHA), seven lesions were targeted for screening by PO: truncus arteriosus, TGA, tricuspid atresia, ToF, total anomalous pulmonary venous return (TAPVR), hypoplastic left heart syndrome (HLHS), and pulmonary atresia.[9] Pulse oximetry screening for duct-dependent CHD in newborns is important to perform before hospital discharge, as pulse oximetry is sensitive enough to detect these abnormalities.[4]

Oxygen saturation generally reaches 95% within 1 hour after birth. Cyanotic CHD babies usually have oxygen saturation of less than 88%.[11] We assessed for an association between low oxygen saturation and CCHD in newborns within 2 to 72 hours after birth, and before hospital discharge. A previous study in California also conducted screening in 13,287 newborns aged 21 hours to 36 hours after birth.[13]

Our study showed that low oxygen saturation occurs in newborns with ToF, with 88% to 89% pre-ductal and 86% to 90% post-ductal SpO_2. For TGA, oxygen saturations were 71% to 80% pre-ductal and 65% to 84% post-ductal (**Table 2**). These findings were similar to those of previous studies in the UK and Sweden that screened newborns' oxygen saturation to attempt to identify CCHD.[8,14] Another study also showed high sensitivity of pulse oximetry in 75% of critical lesions and 49% of other types of CHD in all asymtomatic newborns.[14]

Chi-square test was used to analyze for an association between decreased SpO_2 and CCHD. We found that 5 of 9 infants with $SpO_2 \leq 95\%$ had cyanotic congenital heart disease by echocardiography. As such, $SpO_2 \leq 95\%$ had a significant association with CCHD (P=0.001) (**Table 3**). We noted that 79 of the 80 newborns who had SpO_2>95% showed normal echocardiograms. Similarly, an Indian study found that

of 1,200 newborns screened using pulse oximetry with 66.6% sensitivity and specificity 99.90%, there were 6 with SpO2 ≤ 95%. These 6 children underwent echocardiography, which showed one with TGA, two with truncus arteriosus, and three with normal echocardiography.[15] In addition, a Chinese study found that 46 of 49 newborns (94%) born without symptoms suffered from congenital heart disease. Also, in 8 of 8 newborns (100%) born without symptoms, critical congenital heart disease could be detected by pulse oximetry screening and physical examination when the baby was discharged.[16]

In our study, one newborn had SpO_2 > 95% and echocardiography revealed the child to have acyanotic CHD. Also, a previous study in Sweden found 10 newborns with SpO_2 > 95% screening results, but echocardiography showed one child to have a CHD.[14]

Limitations of this study were the small sample size and not assessing the sensitivity and specificity of the pulse oximetry. Further study is needed with a larger sample size to assess the prevalence and incidence of CHD in North Sumatra. An advantage of this study was that it is a pilot study to assess for an association between oxygen saturation and cyanotic congenital heart disease in newborns, whereas previous studies only assessed the effectiveness and accuracy of pulse oximetry to detect critical congenital heart disease in newborns. In conclusion, decreased oxygen saturation has a significant association with critical congenital heart disease in newborns.

Conflict of Interest

None declared.

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