Assessment of knowledge on pulse oximetry screening for critical congenital heart disease among nursing officers attached to postnatal units of a teaching hospital in Sri Lanka

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Abstract

Introduction: Critical congenital heart disease (CCHD) refers to any severe cardiac anomaly existing since birth and requiring surgical or catheter-based intervention during infancy

Objective: To assess knowledge on pulse oximetry (POS) protocol and its interpretation among nursing officers attached to postnatal wards of Sri Jayewardenepura General Hospital.

Method: A descriptive cross-sectional study was carried out to assess the nursing officers' knowledge on POS. Data were collected from the nursing officers in the postnatal wards who had working experience of one month or more by using an interviewer administered questionnaire. According to the responses, results were graded as unacceptable, acceptable and satisfactory.

Results: Fifty three female nurses working in the postnatal wards participated in the study. The average working experience was 72 months. The average score obtained was 6.4 (SD 1.63) out of a total of 9. Ninety one percent scored above 5, 98% knew the correct sites of saturation measurements, 91% were aware about the purpose of neonatal POS and 66% knew the optimal time of performing the test. Seventy percent knew the test is positive if the SpO_2 difference between limbs is more than 3, but only 43% knew the test is positive if SpO_2 is <90% in any limb. Further, only 52% were aware of interpreting inconclusive test results (SpO_2 90-94%). There was no significant difference ($p<0.05$) in the knowledge according to working experience.

Conclusions: More than 90% of nursing officers had acceptable or satisfactory knowledge of POS. More than 90% knew the purpose of screening and the appropriate limbs to check saturations. Only 66% knew the optimal time to perform the study. Lag of knowledge was seen in interpretation of positive as well as inconclusive results.

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(Key words: Critical congenital heart disease, pulse oximetry screening, knowledge, nursing officers)

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Introduction

Critical congenital heart disease (CCHD) refers to any severe cardiac anomaly existing since birth and requiring surgical or catheter-based intervention during infancy[1]. It consists of cyanotic cardiac defects and left sided obstructive lesions. Congenital heart disease (CHD) occurs in approximately 1% of live births[1]. About one quarter of children with CHD have critical defects[2]. Some babies are diagnosed prenatally or are symptomatic at birth. However, cyanosis is not detected by the human eye until the oxygen saturation reduces to approximately 80%[3]. Thus, the remaining cases are often diagnosed only after hospital discharge[4]. These babies appear healthy at birth but succumb to heart failure or ductal closure during the neonatal period. Delayed diagnosis increases the mortality and morbidity of these life-threatening conditions.

As a measure to improve the detection of newborns with CCHD, universal pulse oximetry screening (POS) was introduced in 2011 in the United States for all babies before discharge from hospital[5]. In Sri Lanka, this intervention was introduced by the Ministry of Health from January 2017 for all babies born in government hospitals by monitoring pre-ductal (right upper limb) and post-ductal (either lower limb) saturations before discharge from hospital[6]. POS is painless, non-invasive and widely used[7]. The test is inexpensive so that screening for CCHD is cost effective[8]. Guidelines and protocols have been issued by the Ministry of Health for screening of CCHD[6]. The guidelines include information on how to perform the test (equipment used, probe placement), who will do the test and when, informing parents, and a simplified algorithm (Figure 1) to interpret the results. This screening

practice is carried out primarily by nursing officers working in postnatal wards. With the introduction of universal pulse oximetry screening of newborns in Sri Lanka, it is imperative that continuous precision in screening is maintained. Therefore, the knowledge of postnatal nurses, of the procedure, protocol and interpretation of results is of paramount importance.

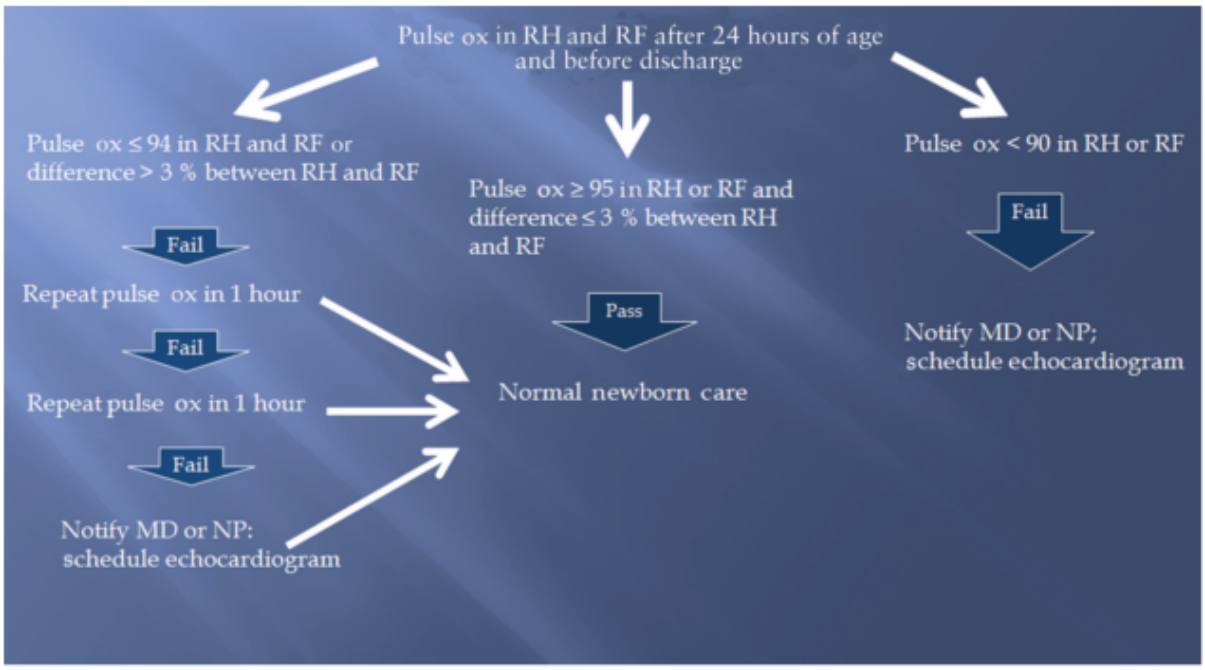

Figure 1: ***Protocol for pulse oximetry screening of newborns to detect critical congenital heart disease***

Introduction of routine POS has led to early detection of CCHD which has led to timely intervention and reduction in morbidity and mortality. Though POS was introduced since January 2017 in Sri Lanka, no studies have been carried out to date to evaluate the nursing officer's knowledge on the methodology or interpretation. Such a study will help to identify areas of lag in knowledge and also quality of practice.

This study focused on assessing the knowledge and understanding of the screening protocol and procedure by nursing officers, who routinely perform this screening in postnatal wards. Furthermore, while collecting data we planned to address areas of lag in knowledge and misunderstandings of protocol.

Objective

To assess knowledge on POS protocol and its interpretation among nursing officers attached to postnatal wards of Sri Jayewardenepura General Hospital.

Method

Design: Descriptive cross sectional study

Setting and population: All nursing officers who give care for postnatal patients for one month or more. Pupil nurses were excluded.

Study instrument: An interviewer administered questionnaire, based on the current guideline was used to assess participants' knowledge. The questionnaire included 9 questions covering key aspects of POS - purpose, timing, measuring sites and interpretation of the results. Answers compatible with the guideline were taken as correct and other answers were marked as incorrect. Each correct answer was given one mark and results were graded depending on the total score.

Analysis: Data was analysed using SPSS 20.

Participants' knowledge was assessed on each component of the questionnaire and were graded according to the total score achieved.

0-5 = Unacceptable knowledge

6-7 = Acceptable knowledge

>7 = Satisfactory knowledge

*Ethical issues***:** The Ethics Review Committee of the Sri Jayewardenepura General Hospital approved the study prior to its initiation. After data collection all participants were educated on their deficiencies in knowledge with regard to POS.

Results

Fifty-three nursing officers working in 4 postnatal units of Sri Jayewardenepura General Hospital were included in the study and all of them were females. Their work experience in the current unit ranged from 1 to 403 months with a mean experience of 72 months (SD 90.47).

The average total score obtained was 6.43 (SD 1.63) with 2 participants (3.8%) obtaining the lowest score of 3 and 6 participants (11.3%) scoring the maximum score of 9. Five (9.4%) of the 53 participants had unacceptable knowledge, while 48 (90.6%) scored above 5 (cumulative acceptable and satisfactory knowledge), with 17 (32%) having a satisfactory knowledge. Grading of knowledge according to the correct answers given is depicted in Table 1.

Table 1: ***Grading of knowledge based on correct answers given regarding pulse oximetry***

Grading of knowledge based on correct answers (from a total score of 9)	Number (%) of participants
Unacceptable (0-5)	05 (09.4)
Acceptable (6-7)	31(58.5)
Satisfactory (>7)	17 (32.1)

Majority of the participants (90.6%) were aware of the purpose of neonatal POS. Thirty-five (66%) nursing officers knew the optimal time to perform the test. Almost all the participants (98.1%) knew the correct sites of pre-ductal and post-ductal saturation measurements. Forty-six out of 53 (86.8%) knew that screening is negative if both limb SpO_2 are above 95% and 37 (69.8%) knew that SpO_2 difference should be less than 4 for a negative screening test. Only 23 (43.4%) knew that the test is positive if SpO_2 is below 90% in any limb. Summary of all the correct responses of each component of the questionnaire is shown in Table 2.

Table 2: ***Number/percentage of correct responses in each component (n=53)***

Component	Number (%) of participants who correctly answered
Purpose of the pulse oximetry (POS)	48 (90.6)
Timing of screening	35 (66.0)
Site of pre-ductal saturation	52 (98.1)
Site of post –ductal saturation	52 (98.1)
POS is negative if SpO_2 >95%	46 (86.8)
POS is negative if SpO_2 difference is <4	37 (69.8)
Screening is positive if SpO_2 <90% in any limb	23 (43.4)
Number of repeated measurements to be taken if SPO2 is 90%-94% or difference >3	28 (52.8)
Time gap between repeated readings	21 (39.6)

Of the 53 nurses, 28 (52.8%) knew that the procedure should be repeated twice in situations where inconclusive SpO_2 results were obtained (i.e. SpO_2 90%-94%), and only 21 (39.6%) knew the time gap should be one hour in such situations. One of the officers who scored a total of 3 was unaware about the correct SpO_2 measuring sites including the rest of the procedure. She had a work experience of 1 month. However, the knowledge of nursing officers who had a working experience below the average (72 months or less) was not significantly different when compared with nursing officers with an experience above 72 months ($p>0.05$).

Discussion

By the end of 1960, newborn screening for metabolic and genetic disorders became standard practice across the United States of America (USA)[9]. However, this practice evoked great interest and controversy. Therefore, in 1968 WHO released a document describing ten important criteria to be fulfilled before a disease is considered for universal screening[10]. This report is currently used as the gold standard before choosing a disease for universal screening.

CHD is the commonest birth anomaly and is a major cause of infant mortality[11,12]. It is responsible for 6-10% of infant mortality and 30-50% of mortality from congenital abnormalities[13]. Over time, CHD prevalence has increased from 0.6 per 1000 live births in the 1930s to 9 per 1000 live births in the 1990s[14]. CHD birth prevalence varies geographically. Each year there are over one million births with CHD worldwide[14].

CCHD prevalence in the USA is 2.9 per 1000 live births[15]. Survival of these newborns depend on early detection and intervention. Studies show that before POS was introduced, about 40% of newborns with CCHD were discharged home undiagnosed in the USA[2]. These estimates emphasize the need to screen newborns for CCHD. Although universal CCHD screening is carried out in the USA since 2011[16,17], only a few European countries include POS in their universal screening panel[18]. In Sri Lanka, it was implemented as a national programme since 2017[6].

In the United Kingdom (UK) 30% of potentially life threatening cardiovascular malformations in infants are diagnosed after discharge and 5% are diagnosed

after death[19]. Delayed or missed CCHD diagnosis accounts for 0.14 of deaths per 1000 live births in the USA[20]. Further, 10% of infants with CCHD die before a diagnosis could be made[21].This diagnosis gap may be even higher in developing countries though sufficient data are not available. Studies show that POS improves early CCHD detection thus reducing the diagnosis gap[22]. POS has a specificity rate greater than 99% and a false-positive rate (FPR) less than 1%[8,15]. Studies also reveal that FPR drops to 0.035% if screening is done 24 hours later. It is also estimated that POS can detect around 60% of infants born with undiagnosed CCHD. Furthermore, about 50% of false positives detected by POS are due to other non-cardiac pathology such as respiratory disorders, infections, pulmonary hypertension and hypothermia. This in turn is an additional advantage of doing POS[17]. The main limitation of POS is the low sensitivity rate estimated by most studies, ranging from 62% to78% due to human error in following protocol, and misinterpretation of algorithm[22].

In our study, knowledge regarding the key aspects of the procedure such as purpose and site of POS (90.6% and 98.1% respectively) was satisfactory. However, only 66% knew the correct time to perform the test. Since the sensitivity of the test is dependent on correct timing, it is important for all the officers to have a clear idea on it. Having this insight will also reduce false positive interpretations since in the first 24 hours of life even a healthy neonate may have a SpO_2 <90%.

Amongst the participants, 90.6% had acceptable or satisfactory level of knowledge. Although nearly 90% of the study population gave correct answers for more than half of the questions, only a minority (11.3%) had good understanding on the entire procedure. For a more effective national programme it is important that the performers have a sound knowledge on all aspects of the procedure. Therefore, programmes to enhance the knowledge and clear doubts on the procedure would be beneficial. However, despite satisfactory knowledge on performing POS, there was a lag in knowledge related to interpretation of positive as well as inconclusive results. Although 86.8% knew the procedure is considered negative if the SpO_2 value was more than 95% and 69% knew POS is negative if SPO2 difference between limbs is less than 4, only a mere 43.4% knew the procedure is positive if SpO_2 is <90% in any limb. Additionally, the participants did not have a clear understanding on steps to be taken with inconclusive results (SPO_2 between 90-94%). Furthermore, only 52.8% knew the test should be repeated twice in such instances, while only 39.6% knew 2 repeated measurements should be done in one hour time gaps. Thus, the need to focus on algorithm interpretation is further highlighted.

Though there was a wide variation in working experience, its effect on knowledge on POS was insignificant. Rather than the working experience, the knowledge and the practical aspects of the procedure may depend on the frequency of performing the procedure. Therefore, work experience per se may not have an impact on the knowledge on POS. The validity and the sensitivity of the screening procedure are dependent on the technique used. Though the knowledge on newborn POS is satisfactory in this study population, an assessment on the techniques adapted in performing the procedure was not looked into. It will be beneficial to look into it in future studies in order to increase the sensitivity of the procedure. Increasing education opportunities for staff on electronic interpretation of data, frequent quality improving by clinical audits, can help in identifying and correcting these issues. A large-scale study involving staff and parents to check their knowledge and perception regarding POS will help to establish more sustainable quality and cost-effective POS.

Conclusions

More than 90% of nursing officers had acceptable or satisfactory knowledge of POS. More than 98% knew the purpose of screening and the appropriate limbs to check saturations. Only 66% knew the optimum time to perform the study. Lag of knowledge was seen in interpretation of positive as well as inconclusive results.

References

1. Oster M. Newborn screening for critical congenital heart disease using pulse oximetry. Available from: https://www.uptodate.com/contents/newborn-screening-for-critical-congenital-heart-disease-using-pulse-oximetry

2. Oster ME, Lee KA, Honein MA, Riehle-Colarusso T, Shin M, Correa A. Temporal trends in survival among infants with critical congenital heart defects. *Pediatrics* 2013; **131**(5): e1502-e1508. https://doi.org/10.1542/peds.2012-3435 PMid: 23610203 PMCid: PMC4471949

3. Hokanson JS. Pulse oximetry screening for unrecognized congenital heart disease in neonates. *Neonatology Today* 2010; **5**(12): 1-6.

4. Wren C, Richmond S, Donaldson L. Presentation of congenital heart disease in infancy: implications for routine examination. *Archives of Disease in*

Childhood-Fetal and Neonatal Edition 1999; **80**(1), F49-F53.
https://doi.org/10.1136/fn.80.1.F49
PMid: 10325813 PMCid: PMC1720871

5. Kumar P. Universal pulse oximetry screening for early detection of critical congenital heart disease. *Clinical Medicine Insights: Pediatrics* 2016; **10**: 35-41.
https://doi.org/10.4137/CMPed.S33086

6. Intranatal and Newborn Care - Circular on Newborn screening to detect critical congenital heart disease. Family Health Bureau, Sri Lanka.

7. Ryan DJ, Mikula EB, Germana S, Silva SG, Derouin A. Screening for critical congenital heart disease in newborns using pulse oximetry: evaluation of nurses' knowledge and adherence. *Advances in Neonatal Care* 2014; **14**(2): 119-28.
https://doi.org/10.1097/ANC.0000000000000047
PMid: 24675632

8. Granelli ADW, Wennergren M, Sandberg K, Mellander M, Bejlum C, Inganäs L, *et al.* Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39821 newborns. *British Medical Journal* 2009; **338**: a3037.
https://doi.org/10.1136/bmj.a3037
PMid: 19131383 PMCid: PMC2627280

9. Guthrie R, Susi A. A simple phenylalanine method for detecting phenylketonuria in large populations of newborn infants. *Pediatrics* 1963; **32**(3): 338-43.
PMid: 14063511

10. Wilson JMG, Jungner G and World Health Organization (1968). Principles and practice of screening for disease. Available from:
http://www.who.int/iris/handle/10665/37650

11. Botto, L. D., Correa, A., & Erickson, J. D. (2001). Racial and temporal variations in the prevalence of heart defects. *Pediatrics*, **107**(3), e32-e32.
https://doi.org/10.1542/peds.107.3.e32

12. Miniño AM, Heron MP, Smith BL. Deaths: preliminary data for 2004. *National Vital Statistics Reports* 2006; **54**(19): 1-49.

13. Rosano A, Botto LD, Botting B, Mastroiacovo P. Infant mortality and congenital anomalies from 1950 to 1994: an international perspective. *Journal of Epidemiology & Community Health* 2000; **54**(9): 660-6.
https://doi.org/10.1136/jech.54.9.660
PMCid: PMC1731756

14. van der Linde D, Konings EE, Slager MA, Witsenburg M, Helbing WA, Takkenberg JJ, *et al.* Birth prevalence of congenital heart disease worldwide: a systematic review and meta-analysis. *Journal of the American College of Cardiology* 2011; **58**(21): 2241-7.
https://doi.org/10.1016/j.jacc.2011.08.025
PMid: 22078432

15. Liske MR, Greeley CS, Law DJ, Reich JD, Morrow WR, Baldwin HS, *et al.* Report of the Tennessee task force on screening newborn infants for critical congenital heart disease. *Pediatrics* 2006; **118**(4), e1250-e1256.
https://doi.org/10.1542/peds.2005-3061
PMid: 17015513

16. Mahle WT, Newburger JW, Matherne GP. Council on Cardiovascular Nursing, and Interdisciplinary Council on Quality of Care and Outcomes Research; American Academy of Pediatrics Section on Cardiology and Cardiac Surgery, and Committee on Fetus and Newborn. Role of pulse oximetry in examining newborns for congenital heart disease: a scientific statement from the American Heart Association and American Academy of Pediatrics. *Circulation* 2009; **120**(5): 447-58.
https://doi.org/10.1161/CIRCULATIONAHA.109.192576
PMid: 19581492

17. Sebelius K. Secretary of Health & Human Services letter to the Secretary's Advisory Committee on Heritable Disorders in Newborns and Children (SACHDNC). 2011.

18. Ewer AK. 2013 Pulse oximetry screening for critical congenital heart defects in newborn infants: Should it be routine? *Archives of Disease in Childhood Fetal and Neonatal Edition*, August 2013; **99**(1).

19. Wren C, Reinhardt Z, Khawaja K. Twenty-year trends in diagnosis of life-threatening neonatal cardiovascular malformations. *Archives of Disease in Childhood Fetal and Neonatal Edition* 2008; **93**(1): F33-F35. https://doi.org/10.1136/adc.2007.119032 PMid: 17556383

20. Kuehl KS, Loffredo CA, Ferencz C. Failure to diagnose congenital heart disease in infancy. *Pediatrics* 1999; **103**(4): 743-7. https://doi.org/10.1542/peds.103.4.743 PMid: 10103296

21. Thangaratinam S, Brown K, Zamora J, Khan KS, Ewer AK. Pulse oximetry screening for critical congenital heart defects in asymptomatic newborn babies: a systematic review and meta-analysis. *The Lancet* 2012; **379**(9835): 2459-64. https://doi.org/10.1016/S01406736(12)60107-X

22. Kochilas LK, Lohr JL, Bruhn E, Borman-Shoap E, Gams BL, Pylipow M, *et al.* Implementation of critical congenital heart disease screening in Minnesota. *Pediatrics* 2013; **132**(3): e587-e594. https://doi.org/10.1542/peds.2013-0803 PMid: 23958775