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ORIGINAL ARTICLE

PERFORMANCE OF PULSE OXIMETRY IN SCREENING OF CRITICAL CONGENITAL HEART DISEASES: META-ANALYSIS OF META-ANALYTIC STUDIES AND SYSTEMATIC REVIEW

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ABSTRACT

Background: Early detection of critical congenital Heart diseases(CCHD) can improve clinical management with a good clinical outcome. Pulse oximetry is cost-effective instrument for detection of CCHD. It can be good an instrument for detection of CCHD. In this study we aimed to see the performance of pulse oximetry by meta-analysis of Meta-analytic studies.

Methods: we included relevant citations by the search engine, Medline, Google Scholar and Cochrane Library. We selected meta-analytic studies that assessed the accuracy of pulse oximetry for the detection of CCHD in asymptomatic newborn. We calculated pooled sensitivity and specifi city, and corresponding 95% CIs for individual studies.

Result: We screened 465 individual studies and identified 10 meta-analytic studies. Of the 10 meta-analytic studies 4 eligible studies with data for 1121912 newborn babies were analyzed . The Pooled Sensitivity of pulse oximetry for detection of critical congenital heart defects was 89 % (95% CI 87%–97%), and pooled specificity was 100% (95% CI 100%–100%). Diagnostic odd ratio of pulse oximetry was 2180.3 and symmetric summary area under curve (SAUC) was 99%.

Conclusion: Our study concluded that Pulse oximetry is 100 % specific for detection on of critical congenital heart defects with moderate sensitivity.

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KEYWORDS

Pulse-oximetry, Newborn, Congenital Heart disease, Meta-analysis.

Introduction

Congenital heart disease (CHD) contributing a major part of birth defect and CHD is the main cause of infant death. The prevalence of definite CHD ranging from 5-15 per 1000 live births.[1] The death from CHD is nearer to 40%.[2] Ante-natally these CHD can be diagnosed by feotal echocardiography with color Doppler and post natally by measuring oxygen saturation by pulse oximeter and by echocardiography. After birth delayed diagnosis leading worse medical and surgical outcome with long duration of hospital stay and consequences of these increasing the cost of treatment.[3] On the other hand timely diagnosis improves outcome.[4,6] The Pulse oximetry is handy point of care screening method to detect the those newborn with CHD and it has very low false positive rate.[5,7] Several meta-analytic studies showed a wide range of sensitivity and specificity both for CHD and CCHD. In this study we pooled data from only meta-analytic studies for CCHD to see the performance of pulse oximeter by calculating the pooled sensitivity and specificity.

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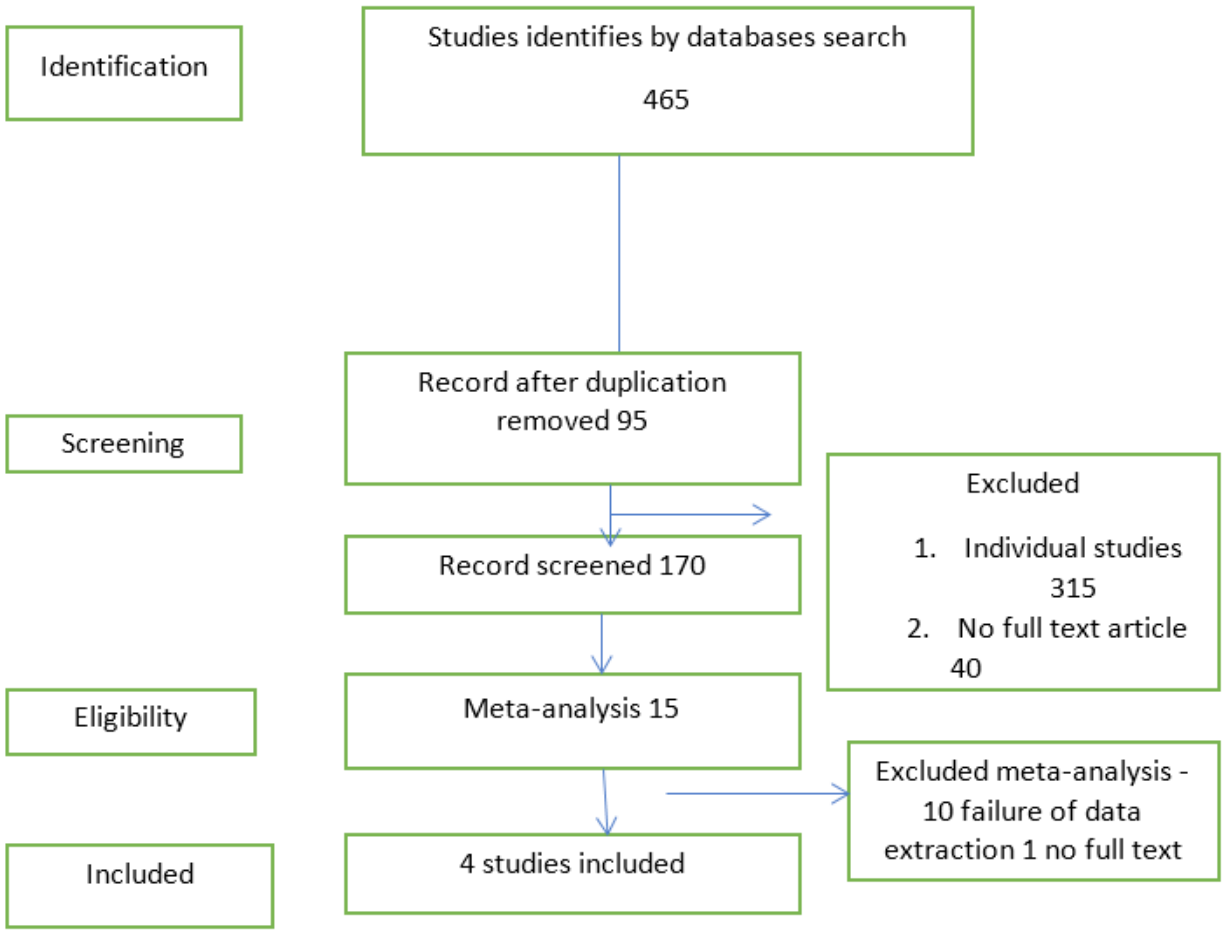
Methods

In this study we followed the criteria for reporting systematic literature reviews and meta-analysis as defined by the PRISMA strategy.8 we included those studies that included asymptomatic neonate who were screened for CCHD by pulse oximetry. Three independent reviewers gone through electronic databases search and obtained the full version of all the articles. From the selected articles only meta-analytic studies were extracted. Disagreement was resolved by consensus.

Literature search we used the following databases: PubMed, Science Direct and Google scholar, with the following keywords: Newborn pulse oximetry, oximetry screening, congenital heart disease, critical congenital heart disease, newborn, oximetry screening, heart defects, and meta-analysis. Of the searched articles we included only meta-analytic studies with English language only. (Figure 1)

Figure 1. Flow of studies through the screening process of the article with CCHD.



Selection of studies and quality assessment as we included only met analytic studies, we did not assess the quality of the studies as all were met-analytic studies, but heterogeneity and publication bias as described by the authors of the included studies are formulated in the tabulated form.

Statistical analysis Data were extracted from the 4 meta-analytic studies with following with the characteristics of the studies: author, year, sample size, screening age, cut-off point of SpO2, true positive, false positives, false negative, true negative rate, sensitivity, and specificity. The characteristics of the studies described in Table 1. We used RevMan 5.3 (Review Manager, Computer program Version 5.3) and MetaDisc 1.4 for data analysis. True positive and false-positive rate at various level of cutoff were presented in summary receiver operating characteristics curve (SROC).

Table 1. characteristics of the included studies.

Authors	Year	Number of included study	Sample size	Screening age (range)	Cut off value (range)	Pooled Sensitivity (95% CI)	Pooled Specificity	Heterogeneity	Publication Bias
Hernan C [9]	2019	6	404 735	6-48 hours	O2sat 90-95%	0. 92 (0.87-0.95)	0.98 (0.89-1)	85.9%	Low
Plana MN[11]	2018	21	436 758	Both <24 hours and =24 hours	<or=95%	0.76 (0.69-0.82)	0.99 (0.99-0. 99)	Variable for sensitivity and specificity	Low
Shakila T[5]	2012	13	229 421	Both< 24 hours and = 24 hours	--	76.5% (67.7–83.5)	99.9% (99.7–99.9)	98.5%-25%,	Low
William [10]	2009	10	123 955	<24 hrs-72 hrs	92-96%	75 (95% not found)	99.3 (95% not found)	Not mentioned	Not mentioned

Results

Article selection and quality assessment

A total of 465 papers were identified from the database PubMed, Science Direct and Google scholar .We selected for full-text version by their title and abstract review. Out of these, 95 papers were excluded due to duplication, 355 were not meta-analytic studies. Out of 15 meta-analyses we included those 4 studies that mentioned true positive (TP), false positive (FP), True negative (TN), False negative (FN) data. For quality assessment, risk bias was observed in individual studies (Table 1).

Data extraction and pooled data

Of the 4 included studies, a total of 1121912 newborn babies were analyzed. Our Pooled sensitivity of pulse oximetry for detection of CCHD is 89% (95%CI, 92-96%) and pooled specificity was 100% (95%CI, 100% -100%) Figures 2 and 3. But there is substantial heterogeneity in the studies (I2 92.9%). We found that Diagnostic Odd ratio for pulse oximetry screening was 2180.3 (95% CI 777.99 -1738%) Figure 4. Figure 5 showed Summary ROC and area under curve is 99.1%. Pooled Positive and negative likelihood ratio were 249.7(95% CI 119.8-520.30) and 0.13(0.07-0.24) respectively (Figure 6, 7).

Figure 2. Pooled sensitivity of Pulse oximetry In CCHD.

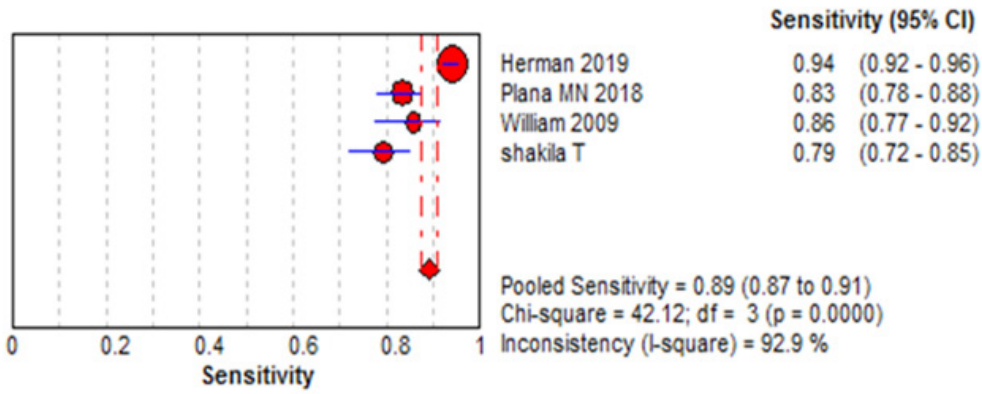


Figure 3. Pooled specificity of Pulse oximetry in CCHD.

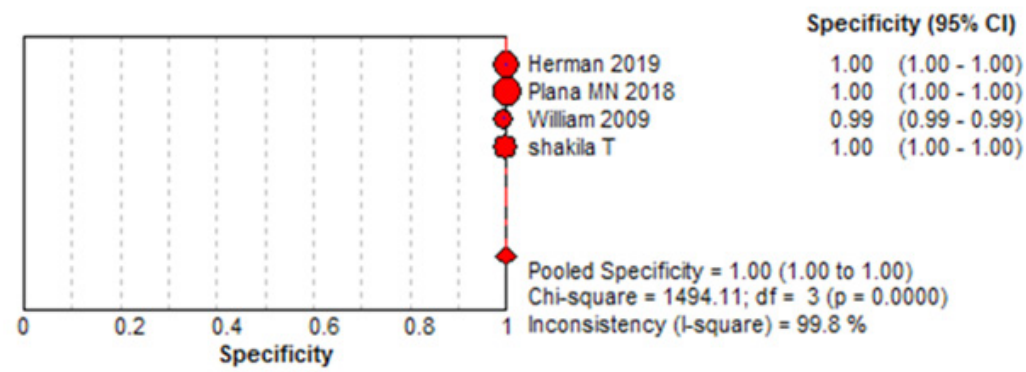


Figure 4. Pooled Diagnostic odd ratio of Pulse oximetry in CCHD.

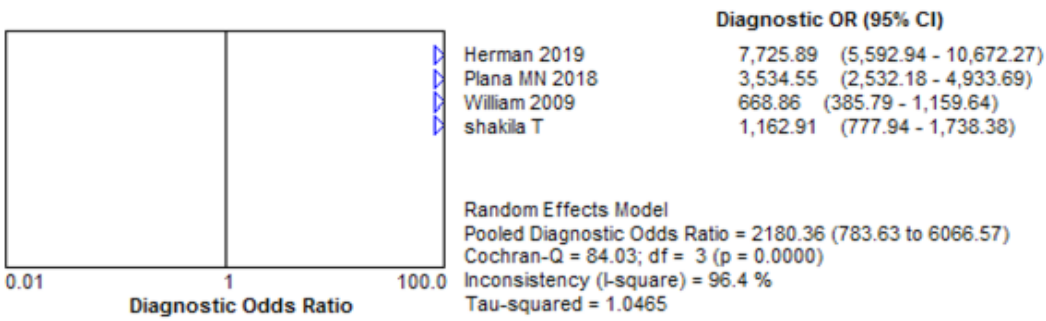


Figure 5. Summary ROC curve of Pulse oximetry in detecting CCHD.

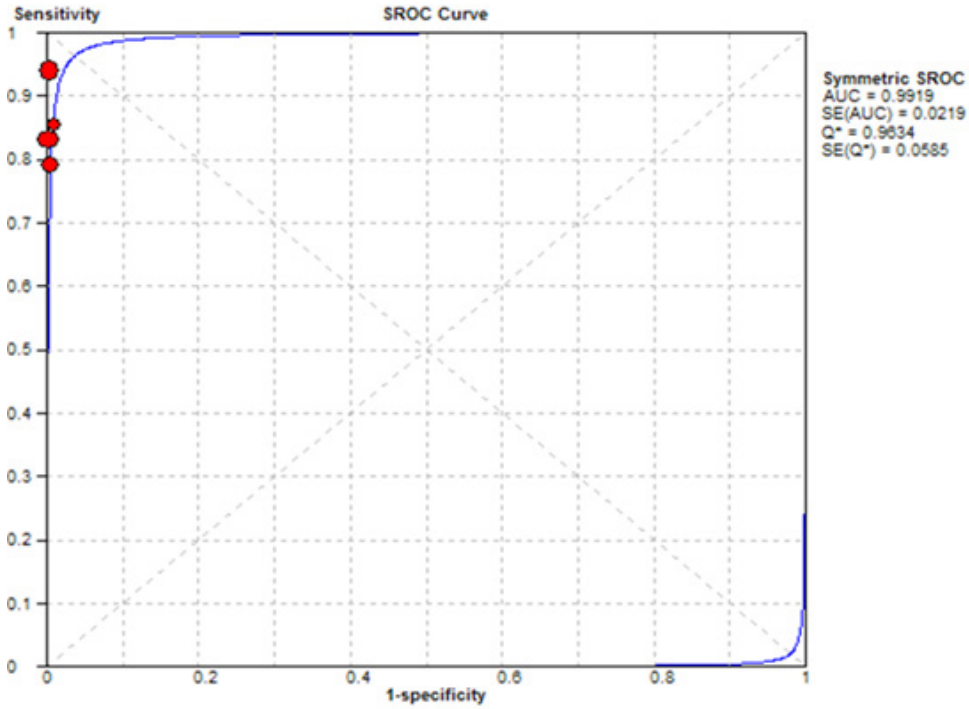


Figure 6. Pooled positive likelihood ratio of Pulse oximetry in CCHD.

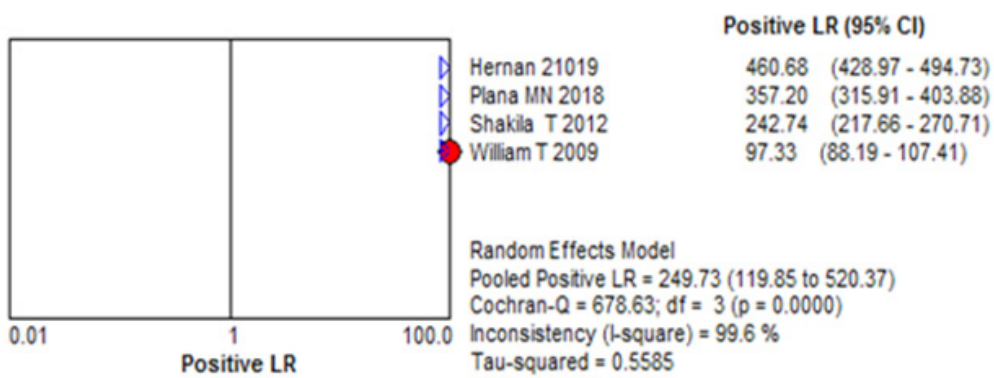
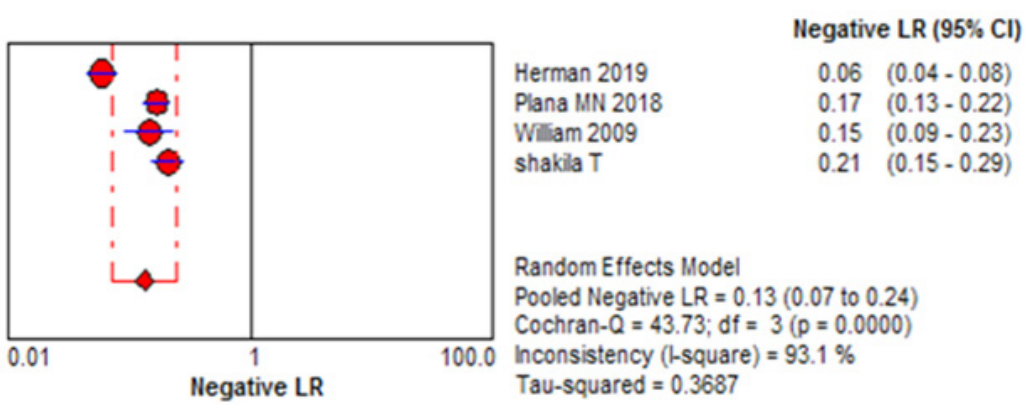


Figure 7. Pooled negative likelihood ratio of Pulse oximetry in CCHD.



Discussion

Our study estimated that pulse oximetry is highly specific for detection of CCHD and moderate high sensitivity. The Sensitivity of the individual meta-analytic studies ranging from 75-92%.[5,9,10,11] Our Pooled data increases the sensitivity 87-91% and specificity up to 100%. Various non-meta-analytic studies showed the sensitivity ranges from lowest 60-to highest 95.2% but specificity nearer to 100%.[12,13,14,15,16,17]

Among the included studies timing of pulse oximetry varies from <24 hours up to 72 hours. Some studies mentioned that false-positive rate for detection of CCHD was low when newborn pulse oximetry was done after 24 hours of birth than when it was done before 24 hours of birth but this timing of pulse oximetry does not compromise sensitivity.[5,11]

We did not do any subgroup analysis on timing of oximetry, pre-ductal post-ductal SPo2, this is the main limitation of our study and there was significant heterogeneity was found during analysis .Within these 4 meta-analytic studies, individual 9 studies are commonly included.[12,14,15,18,20,21,22,23,24,25,26] The main strength our studies was only meta-analytic articles were included with low variability of sensitivity and specificity and low risk bias.

The disease specific sensitivity were not shown in any study and definition of severity of CCHD disease varies in different published articles and the presence of multiple defects can influence study findings. Despite of some limitations we recommend pulse oximetry as point of care screening method in clinical practice.

Conclusion

Pulse oximetry is excellent screening tool with high specificity and sensitivity in detecting CCHD.

Compliance with Ethical Standards

Funding None

Conflict of Interest None

References:

1. Payne RM, Johnson MC, Grant JW, Strauss AW. Toward a molecular understanding of congenital heart disease. Circulation 1995; 91(2): 494-504.
2. Chang RKR, Gurvitz M, Rodriguez S. Missed diagnosis of critical congenital heart disease. JAMA Pediatrics 2008;162(10): 969-974.
3. Liu S, Joseph KS, Lisonkova S. Association between maternal chronic conditions and congenital heart defects: A population-based cohort study. Circulation 2013; 128(6): 583-58.
4. Thangaratinam S, Daniels J, Ewer AK, et al: Accuracy of pulse oximetry in screening for congenital heart disease in asymptomatic newborns: A systematic review. Arch Dis Child Fetal Neonatal Ed. 2007; 92(3): 176-180.
5. Thangaratinam S, Brown K, Zamora J, et al: Pulse oximetry screening for critical congenital heart defects in asymptomatic newborn babies: A systematic review and meta-analysis. Lancet. 2012; 379(9835): 2459-2464.
6. Wren C, Richmond S, Donaldson L: Presentation of congenital heart disease in infancy: implications for routine examination. Arch Dis Child Fetal Neonatal Ed. 1999; 80(1): F49-53.
7. Aranguren Bello HC, Londoño Trujillo D, Troncoso Moreno GA et al. Oximetry and neonatal examination for the detection of critical congenital heart disease: a systematic review and meta-analysis [version 1; peer review: 2 approved] F1000 Research 2019, 8:242.
8. Liberati A, Altman DG, Tetzlaff J, et al.: The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. PLoS Med. 2009; 62(7): e1-34
9. Aranguren Bello HC, Londoño Trujillo D, Troncoso Moreno GA et al. Oximetry and neonatal examination for the detection of critical congenital heart disease: a systematic review and meta-analysis [version 1; peer review: 2 approved]F1000Research 2019, 8:242.
10. William TM, Chair J W, Newburger, GPM, Frank CS, Tracey RH et al: Role of Pulse Oximetry in Examining Newborns for Congenital Heart Disease: A Scientific Statement from the AHA and AAP. PEDIATRICS August 2009; 124(2) :823-36.
11. Plana MN, Zamora J, Suresh G, Fernandez-Pineda L, Thangaratinam S, Ewer AK. Pulse oximetry screening for critical congenital heart defects. Cochrane Database of Systematic Reviews 2018, Issue 3. Art. No.: CD011912. DOI:10.1002/14651858.CD011912.pub2.
12. Granelli DA, Wennergren M,Kenneth Sandberg K, Mellander M, Bejlum C, Ingana¨s L, et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39 821 newborns.BMJ 2009 : 338;145-149.
13. Andrew K Ewer, Lee J Middleton, Alexandra T Furmston, Abhay Bhoyar, Jane P Daniels, Shakila Thangaratinam, Jonathan J Deeks, Khalid S Khan, on behalf of the PulseOx Study Group. Pulse oximetry screening for congenital heart defects in newborn infants (PulseOx): a test accuracy study. Lancet 2011; 378: 785-94.
14. Meberg A, Brügmann-Pieper S, Due R Jr, et al. First day of life pulse oximetry screening to detect congenital heart defects. J Pediatr 2008; 152: 761-65.
15. Riede FT , Wörner C , Dähnert I , Möckel A , Kostelka M,Schneider P. Effectiveness of neonatal pulse oximetry screening for detection of critical congenital heart disease in daily clinical routine-results from a prospective multicenter study. Eur J Pediatr 2010 ;169:975-981.
16. O¨ zalkaya E, Arzu Akdagˇ , Sen I, Co¨mert E, Yaren HM.Early screening for critical congenital heart defects in asymptomatic newborns in Bursa province. The Journal of Maternal-Fetal & Neonatal Medicine. 2016;29(7):1-3.doi: 10.3109/14767058.2015.1035642
17. Mathur NB,Gupta A ,Kurien S. Pulse Oximetry Screening to Detect Cyanotic Congenital Heart Disease in Sick Neonates in a Neonatal Intensive Care Unit. Indian Paediatrics ,September 2015;52:769-72.
18. Bakr AF, Habib HS. Combining pulse oximetry and clinical examination in screening for congenital heart disease. Pediatr Cardiol 2005; 26: 832-35.
19. Arlettaz R, Bauschatz A, Mönkhoff M, Essers B, Bauersfeld U. The contribution of pulse oximetry to the early detection of congenital heart disease in newborns. Eur J Pediatr 2006; 165: 94-98

20. Sendelbach DM, Jackson GL, Lai SS, Fixler DE, Stehel EK, Engle WD. Pulse oximetry screening at 4 hours of age to detect critical congenital heart defects. Pediatrics 2008; 122: e815-20.
21. Reich J, Miller S, Brogdon B, et al. The use of pulse oximetry to detect congenital heart disease. J Pediatr 2003; 142: 268-72.
22. Koppel RI, Druschel C, Carter T, et al. Eff ectiveness of pulse oximetry screening for congenital heart disease in asymptomatic newborns. Pediatrics 2003; 111: 451-55.
23. Rosati E, Chitano G, Dipaola L, De Felice C, Latini G. Indications and limitations for a neonatal pulse oximetry screening of critical congenital heart disease. J Perinat Med 2005; 33: 455-5.
24. Richmond S, Reay G, Abu H. Routine pulse oximetry in the asymptomatic newborn. Arch Dis Child Fetal Neonatal Ed 2002; 87: F83-88.
25. Ewer AK, Middleton LJ, Furmston AT, et al. Pulse oximetry screening for congenital heart defects in newborn infants (PulseOx): a test accuracy study. Lancet 2011; 378: 785-94.
26. Kawalec W, Blaz W, Turska-Kmiec A, Zuk M, Helwich E, Tobota Z. Pulse oximetry as a population screening test in detection of critical congenital heart disease in pre symptomatic newborns: Polish multicentre study. Cardiol Young 2006; 16: 25.