IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 17, Issue 6 Ver. 13 (June. 2018), PP 82-87
www.iosrjournals.org

Our one-year neonatal pulse oximetry screening test results and congenital heart disease frequency

Kamil Sahin[1], Murat Elevli[2], Canan Yolcu[3], Hatice Nilgun Selcuk Duru[4]
1. University of Health Sciences, Haseki Training and Research Hospital, Department of Pediatrics, Fellow, Fatih, Istanbul, Turkey
2. University of Health Sciences, Haseki Training and Research Hospital, Department of Pediatrics, Prof, Fatih, Istanbul, Turkey
3. University of Health Sciences, Haseki Training and Research Hospital, Department of Pediatrics, Pediatric Cardiology, Fellow, Fatih, Istanbul, Turkey
4. University of Health Sciences, Haseki Training and Research Hospital, Department of Pediatrics, Assoc Prof, Fatih, Istanbul, Turkey
Correspondıng Author: Kamil Sahin

Abstract:*The aim of this study was to perform pulse oximetry test (POT) with two extremities on all healtly neonates, to determine for critical congenital heart disease, diagnostic value of the test by performing echocardiographic examination, and to calculate the frequency of congenital heart disease in these babies. The arterial oxygen saturation test was applied using pulse oximeter from the right hand and either foot within 24 h of birth of all healthy neonates born over 35 weeks. The false positivity rate in our study was (1/638)0.15%, the exclusion rate was 100% and the accuracy rate was 99.8%. Congenital heart disease rate is 172/638 (%26). The most common diagnoses in these patients were atrial septal defect (ASD), ventricular septal defect, inter atrial septal aneurysm, and aortic failure. One case of a test-positive patient with persistent fetal circulation leading to cyanosis creating non anatomical but functional right-to-left shunt was identified in the early period and treated in intensive care.*

By doing two extremities, we found that POT's accuracy rate is high. In conclusion, we think that POT is a reliable and suitable test, for routine use in the early diagnosis of severe cyanotic heart disease. The high CHD levels in our study derive from the numbers of patent foramen ovale, patent ductus arteriosus and small ASD cases not closing in the first month.

Date of Submission: 12-06-2018 Date Of Acceptance: 27-06-2018

I. Introduction

Congenital heart disease (CHD) is one of the most common congenital anomalies, a significant part of which cannot be diagnosed at routine examination. The significance of CHDs lies in the fact that they are responsible for 3% of all infant deaths and 46% of deaths related to congenital malformation (1). Another study determined that CHD was responsible for 6-10% of infant deaths and for 2-40% of fatal congenital anomalies (2). Fifty percent of PDA-related cyanotic heart diseases not diagnosed before discharge present to hospital with severe cyanosis attacks in the first weeks. Mortality in cases diagnosed before discharge is 0.9%, rising to 14.8% in subjects discharged without diagnosis (3).

The approximate incidence of CHD is 8/1000 live births (1,4). Approximately 25% of these defects are critical congenital heart diseases ($CCHD_s$) capable of causing hypoxia in newborns, that require treatment in the first year and that involve severe mortality and morbidity if not treated (1,4). One study from Australia reported that CHD-related deaths represented 30% of all childhood mortalities (5). The most important of these diseases are hypoplastic left heart syndrome, pulmonary atresia, tetralogy of Fallot (TOF), anomalous pulmonary venous return (APVR), transposition of the great vessels (TGV), tricuspid atresia and truncus arteriosus. In addition, despite leading to less hypoxia, this group also includes aortic coarctation, double outlet right ventricle, Ebstein anomaly, interrupted aortic arch, severe pulmonary and tricuspid valve stenosis and complex single ventricle (4). Cyanosis generally begins to appear when unoxygenated hemoglobin exceeds 4 g/dl. This is equivalent to saturation values below 80%. Cyanosis may not always be noticeable at 80-95% values. The pulse oximetry test (POT) has been investigated for early diagnosis and treatment in this patient group (6). POT is an inexpensive, non-invasive, painless and simple test that measures the percentage of unoxygenated hemoglobin in blood. It can be life-saving, particularly in the diagnosis of right-left shunt and ductus-dependent CCHDs.

The purpose of this study was to determine the reliability of this test by applying it to newborn babies in our clinic over a period of one year and then performing echocardiography on all patients, and also to determine the prevalence of CHD in our clinic.

II. Material and Methods

Our single center prospective clinical study began following receipt of approval from the local ethical committee (No. 144 dated 20.08.2014). All healthy babies born after 35 weeks in the our hospital Obstetrics Department between 21 August, 2014, and 21 August, 2015, were included in the study. A total of 1246 babies were born in the Obstetrics Department during this period, of which 42 (3%) were stillborn. Of the remaining 1204 live births, 237 (19%) were excluded because of admission to the pediatric care department due to birth age less than 35 weeks or for other reasons. Three hundred seventeen newborns were excluded for not attending postnatal echocardiography within the first month or due to families' refusal to participate. Subjects born under 35 weeks, with disease determined after birth and subsequently admitted to intensive care or hospital and babies whose families refused to provide informed consent were excluded from the study. Cases in which echocardiography could not be performed in neonatal period despite POT being carried out were also excluded. Consent was obtained from babies' mothers or fathers. Patients were examined in 13 monthly groups between 20.08.2014 and 20.08.2015.

On postnatal hour 24, a Nellcor neonatal disposable pulse oximetry probe was attached to the right arm and either leg of all babies. Oxygen saturation was measured for at least 3 min, with the baby breathing room air, using an approved and regularly calibrated US-made Nellcor N-560 pulse oximetry device with a separate probe for each patient. Values were recorded onto patient monitoring forms. Values of 96% or above for both extremities and differences of 3% or less between the two extremities were regarded as negative. Values of 90% or less for any extremity were regarded as positive, and emergency echocardiography was performed. Values of 90-95% were regarded as doubtful, and the test was repeated after a 1-h interval. Values of 96% or above were regarded as positive. In the case of babies with values of 95% or less, the test was repeated a second time after 1 h. If values again did not exceed 96%, the test was regarded as positive and emergency echocardiography was performed. Patients with negative test results were discharged and invited to the cardiology clinic for echocardiography. Echocardiography was performed in the hospital in the case of some patients whose hospitalization was prolonged due to maternal problems. Patients' physical measurements, demographic data, POT values and echocardiography results were recorded. The results were then subjected to statistical analysis.

Statistical analysis was performed on SPSS 15.0for Windows software. Categorical variables were expressed as number and percentage and numerical variables as mean plus standard deviation. Comparisons of numerical variables in more than two independent groups were performed using one-way ANOVA when normal distribution was established, or using the Kruskal Wallis test in the absence of normal distribution. Subgroup analyses were performed using the parametric Tukey test and the non-parametric Mann Whitney U test with Bonferroni correction. Comparisons of categorical variables between groups were performed using the chi-square test. Alpha significance was accepted <0.05.

III. Results

There was no statistically significant difference between the patient groups in terms of birth weights (p>0,05) but, there was statistically significant difference between groups in terms of birth lengths, head circumferences and birth weeks (p<0,005) (Table 1)

Table 1: Patients' mean length, head circumference, birth week and birth weight values

		Birth length	**Head circumference**	**Birth week**	**Birth weight**
	No. (%)	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Total	650	50.2±2.8	34.8±1.6	38.7±1.3	3280.7±453.6
Group 1	24 (3.7)	50.2±2.1	34.8±1.5	38.3±1.1	3245.0±528.4
Group 2	15 (2.3)	50.3±1.6	34.9±1.4	38.9±0.8	3324.0±395.9
Group 3	35 (5.4)	50.5±2.0	34.9±1.2	38.6±1.3	3293.1±428.1
Group 4	58 (8.9)	51.1±6.5	34.6±1.4	38.6±1.6	3277.8±488.2
Group 5	64 (9.8)	50.1±2.0	34.8±1.3	38.6±1.1	3289.1±372.4
Group 6	75 (11.5)	50.8±1.9	35.6±2.4	38.5±1.5	3369.3±453.2
Group 7	58 (8.9)	50.4±2.0	34.6±1.4	39.2±1.1	3326.4±403.5
Group 8	63 (9.7)	49.7±2.4	35.0±1.5	39.0±1.2	3228.7±487.6
Group 9	49 (7.5)	50.0±2.1	35.2±1.3	38.8±1.3	3334.9±441.8
Group 10	25 (3.8)	50.4±2.3	34.6±1.7	39.4±1.9	3291.6±480.3
Group 11	65 (10.0)	50.1±2.0	34.8±1.3	38.8±1.0	3261.1±443.5
Group 12	64 (9.8)	49.5±1.8	34.5±1.3	39.1±1.1	3217.5±488.7
Group 13	55 (8.5)	49.9±2.3	34.2±1.5	38.1±1.0	3203.8±488.3

P		**0.029**	**<0.001**	**<0.001**	0.766

In the group, %50 patients (325/650) were born normal spontaneous delivery and, %50 patients (325/650) were born cesarean section delivery.

There was no statistically significant difference between the patient groups in terms of pulse oximetry right hand values (p=0,110) but, there was statistically significant difference between the patient groups in terms of pulse oximetry foot values, and inter extremities saturation difference (p<0,05) (Table 2).

Table 2: Patients' right hand and foot oxygen saturation values and mean differences between these

		Birth length	**Head circumference**	**Birth week**	**Birth weight**
	No. (%)	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Total	650	50.2±2.8	34.8±1.6	38.7±1.3	3280.7±453.6
Group 1	24 (3.7)	50.2±2.1	34.8±1.5	38.3±1.1	3245.0±528.4
Group 2	15 (2.3)	50.3±1.6	34.9±1.4	38.9±0.8	3324.0±395.9
Group 3	35 (5.4)	50.5±2.0	34.9±1.2	38.6±1.3	3293.1±428.1
Group 4	58 (8.9)	51.1±6.5	34.6±1.4	38.6±1.6	3277.8±488.2
Group 5	64 (9.8)	50.1±2.0	34.8±1.3	38.6±1.1	3289.1±372.4
Group 6	75 (11.5)	50.8±1.9	35.6±2.4	38.5±1.5	3369.3±453.2
Group 7	58 (8.9)	50.4±2.0	34.6±1.4	39.2±1.1	3326.4±403.5
Group 8	63 (9.7)	49.7±2.4	35.0±1.5	39.0±1.2	3228.7±487.6
Group 9	49 (7.5)	50.0±2.1	35.2±1.3	38.8±1.3	3334.9±441.8
Group 10	25 (3.8)	50.4±2.3	34.6±1.7	39.4±1.9	3291.6±480.3
Group 11	65 (10.0)	50.1±2.0	34.8±1.3	38.8±1.0	3261.1±443.5
Group 12	64 (9.8)	49.5±1.8	34.5±1.3	39.1±1.1	3217.5±488.7
Group 13	55 (8.5)	49.9±2.3	34.2±1.5	38.1±1.0	3203.8±488.3
P		**0.029**	**<0.001**	**<0.001**	0.766

Abnormal echocardiography findings were present in 533 (82%) of the 650 patients, while echocardiography was normal in 117 (18%).

Exclusion of PFO and PDA, CHD was positive in 172/650 (%26) cases and negative in 478/650 (%74)

There was no statistically significant difference between sex distributions in the groups (Male:321, female:329, p=1)).

Table 3: Defect findings and numbers determined at echocardiography (ECHO)

ECHO finding	**Alone**	**With others**	**Total**	**% N=650**
Patent Foramen Ovale	196	198	394(48.5%)	(60.6%)
Patent Ductus Arteriosus	40	189	229(28.2%)	(35.2%)
Atrial septal defect	42	47	89(10.9%)	(13.6%)
Ventricular septal defect(VSD)	2	30	32(4%)	(4.9%)
Interatrial septal aneurysm(İASA)	3	26	29(3.6%)	(4.5%)
Aortic insufficiency	0	15	15(1.9%)	(2.3%)
Mitral insufficiency	0	15	15(1.9%)	(2.3%)
Pulmonary stenosis(PS)	0	6	6(0.7%)	(0.9%)
Ebstein anomaly	0	1	1(0.12%)	(0.15%)
Bicuspid aorta	0	1	1(0.12%)	(0.15%)
Persistent fetal circulation	0	1	1(0.12%)	(0.15%)
Total	**283**	**529**	**812**	

One or more findings were determined at echocardiography in 533 (82%) of the 650 babies. Echocardiography was normal in 177 (18%). The pulse oximetry test was positive in only one patient. Persistent fetal circulation, a potentially life-threatening functional cyanotic heart disease, rather than an anatomical cyanotic heart disease, was determined in that patient.

Table 4: Echocardiography findings after exclusion of patent foramen ovale and patent ductus arteriosus

Congenital Heart Disease	**Alone**	**Together with others**	**Total**
Atrialseptal defect	42	47	89(13.6%)
Ventricular septal defect	2	30	32(5%)
Interatrial septal aneurysm	3	26	29(4.4%)
Aortic insufficiency(AI)	0	15	15(2.3%)
Mitral insufficiency(MI)	0	15	15(2.3%)
Pulmonary stenosis	0	6	6(1%)
Ebstein anomaly	0	1	1(0.15%)
Bicuspid aorta	0	1	1(0.15%)
Total	**47**	**141**	**188(28.9%)**

IV. Discussion

When we investigated the frequency of cyanotic CCHD based on our findings, we were unable to calculate test sensitivity since there was no cyanotic heart disease in the study group. However, $CCHD_s$ was not determined in POT-negative patients. The differentiation rate was 649/649x100=100%. One case of a test-positive patient with persistent fetal circulation leading to cyanosis creating non anatomical but functional right-to-left shunt was identified in the early period and treated in intensive care. When the positivity in this case is regarded as false positivity, the accuracy of our test is 649/650x100=99.8%.

There was no difference between the patient groups in terms of sex distribution ($p>0.05$) . While there was no difference between the groups in terms of birth weights, significant differences were determined in terms of birth height, head circumference and birth weeks($p<0.05$) (Table 1).

Six hundred fifty babies were included in the study. Patients including stillborn babies after intrauterine death on whom autopsy could not be performed, or with test positivity due to respiratory difficulty in premature babies, cases in which families refused to permit the test and in which echocardiography was not performed in the first month were excluded. Our patient numbers are for these reasons low. Since the majority of pregnant women giving birth were of low socioeconomic level and since the majority were not being monitored, no patients were diagnosed with intrauterine CHD in our patient group. In addition, since our hospital has no pediatric cardiovascular surgery center, patients with intrauterine diagnosis and requiring emergency postnatal heart surgery are not referred to our hospital, and this another factor in the absence of intrauterine diagnoses of $CCHD_s$ and of positive cases.

One meta-analysis published in 2012 collected 229,421 newborns in 552 studies and determined sensitivity for POT of 76.5%, specificity of 99.9%, and false positivity of 0.14% in subjects undergoing POT in the first 24 h and of 0.5% in those undergoing POT after 24 h. High specificity and moderate sensitivity were reported for POT (7). One study from Australia reported sensitivity of 76.5% for POT, specificity of 99.5% and false positivity of 0.14%(5). The true rates may not have been calculated exactly in these studies since echocardiography was not performed on every patient enrolled. The accuracy rate for $CCHD_s$ was higher in our study, while other rates were compatible with our findings.

Saturation was measured from one foot only in a study from India, and values less than 95% were regarded as positive. Echocardiography was performed on all babies in that study. Subjects with small PDA and no echocardiography findings, and with PFO and ASD less than 5 mm were evaluated as normal, while cases requiring cardiac surgery in the first 28 days were regarded as $CCHD_s$. All newborns were included in the study, including those born prematurely. CHD was diagnosed in 159 patients (8,36/1000). The authors identified 89 cases of minor CHD, 44severe cases and 26 critical cases (3.68/1000). They reported minor CHD diagnosis sensitivity of 47.2% with POT and major CHD sensitivity of 54.9%(8). In that study, pulse oximetry measurement was performed only from the foot, and not from the right arm, which shows flow before the ductus arteriosus. In our study, pulse oximetry was measured from the right arm and the foot. When measured from the foot alone, the test may also result positive, in addition to severe CHD, in minor and acyanotic diseases. The purpose of our test was to identify CCHDs.

Atrial septum patency exceeding 3 mm was regarded as ASD in our study. When classified on that basis, the frequency of ASD was 13.6% and the frequency of CHD was 26%. Postpartum echocardiography was performed between days 1 and 28, with a mean value of approximately 3 days. This led us to detect minor echocardiographic findings, including fine PDA and PFO, in 82% of all echocardiographies. All small atrial septum patency less than 3 mm in size diagnosed before the age of 3 months and 80% of those 3-8 mm in size have been reported to close spontaneously before the age of 18 months. Functional closure of PDA can occur on the first postnatal day, while anatomical closure may take 2-3 weeks. Although PFO closes functionally in the first days of life, defect still persists in 75% of newborns and in 25% of adults. IASA has been reported in 4-8% of newborns (9). We determined incidences of PFO of 60%, PDA of 35% and IASA of 4.5%. Our findings are compatible with the previous literature.

One study from Norway reported that since oxygen saturation is lower in the first hours after birth, the mean value is 97%. POT was recommended 24 h after birth. The study also reported that POT values can give negative saturation results by exceeding 95% in subjects with aortic coarctation and hypoplastic left ventricular anomalies (6). Ewer et al. reported diagnostic sensitivity of 75% for $CCHD_s$ and 49.1% for all major CHDs with POT screening of healthy newborns over 35 weeks (10). In our study, POT was performed after 24 h. We determined no test positivity in other CHD_s apart from CCHD. Mean right arm saturation was approximately 97% and mean saturation from the foot approximately 98% (Table 2). This finding is compatible with previous studies.

The two most important causes of neonatal and infant mortality are preterm delivery and CHD. One study involving large series and in which PDA and ASD were disregarded reported a CHD incidence of 5.1 per 1000 live term births and of 12.5 per 1000 live preterm births. Preterm birth was observed to increase the risk of CHD 2,4-fold (11).One study performed in Czechoslovakia in a community of 6.3 million, monitoring CHD

over a 4-year period and investigating CHD with autopsy in still births, reported a prevalence of CHD of 6.4/1000. The most common, CHD at 31.4%, was VSD, followed in decreasing order by ASD, AS, pulmonary stenosis (PS), aortic coarctation, TGV, PDA, atrioventricular septal defect (AVSD), hypoplastic left heart syndrome and TOF. In addition, 25.6% of these CHD patients died during 4-year follow-up (12). In a recent study from Taiwan in 2010, a CHD rate of 13/1000 live births was determined. ASD, PDA and small VSDs were regarded as severe CHD. The CHD rate of 13/1000 consisted of simple CDH at 11.66/1000 and severe CHD at 1.42/1000. The most common CHD was VSD, followed in descending order by ASD, PDA, PS, AVSD, double outlet right ventricle, transposition of the great vessels, and AS (13).There has recently been a worldwide increase in CHD rates at examination of fetus materials from terminated pregnancies. TGV and hypoplastic left heart syndrome have been determined at levels ranging from 21% to 58% at abortus examinations from different regions of France (13). The global prevalence of CHD ranges between 4 and 50 per 1000 live births. This variation is reported to derive from differences in the prevalence of VSD between communities (14).

A study from China retrospectively examined patient records and reported that the most commonly determined CHDs were VSD, ASD, cardiomegaly, TOF and AVSD. Fifty-seven percent of these CHDs were diagnosed antenatally, and 36% were terminated antenatally. The prevelance of CHD was 0.35%. Eight percent of these patients died in the first week and 22% in the first year. The reason for these low levels is that the study involved babies older than 28 weeks and did not include those terminated after 20 weeks (15). Another study reported a rate of ductus-related cyanotic heart disease of 82.8%, with a false positivity rate of 0.17%. No cases of death from CCHD were reported in the same region in hospitals in which POT was performed within 3 years (3). That study also reported that other congenital heart problems and infections were determined in false positive cases. Persistent fetal circulation and pulmonary hypertension are responsible for 20% of false positive causes. These patients improve after the requisite medical treatment with hospitalization in the neonatal intensive care department. This study shows that POT permits early treatment by screening diseases such a s sepsis and persistent fetal circulation capable of constituting a life-threatening risk in the event of false positivity, in addition to $CCHD_s$, in the asymptomatic period (3).

False positivity was determined in one patient in our study. The rate of 1/650x100=0.15% is compatible with the previous literature (3). The CCHDs were determined in our patient group in decreasing prevelances, ASD, VSD, IASA, AI, MI, PS, Ebstein anomaly and bicuspid aorta. Considering that ASD and IASA were common in the first month and that PDA was not included in this classification, the picture is similar to that in the previous literature.

V. Conclusion

In conclusion, when applied simultaneously from the right arm and a lower extremity, POT, a CCHD screening test, has high sensitivity and discrimination rates, Findings in our study similar to those from numerous other studies, were confirmed with the application of echocardiography to all babies. We think that since it can indicate other life-threatening neonatal diseases in the event of false positivity, the test should be routinely applied in all obstetric units. Our study is also important in showing that high levels of PFO, PDA and ASD may be seen at echocardiography performed in the first month of life, and that in order to determine the true incidence of CHD, assessment should be performed when children are older than one month.

Key words: congenital heart disease, cyanosis, newborn, pulse oximetry

Acknowledgement

The authors would like to express their gratitude to all the doctors, neonatal nurses and Pediatric Cardiology secretaries in the Haseki Training and Research Hospital Pediatric Department who assisted with this study.

No funding.

No conflict interest.

References

[1]. Knowles R, Griebsch I, Dezateux C, Brown J, Bull C, Wren C. Newborn screening for congenital heart defects: a systematic review and cost-effectiveness analysis. Health Technol Assess. 2005 Nov;9(44):1-152.

[2]. 2.Abu-Harb M, Hey E, Wren C. Death in infancy from unrecognised congenital heart disease. Arch Dis Child1994;71:3-7.

[3]. de-Wahl Granelli A, Wennergren M, Sandberg K, Mellander M, Bejlum C, Inganäs L, Eriksson M, Segerdahl N, Agren A, Ekman-Joelsson BM, Sunnegårdh J, Verdicchio M, Ostman-Smith I. 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 Jan 8;338:a3037.

[4]. Klausner R, Shapiro ED, Elder RW, Colson E, Loyal J. Evaluation of a Screening Program to Detect Critical Congenital Heart Defects in Newborns. Hosp Pediatr. 2017 Apr;7(4):214-218.

[5]. 5.Bhola K, Kluckow M, Evans E. Post-implementation review of pulse oximetry screening of well newborns in an Australian tertiary maternity hospital. Journal of Paediatrics & Child Health 2014:50;920-925.

[6]. 6. Meberg A, Brügmann-Pieper S, Due R Jr, Eskedal L, Fagerli I, Farstad T, at al. First day of life pulse oximetry screening to detect congenital heart defects. J Pediatr. 2008 Jun; 152(6): 761-5.

[7]. 7. 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. Lancet. 2012 Jun 30;379(9835):2459-64.

[8]. 8.Saxena A, Mehta A, Ramakrishnan S, Sharma M, Salhan S, KalaivaniM et al. Pulse oximetry as a screening tool for detecting major congenital heart defects in Indian newborns. Archives of Disease in Childhood - Fetal and Neonatal Edition Published Online First: 02 June 15. archdischild-2014-307485.

[9]. 9.Myung K. Park, Park's pediatric cardiology for practitioners, sixth Edition, chapter 4. Specific Congenital Heart Defects part 12. Left-to-Right Shunt Lesions, p 277-320, Elsevier 2014.

[10]. 10.Ewer A, Furmston A, Middleton L, Deeks J, Daniels J. Pulse oximetry as a screening test for congenital heart defects in newborn infants: a test accuracy study with evaluation of acceptability and cost-effectiveness. HealthTechnol Assess 2012;16(02).

[11]. 11. Tanner K, Sabrine N, Wren C. Cardiovascular Malformations Among Preterm Infants. Pediatrics Dec 2005, 116 (6) e833-e838.

[12]. 12. Samánek M, Slavík Z, Zborilová B, Hrobonová V, Voríšková M, Skovránek J. Prevalence, treatment, and outcome of heart disease in live-born children: a prospective analysis of 91,823 live-born children. Pediatr Cardiol. 1989 Fall;10(4):205-11.

[13]. 13. Wu MH, Chen HC, Lu CW, Wang JK, Huang SC, Huang SK. Prevalence of congenital heart disease at live birth in Taiwan. J Pediatr. 2010 May;156(5):782-5.

[14]. 14.Hoffman JIE, Kaplan S. The incidence of congenital heart disease. J Am Coll Cardiol 2002;39:1890-900.

[15]. 15. Xie D, Wang H, Liu Z, Fang J, Yang T, Zhou S, Wang A, Qin J, Xiong L. Perinatal outcomes and congenital heart defect prognosis in 53313 non-selected perinatal infants. PLoS One. 2017 Jun 7;12(6).

Kamil Sahin1 "Our one-year neonatal pulse oximeter screening test results and congenital heart disease frequency."IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 17, no. 6, 2018, pp 82-87.