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ORIGINAL ARTICLE

Prevalence of Critical Congenital Heart Disease Detected in the Pulse Oximetry Test in Asymptomatic Newborns, ≥35 Gestational Weeks, in a Maternity in Southern Brazil

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Abstract

Background: Congenital heart diseases (CHD) are one of the most prevalent malformations, and the screening tests to identify critical congenital heart disease (CCHD) is the pulse oximetry test, with subsequent investigation and treatment.

Objective: To quantify positive pulse oximetry tests and verify the prevalence of CCHD detected by it in asymptomatic newborns, ≥35 gestational weeks, in a Brazilian maternity hospital.

Methodology: This is an observational, retrospective, quantitative, analytical and cross-sectional study, conducted from October 2020 to May 2022, in a maternity hospital in southern Brazil, through the collection of records of positive oximetry pulse tests, following the norms of screening CCHD test of the Brazilian Society of Pediatrics (SBP), after they were evaluated with echocardiography for confirmation or exclusion of CHD.

Results: A total of 5,667 newborns were evaluated in this study, according to the inclusion criteria; 0.17% (n = 10) had a positive pulse oximetry test. Regarding the results of the echocardiography of the neonates with a positive test, two were normal, seven were cases of patent foramen ovale (PFO), and one was a case (0,017%) with interatrial communication (IAC) diagnosis. In the same period, five neonates with CCHD were born, symptomatic, diagnosed by physical examination, and referred to neonatal intensive care units (NICU) before taking the neonatal cardiac screening (< 24 hours of life).

Conclusion: The prevalence of positive pulse oximetry tests was 0.17% and none CCHD was detected. Five cases of CCHD were born in this period, but they were diagnosed before the recommend time to perform the screening test.

Keywords: Infant, Newborn, Heart Defects, Congenital, Neonatology, Oximetry/methods, Echocardiography/methods.

Introduction

During the intrauterine period, prenatal echocardiography is an exam capable of visualizing the four heart chambers, as well as the ventricular outflow tracts and the aortic arch, and is performed from 18 weeks of conception; however, its use in the Unified Health System is restricted to pregnancies classified as high risk.[1-3] Even performing the imaging exam, the importance of neonatal screening with pulse oximetry should not be discarded.[4]

At birth, the patient's cardiovascular physical examination is performed through cardiac auscultation - observing murmurs, palpation of peripheral pulses and observation of dyspnea and central cyanosis. Between 24 and 48 hours after birth, pulse oximetry is performed in an attempt to diagnose critical congenital heart disease (CCHD), with a sensitivity of 70% and specificity of 99.9%.[1,4] If performed before 24 hours of life, the test may result in false positives due to the variability of oxygen saturation presented by newborns.[4]

It should be noted that a decrease in oxygen saturation can occur in newborns with a heart disease even before clinical manifestations and, therefore, the role of pulse oximetry is to detect this reduction early, and screen

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Central Illustration: **Data found from the pulse oximetry test evaluation of 5,667 newborns.**

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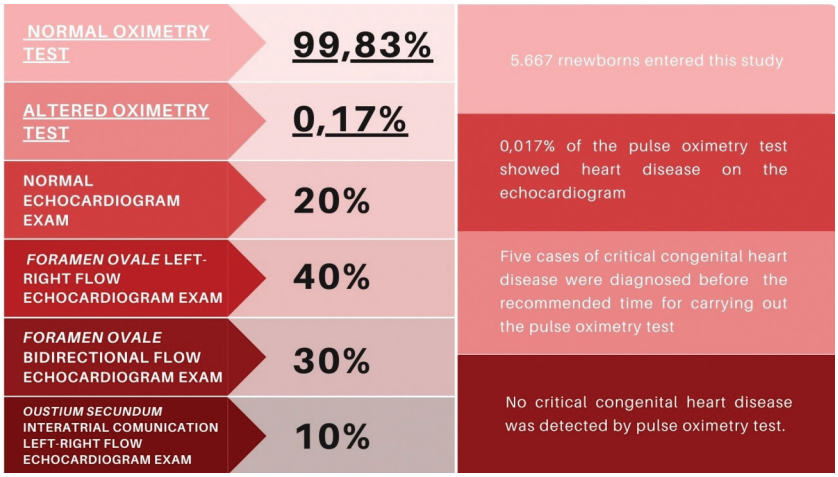

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for serious heart diseases, such as: heart diseases with oxygen-dependent pulmonary flow on the ductus arteriosus (pulmonary atresia and similar), heart diseases with systemic flow on the ductus arteriosus (hypoplastic left heart syndrome, critical aortic coarctation and similar) and heart diseases with parallel circulation (transposition of the great arteries). These serious heart diseases are called CCHD.[5]

Reports from the World Health Organization revealed that in high-income countries the incidence of congenital heart disease (CHD) is eight for every thousand live newborns, while in low-income countries, the number corresponds to twelve for every thousand live newborns.[4] In Brazil, in turn, the prevalence of CHD corresponds to a number of eight to ten for every thousand live newborns.[6] These data reflect the need for effective tracking in cardiac screening, given that 40% of congenital malformations are related to the heart and circulatory system[4] and up to 30% of newborns develop serious complications – hypoxia, shock or death – after hospital discharge without receiving an early diagnosis.[5] In this sense, it is crucial to optimize prenatal screening programs for CHDs using obstetric ultrasound, as well as plans recommended by the International Society of Obstetric and Gynecological Ultrasonography; however, access in the Unified Health System to this resource is limited, and it is not routinely used for all pregnant women.[7] In this sense, cardiac screening in the neonatal period with pulse oximetry must be compulsorily carried out universally.[4]

The present study aims to quantify positive pulse oximetry tests and verify the prevalence of CCHDs detected in asymptomatic full-term newborns in a hospital in southern Brazil.

Methodology

This is an observational, quantitative, retrospective, analytical and cross-sectional study with the population of neonates in a regional reference maternity hospital located in the city of Itajaí-Santa Catarina, southern Brazil. It was approved under number 5.467.414, on June 13, 2022, by the Research Ethics Committee of Universidade do Vale do Itajaí. The data were obtained through research in electronic medical records and the maternity's neonatal cardiac screening record book. The study included all asymptomatic newborns, ≥ 35 weeks of gestational age, born from October 2020 to May 2022, who underwent the pulse oximetry test after more than 24 hours of life. Newborns who presented clinical symptoms of heart disease before the test were excluded. The data collected from newborns with a positive test were: weight, Capurro, sex, race, number of prenatal consultations, hours of life in which the pulse oximetry test was performed, and echocardiography results. All newborns underwent the pulse oximetry test according to the protocol of the Brazilian Society of Pediatrics (SBP)[8] and those with a positive test underwent an echocardiogram. CHDs

diagnosed through transthoracic echocardiography will be classified according to the prognostic scale proposed by the authors Allan and Huggon,[9] in order to determine their degree of severity.

Statistical analysis

The data were tabulated using Microsoft Excel and then subjected to descriptive statistical analysis, being presented in absolute and relative frequencies.

Results

From a total of 6,324 births during the period from October 2020 to May 2022, 5,667 individuals entered this study, according to the inclusion criteria. Seven patient records were excluded because the pulse oximetry test had been performed before 24 hours of life, and ten (0.17%) positive pulse oximetry tests were observed.

Among the positive pulse oximetry test cases, six were female (60%) and four were male (40%). It was found that one case had an APGAR score in the first minute of life lower than five, while the other infants (90%) had a score greater than or equal to seven. This difference was not observed in the fifth minute of life, as none of the newborns maintained APGAR lower than seven. In relation to the newborns' weight/gestational age, the majority were born adequate for gestational age (AGA) n = 9 (90%), with only one newborn being large for gestational age (LGA) (10%), and none were small for gestational age (SGA). As recommended by the Ministry of Health, all mothers had more than six prenatal consultations.

Given the changes in the pulse oximetry test, an echocardiogram was performed to investigate the possibility of CCHD, in accordance with the neonatal screening proposal. The 10 (0.17%) cases of positive tests were subjected to echocardiographic analysis, with two (20%) having normal results, seven (70%) being diagnosed with patent *foramen ovale* (PFO) and one patient (10% of patients with positive tests, and 0.017% of the total sample) was diagnosed with a CHD – *ostium secundum* interatrial communication (IAC) – which is not considered critical, according to the Allan & Huggon prognosis scale.[9] In this studied sample (5,667 newborns) there were no cases of CCHD (n = 0) detected by the pulse oximetry test.

During this same period, five patients with CCHD were identified through physical examination, but they were not part of the sample, as they were symptomatic before 24 hours of life, that is, before the recommended waiting time for the pulse oximetry test as a screening test.

The results found in the pulse oximetry test are described in Table 1 and the transthoracic echocardiography results are in Table 2.

Discussion

During the 18-month period of this study, no CCHD was detected in the period by the screening test, with 0.17% (n =10) of positive pulse oximetry tests. The incidence of CHD has increased significantly over the years. Worldwide during the 20th century, it went from 0.6:1000 in the 1930s to 9.1:1000 in the 1990s, due to improvements in the diagnosis of CHDs. In a study carried out in Brazil with data from 2008, it is estimated that there were 25,757 new cases of CHDs, most being present in the Southeast region, with 10,112 cases, followed by the Northeast region with 7,570 cases. The South region had 3,329 cases, the North region 2,758 cases, and the Central-West region 1,987 cases.[10] DATASUS/MS publication shows 1,337 births with CHDs in 2010, a value that corresponds to 5.3% of the 9:1000 births estimated by a meta-analysis, demonstrating the great level of under-diagnosis of these heart diseases in Brazil and the importance of an effective screening test.[11]

CHDs are the main congenital malformations presented by newborns. 25% of the cases are CCHD, requiring some medical intervention such as surgery or catheterization until the first year of life, being a major cause of infant death, especially when associated with late diagnosis.[12] In order to early recognize CCHD in asymptomatic newborns, in 2014 the Ministry of Health instituted the pulse oximetry test as a routine after 24 hours for all births in Brazilian territory, known as the "little heart test".[2]

According to SBP, the pulse oximetry test for newborns over 35 weeks and asymptomatic, between 24-48 hours of life, is considered negative when the oxygen saturation value is greater than or equal to 95% and the difference between measurements on the right upper limb and lower limb is less than or equal to 3%. On the other hand, the test is considered positive when saturation is less than or equal to 89% in one of the lower limbs or the right upper limb. The test is unreliable when oxygen saturation is between 90 and 94% or the difference between the right upper limb and lower limb is greater than or equal to 4%, and it is necessary to measure again

one hour after the first measurement. If the test remains doubtful, it must be repeated once again after one hour. If, after these 3 measurements, the same parameters remain, the patient is considered positive for neonatal cardiac screening, requiring a cardiological evaluation with echocardiography.[8]

The present study included a number of 6,324 births during the period from October 2020 to May 2022. Using a gestational age of less than 35 weeks, exams carried out before 24 hours of life and symptomatic newborns as exclusion criteria. Pulse oximetry exams on 5,667 individuals were included in the study, identifying ten (0.17%) patients with a positive test, one (0.017%) patient with a CHD and no case of CCHD (n = 0).

The Ministry of Health recommends that the pulse oximetry test be carried out between 24 and 48 hours of the newborn's life, due to the increased incidence of false positives when carried out in the period before 24 hours, as newborns may present variability in saturation of oxygen.[4] Within the scope of the present study, performing pulse oximetry before 24 hours of life was one of the criteria used to exclude seven medical records, whose tests were conducted before 24 hours of life, and were not included in the results. The fact that we are faced with a sample of 5,667 newborns and none of them have CCHD diagnosed by the screening test does not mean that there were no cases of CCHD diagnosed during the period, in the hospital studied. At the same time, five patients with CCHD were identified through physical examination. They decompensated before completing 24 hours of life, and were therefore symptomatic, classified with a score of 4-6 on the Allan and Huggon scale,[9] not being included in our sample study. These five cases of newborns with CCHD were referred to the Neonatal Intensive Care Unit, demonstrating that in the hospital analyzed, newborns with life-threatening heart diseases, during the period studied, did not benefit from the pulse oximetry test as a screening test. It should be taken into account that the service in question has professionals specialized in pediatric intensive care, neonatology and pediatric cardiology, which may not reflect the reality of other Brazilian services.

When the pulse oximetry test is positive, neonatal echocardiography should be performed, which is the gold standard method for confirming and diagnosing CHD. It has sensitivity and specificity of 69% and 95%, respectively.[8]

In the sample of 10 cases of infants with a positive pulse oximetry test, only one confirmed echocardiographic findings of heart disease, being female. Regarding sex and association with CHDs, the studies by Belo et al.,[13] and Carmo et al.,[14] had a mostly female population with this pathology, with n = 41 (53.2%) and n = 22 (62.9%) of female patients, respectively. However, Soares & Nascimento,[6] with a sample of 58 medical records with a diagnosis of heart disease, obtained an incidence of n = 39 (68%) in males, compared to n =19 (32%) in females.

Table 1 – Results of pulse oximetry test over a period of 18 months.

Pulse oximetry test	Amount (n = 5667)	Percentage
Negative	5657	99.83%
Positive	10	0.17%

Table 2 – Echocardiographic findings of positive pulse oximetry tests over a period of 18 months.

Ultrasound report	Amount (n = 10)	Percentage
Normal	02	20%
PFO left-right flow	04	40%
PFO bidirectional flow	03	30%
Ostium secundum IAC with left-right flow	01	10%

IAC: interatrial communication; PFO: Patent foramen ovale

In the report of the present study, the case of diagnosed CHD was not critical, which may reflect a good score in the first and fifth minutes of the APGAR index, with ninety (90%) of the newborns having a score greater than or equal to seven on the APGAR from the first minute and, in the fifth minute, this percentage became maximum. According to Silveira's study, patients with CCHD generally present significant changes in the APGAR score, especially in the first minute.[15]

The case diagnosed with CHD, after a positive screening test, had an adequate weight for the gestational age. Likewise, in a study carried out by Araújo et al., it was observed, in a cohort of 268 patients with CHD, that the majority of individuals in the sample n = 195 (72.8%) were AGA, followed by SGA n = 47 (17.5%) and, finally, LGA n = 26 (9.7%).[16]

The mothers of the 10 cases with a positive pulse oximetry test had six or more prenatal consultations, being worth pointing out that the Ministry of Health suggests prenatal consultations as follows: one consultation in the first trimester, two in the second trimester and three in the third trimester, totaling six consultations or more, to consider it complete.[17]

The mothers in our study can be considered well cared for, taking into account a single heart disease found, *ostium secundum* IAC, which cannot be detected intrauterine, as, in fetal life, this communication does not correspond to a pathology.[18] In the study by Santos, Menezes and Sousa, an analysis of the profile of newborns with CHD, there was a prevalence of 87% of women who underwent prenatal care, among a sample of 168 newborns with CHD; however, only 28% of postpartum women had undergone six consultations or more.[19]

Among the 10 (0.17%) positive pulse oximetry tests, no case of CCHD was identified, considering false-positive tests. Being an adequate false-positive percentage for a screening test, compatible with worldwide literary findings of 0-1.8%, it may mean that the conduction of the screening test by the service is satisfactory.[20,21] This result differs from some Brazilian studies, which reported that 40% of pulse oximetry tests had normal echocardiographic reports.[22]

Regarding echocardiographic findings, one had a diagnosis of IAC type *ostium secundum* with left-to-right flow, considered a non-critical CHD, and seven had a report of PFO, four of which had PFO with flow from left to right, and three PFO with bidirectional flow, considered a physiological state, as under usual circumstances it closes in the first year of life.[23] These changes, when assigned a grade under the Allan and Huggon parameter, which range from 1 to 10, with 1 being the best prognosis and 10 being the worst, are classified with a grade of 2, making it possible to predict a good prognosis and low rates of morbidity and mortality in the long run.[9] PFO was also the most common finding by Carvelo et al.,[24] in an analysis of positive pulse oximetry tests, totaling 40%, followed by IAC (5.7%), PFO + IAC (3.8 %), patent ductus arteriosus (3.8%), FOP + pulmonary hypertension (1.9%), FOP + patent ductus arteriosus + pulmonary hypertension (1.9%), FOP + aortic hypoplasia (1.9%).[24]

An obstacle encountered in carrying out our study was the turnover of professionals responsible for measuring the newborns' oximetry. Nevertheless, this was slowed down with repetition of the tests by different trained individuals, when indicated, following the SBP protocol, and thus reducing the chances of error, in addition to the presence of the chief nurse when there was a positive test. Another difficulty was the use of more than one pulse oximeter device, mainly because it was a long-term study with a large sample. To reduce possible biases, a maintenance team was requested if necessary. These obstacles may reflect limitations of the study.

Due to what was mentioned, the pulse oximetry test in our service did not detect CCHD in the period studied in asymptomatic neonates, and similar data was found by Carvelo et al.,[24] The main data resulting from the study can be found in Central Illustration.

Therefore, it is possible to infer that, in this sample, neonatal screening with the pulse oximetry test allowed the identification of an asymptomatic patient with CHD, but not CCHD. This data may be related to early detection by the specialized neonatal team or simply the lack of asymptomatic cases of CCHD in the period studied. The importance of carrying out prenatal diagnosis is reaffirmed, through intrauterine morphological ultrasound and fetal echocardiographic studies when indicated. Carrying out a cardiological neonatal screening test is justified by the high morbidity and mortality of newborns, as 30% develop serious complications, including death, when they have critical cardiac pathologies without early diagnosis.[6] It is observed that there are centers that do not have specialists to care for newborns, making the early diagnosis of CCHD difficult. Therefore, the pulse oximetry test is an important tool that should be used to promote the health of Brazilian newborns.

Conclusion

The prevalence of a positive pulse oximetry test in the studied sample was 0.17% (n = 10), of which 0.017% (n = 1) had a diagnosis of non-CCHD confirmed by echocardiographic evaluation, and no CCHD was identified.

Five cases of CCHD were born during this period, but were diagnosed before the recommended time for carrying out the screening test and sent to the neonatal intensive care unit. Although the test did not reveal critical changes in this sample, it is indicated as a screening test, due to the importance of early detection of heart diseases, as they have high morbidity and

mortality. It must be taken into account that there are centers without specialists to care for newborns and mothers, making early diagnosis difficult and, therefore, the pulse oximetry test works as a screening tool favoring the health of newborns. More studies are needed in other centers, especially those that do not have specific neonatal support, to better understand it as a screening test.

Author Contributions

Conception and design of the research: Witkowski SM; acquisition of data: Pereira AF, Torres RB, Soares MF; analysis and interpretation of the data and statistical analysis: Witkowski SM, Pereira AF, Torres RB; writing of the manuscript: Witkowski SM, Pereira AF, Torres RB, Sene LF, Cruz TF; critical revision of the manuscript for intellectual content: Witkowski SM, Guerra CM, Wilde MOR.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee on Animal Experiments of the Universidade do Vale do Itajaí under the protocol number 5.467.414.

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