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Benefits of pulse oximetry in neonatal screening to detect congenital heart diseases

Beneficios de la pulsioximetría en el cribado neonatal para detectar las enfermedades cardíacas congénitas**Benefícios da oximetria de pulso na triagem neonatal para detectar cardiopatias congênitas****ABSTRACT**

OBJECTIVE: To evaluate the effectiveness of pulse oximetry in neonatal screening in order to facilitate the diagnosis of congenital heart diseases as well as to observe the most sensitive to the test. **METHODS:** This is a systematic literature review that included articles published between 2014 and 2018. The chosen keywords were entered into PubMed and MedLine databases. **RESULTS:** The search resulted in 34 articles, from which 5 articles that met the established exclusion and inclusion criteria were evaluated. Based on the results of these studies, the accuracy of oximetry was evaluated according to sensitivity, which ranged from 60 to 100%, and specificity, which ranged from 94 to 99.9%. **CONCLUSIONS:** Oximetry has shown an important role in the process preceding the diagnosis of congenital heart defects by allowing early assistance and surgical intervention in cases that require urgent correction of the heart defect.

DESCRIPTORS: Pulse Oximetry; Benefits; Congenital; Screening; Newborns.

RESUMEN

OBJETIVO: Evaluar la efectividad de la oximetría de pulso en el tria neonatal para facilitar el diagnóstico de las cardiopatías congénitas, así como observar las más sensibles a el test. **MÉTODOS:** Se trata de una revisión bibliografía sistemática que incluye artículos publicados entre 2014 y 2018. Los descriptores elegidos fueron insertados en las bases de datos PubMed y MedLine. **RESULTADOS:** La búsqueda dio lugar a 34 artículos, y fueron evaluados 5 artículos que cumplían los criterios de exclusión e inclusión establecidos. Basándose en los resultados de esos estudios, la precisión de la oximetría se evaluó según la sensibilidad, que osciló entre el 60 y el 100%, y la especificidad, que osciló entre el 94 y el 99,9%. **CONCLUSIONES:** La oximetría ha demostrado tener un papel importante en el proceso que precede al diagnóstico de los defectos cardíacos congénitos al permitir una asistencia e intervención quirúrgica precoz en los casos que requieren una corrección urgente del defecto cardíaco.

DESCRIPTORES: Oximetría de pulso; Beneficios; Congénito; Seguimiento; Recién nacidos.

RESUMO

OBJETIVO: Avaliar a efetividade da oximetria de pulso na triagem neonatal a fim de facilitar o diagnóstico de cardiopatias congênitas bem como observar as mais sensíveis ao teste. **MÉTODO:** Trata-se de uma revisão sistemática da literatura que incluiu artigos publicados entre 2014 e 2018. Os descritores escolhidos foram inseridos nas bases de dados PubMed e MedLine. **RESULTADOS:** A busca resultou em 34 artigos, sendo avaliados 5 artigos que respeitavam os critérios de exclusão e inclusão estabelecidos. Com base nos resultados desses estudos, a acurácia da oximetria foi avaliada de acordo com a sensibilidade que variou de 60 a 100% e a especificidade que girou em torno de 94 a 99,9%. **CONCLUSÕES:** A oximetria evidenciou papel importante no processo que antecede o diagnóstico das cardiopatias congênitas ao permitir assistência e intervenção cirúrgica precoce nos casos que demandam correção urgente do defeito cardíaco.

DESCRIPTORIOS: Oximetria de pulso; Benefícios; Congênito; Rastreamento; Recém-nascidos.

RECEIVED ON: 01/27/2021 **APPROVED ON:** 04/05/2021**Isabella Ellen de Souza Gomes**

Medical student at the Catholic University of Pernambuco.
ORCID: 0000-0002-3516-9370

Maryna Morais de Andrade Cavalcanti

Medical student at the Catholic University of Pernambuco.
ORCID: 0000-0003-4657-8820

Isabelly Stefany Silva de Paula

Medical student at the Catholic University of Pernambuco.
ORCID: 0000-0002-3319-6076

Letícia Dowsley

Medical student at the Catholic University of Pernambuco.
ORCID: 0000-0002-4775-9888

Luiza Maria Lopes Padilha

Medical student at the Catholic University of Pernambuco.
ORCID: 0000-0003-4201-8033

Thainá de Oliveira Siqueira

Medical student at the Catholic University of Pernambuco.
ORCID: 0000-0001-5394-3705

INTRODUCTION

Congenital heart diseases are due to changes in the structure of the heart or great vessels that are present from birth. These changes represent about 40% of all congenital malformations and lead to a high rate of neonatal and infant morbidity and mortality, being the second leading cause of death in newborns less than one year old.^{1,2}

According to 2018 data from the Ministry of Health, the incidence of these heart diseases in Brazil is estimated at 1 in every 100 live births (1%), that is, approximately 30.000 children are born in Brazil with this disease every year.³ The number of deaths related to congenital heart disease in 2015 in Brazil was 107 cases for every 100.000 live births, in which 30% of these deaths occurred in the early neonatal period. Thus, the sooner these malformations are detected, the greater the chance of treating these conditions quickly and thus reducing mortality.⁴

Pulse oximetry is an accessible test, with immediate results and easy to apply, which consists of applying a transducer on the wrist of the right upper limb and another on the ankle of any of the baby's lower limbs. The results of both saturation measurements are compared so that the exam is said to be altered when the saturation is less than 95% or when the difference in limb saturation is greater than or equal to 3%. After identifying and

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confirming the change, the baby needs to undergo an echocardiogram, which is the most effective test for confirming heart disease.⁵

Thus, this methodological review aims to gather results about the accuracy and benefits of pulse oximetry in the early detection of congenital heart disease. Thus, we intend to question the usefulness of this method and its effects in reducing the morbidity and mortality caused by these pathologies.

OBJECTIVE

Evaluate the effectiveness of pulse oximetry in detecting congenital heart disease in neonates. By identifying the number of newborns diagnosed in the first hours of life during screening. As well as distinguishing the types of congenital heart disease that have greater sensitivity to the examination and evaluating the impact of early diagnosis of congenital heart disease in determining a favorable prognosis.

METHOD

This study is an integrative literature review developed from August to September 2018. The search was carried out in two databases: Public Medicine Library (PubMed) and Medical Analysis Retrieval System Online (MedLine). In this research, the following descriptors were used: oximetry pulse, newborns, be-

nefits, congenital and screening with the Boolean operator “AND”.

In the search on both platforms, the filter referring to the study design was used and systematic reviews and original articles published between 2014 and 2018 were included. Thus, the search resulted in 34 articles whose titles and abstracts were analyzed by two authors independently. The chosen criteria excluded duplicate articles and those that did not address the guiding question or the main objective of the research.

Finally, the texts were critically read in full and the scientific data that served as the basis for the construction of this study were analyzed. As for the language criterion, the English and Spanish languages were included, leaving⁵ articles in the composition of this review according to the adopted eligibility criteria.

RESULTS

Most studies were carried out in maternity hospitals where the examination was carried out in two stages. When the saturation of the first stage was low, that is, less than or equal to 95%, the newborns were again submitted to the oximeter measurement. Those who obtained abnormal saturation in the second measurement underwent echocardiography in order to confirm the pathology.^{6,7}

A study conducted in China included 6,750 newborns in which the oximeter detected abnormal saturation in 46 of the 49 asymptomatic cases of heart disease requiring intervention during childhood. The 8 asymptomatic cases of critical congenital heart disease, which require intervention in the first 28 days of life, were also identified. The oximeter alone was able to detect 100% of cases of critical

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pulmonary stenosis, tetralogy of Fallot and pulmonary atresia. When the oximeter was associated with clinical examination, there was an increase in the percentage of detection of the following heart diseases: Truncus arteriosus (↑20%), single ventricle (↑9%), pulmonary atresia (↑7%), transposition of the great arteries (↑9%), right ventricular double outflow tract (↑33%), left heart hypoplasia syndrome (↑24%), coarctation of the aorta (↑14%), interrupted aortic arch (↑40%) and total anomalous drainage of the pulmonary veins (↑47%).⁷

Another survey conducted in Australia looked at oximetry in 18,801 babies over a 42-month period. There were changes in screening in 15 of them, of these, 4 were later confirmed by echocardiography as having heart disease (true positive). The identified cardiopathies were: transposition of great arteries, severe aortic stenosis, total anomalous pulmonary vein drainage and critical duct-dependent pulmonary stenosis. The 6 false positives with altered oximetry had some pathology of pulmonary origin.⁶

In the review by Engel and Kochilas⁸ is mentioned a protocol that defines seven primary lesions capable of being highly diagnosed after suspicion indicated by oximetry, they are: hypoplastic left heart syndrome, pulmonary atresia, total anomalous of drainage pulmonary veins, transposition of the great arteries, tetralogy of Fallot, tricuspid atresia, truncus arteriosus, although other conditions are also possibly screened for by the examination.⁸

Thus, based on the articles evaluated, the results revealed a variation in the sensitivity of oximetry from 60 to 100%, while the specificity ranged on average from 94 to 99,9%. As for the false positive rate, the values ranged from 0 to 1,8%.^{6, 8, 9, 10} (See table 1)

The pulse oximetry test showed changes in the sensitivity and specificity rates depending on the lifetime in which it was performed in newborns. There was a reduction in the sensitivity rate when the exam was performed before 24 hours and

Table 1 - Accuracy of pulse oximetry during neonatal screening

FIRST AUTHOR, YEAR	ZHAO, Q. (2014)	PLANA (2018)	NARAYEN (2015)	BHOLA, K. (2014)	ENGEL, M. (2016)
Sensibility (%)	90,2-93,2	76,3	60-100	80	69,9-76,5
Specificity (%)	99,4-99,7	99,9	≥94	99,8	99,9
False-positives (%)	0,26-0,55	0,14	0-1,8	0,13	0,14

after that period (88,2% vs 78,4%). 7,10 The specificity rate was 99,4% before 24h and 99,7% after 24h. The false positive rate also changed, being 0,55% in the first 24 hours, 0,29% between 25 and 48 hours and 0,26% between 49 and 72 hours. 7

DISCUSSION

The diagnosis of congenital heart disease is made through careful observation of some clinical signs, the main ones being cyanosis, tachypnea and the presence of a heart murmur. 11 The high concentration of hemoglobin makes it possible to perceive cyanosis only when oxygen saturation is below 80%, and hypoxia is difficult to detect in newborns. 12

One of the main roles of oximetry is in recognizing 60 to 100% of newborns who have critical congenital heart disease. These are characterized by a specific cardiac defect in which 80% of cases require surgical intervention or catheterization and 50% that these procedures are performed in the first year of life. 13, 14, 15

In 2010, the Advisory Committee of the Secretariat on Hereditary Disorders in Newborns defined that the most detected heart diseases are, above all, among 7 specific defects taken as targets for screening by oximeter, they are: left heart hypoplasia syndrome, pulmonary atresia, total anomalous pulmonary venous drainage, transposition of great arteries, tetralogy of Fallot, tricuspid atresia and truncus arteriosus. 8 These lesions, commonly associated with hypoxemia, cause significant morbidity and mortality when the diagnosis is made late due to the possibility of circulatory collapse before hospital discharge. 8, 16

The pulse oximetry test showed high accuracy in the screening of congenital heart diseases with high sensitivity and specificity values, reaching numbers close to 100%, as well as low numbers of false positives that did not exceed the rate of 2%. 6, 7, 8, 9, 10

Although the test has a low rate of false positives, between 35 and 74% of them it was possible to detect other non-critical heart diseases, infections and the initial stage of hormonal disturbances. Thus, the oximeter proved to be able to assume the

presence of other pathologies besides cardiac ones. 9

The justification for the high accuracy of oximetry lies in the fact that certain heart diseases present degrees of hypoxia in the neonatal period as a result of the mixture of blood from the systemic and pulmonary circulation, which leads to a reduction in peripheral saturation. The identification of the drop in saturation also helps in the diagnosis of asymptomatic newborns and, in this way, makes the treatment of heart disease feasible. From this change found by the oximeter, babies are referred to undergo an echocardiogram and then be evaluated by a specialist. Based on the detection of hypoxia, it is possible to make an early diagnosis, even within the first 24 hours. 1, 5, 12

The mechanism of origin of the symptoms of these heart diseases is due to the transition from fetal circulation to neonatal circulation, which in these cases will be altered due to cardiovascular defects. 17 It was observed that the peripheral saturation levels can change according to the time of life, as the closure of the ductus arteriosus occurs from 24 to 48 hours after birth and from this event on, the clinical manifestations become more evident. 16

The sensitivity rate was higher when screening was applied before 24h of life. However, in cases where oximetry was performed after 24h, there was a significant increase in the specificity rate with a reduced rate of false-positives. However, despite this gain in specificity, the delay in performing oximetry makes possible the appearance of severe symptoms in which 9% of cases of critical congenital heart disease suffer circulatory collapse. 9

Thus, early diagnosis could avoid problems arising from the evolution of the condition, such as hemodynamic decompensation, shock and acidosis, which in the short term imply a poor prognosis such as perioperative mortality, and in the long term, neurological sequelae. 12

The diagnosis of congenital heart disease is made through careful observation of some clinical signs, the main ones being cyanosis, tachypnea and the presence of a heart murmur. The high concentration of hemoglobin makes it possible to perceive cyanosis only when oxygen saturation is below 80%, and hypoxia is difficult to detect in newborns.

CONCLUSION

The pulse oximeter used in the screening of newborns proved to be effective in helping to detect hypoxia-causing congenital heart diseases. This is because oximetry showed high accuracy in identifying not only heart

disease but also other conditions, especially when the exam was performed in the first 24 hours of life. The diagnosis made in the first hours of life allows the newborn to receive adequate treatment earlier and thus prevent the worsening of the condition.

Due to the high incidence and severity

of congenital heart diseases, these studies that emphasize the role of the oximeter in the early diagnosis of these pathologies should serve as a basis for the promotion of protocols that implement its use in screening, especially in places where prenatal care is precarious. ■

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