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Review Paper

Pulse Oximetry as a Tool for Neonatal Screening and Early Diagnosis of Critical Congenital Heart Disease

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ABSTRACT:
Congenital heart disease is a disease in which there is an abnormality in the function or structure of the heart from the moment the baby is born. There are various types of congenital malformations, but among the most common are anomalous communication between the left and right atria, interatrial communications and interventricular communications. Some tests are therefore carried out in the baby's first hours. The pulse oximetry test (POTS), or Little Heart Test, is recognized worldwide as a method for the early identification of CCC in asymptomatic NBs. It is a neonatal screening test that stands out for being quick to administer, widely available, low-cost, highly sensitive and specific, and non-invasive. Congenital heart defects (CHD) are the main congenital malformations and are one of the main causes of infant deaths. TOP needs to be applied continuously and effectively to ensure early detection of CHD and thus favor a better quality of life for these newborns. The aim of this study is to present, through a literature review, the importance of pulse oximetry as an early diagnostic tool for neonatal screening in newborns with critical congenital heart disease. Through this literature review, the importance of routinely measuring pulse oximetry in newborns between 24 and 48 hours of life, prior to hospital discharge, has been shown to have high sensitivity and specificity for the early detection of heart disease.

Key words: congenital heart disease; pulse oximetry test; Little Heart Test.

INTRODUCTION:

The Neonatal Screening Tests listed in the system are mandatory and extremely important. They enable early diagnosis of diseases and appropriate treatment, providing children with a better quality of life, thus avoiding disabilities and premature death (AAMIR et.al, 2007). According to the studies by Hishinuma et.al (2017), the Neonatal Screening tests listed in the system are mandatory and extremely important. They enable early diagnosis of diseases and appropriate treatment, providing children with a better quality of life, thus avoiding disabilities and premature death.

Every baby born in Brazil has the right to undergo four very important health tests free of charge. These are the so-called "neonatal screening tests": the little foot test, the little eye test, the little ear test and the little heart test (GALVÃO et.al, 2021).

Kumar et.al (2016) defines critical congenital heart defects (CCHD) as those requiring surgical treatment or catheterization in the first year of life. These malformations account for 25% of congenital heart disease cases.

For Mouledoux et.al (2013), there are different types of heart disease, which can be mild and only discovered in adulthood, up to the most serious, which are cyanotic heart diseases, capable of causing altered blood flow to the body.

The Comprehensive Child Health Care Policy includes surveillance of infant mortality and newborn health care. The main indicators of a population's

quality of life are those that measure the levels and characteristics of mortality, such as the infant mortality rate, the maternal death ratio and life expectancy at birth (OLIVEIRA et.al 2022).

Linhares (2021) points out that on the international stage, Brazil has taken on the goals of the Millennium Development Goals, including reducing the mortality of children under 5 years of age by two thirds between 1990 and 2015.

According to Oliveira (2018), the Brazilian infant mortality rate in recent decades (children under one year old) has fallen significantly, thanks to the strategies implemented by the federal government, such as actions to reduce poverty, expand the coverage of the Family Health Strategy, among others, decreasing from 47.1 per thousand live births in 1990 to 16 in 2011.

Silva et al (2018), cite that the goal of guaranteeing the right to life and health to every Brazilian child has not yet been achieved. Early neonatal mortality represents around 60 to 70% of infant mortality, with 25% of deaths occurring on the first day of life. Congenital heart disease accounts for around 10% of infant deaths and 20-40% of deaths due to malformations.

OBJECTIVES:

To define and describe through a literature review the importance of early diagnosis of critical congenital heart disease in neonates, using pulse oximetry as a method.

METHODOLOGY:

This article is a literature review based on a methodology that sought to identify early diagnosis of critical congenital heart disease in neonates by analyzing previous studies. A search strategy was developed based on the evaluation of an objective on the subject in question, which forms the basis of the study. The search descriptors were selected from the Descriptors in Health Sciences (DeCS) website and then combined with the Boolean operator "AND". The databases used for the search were PubMed and the Virtual Health Library (VHL), which evaluated cross-sectional, cohort and case-control studies in Portuguese, English and Spanish. The inclusion criteria were cross-sectional studies that were freely available and focused on the early diagnosis of critical congenital heart disease in neonates.

The exclusion criteria were studies which were not based on the subject or which did not focus on pulse oximetry as a neonatal screening tool.

In all, the result of the search in the databases using the descriptors, but without the application of filters, resulted in fifty-seven (57) available articles.

After pre-selecting the articles, a research protocol was created, which clearly illustrated the aim of the study, the data collection process and the criteria involved in including the articles. After the analysis, twenty-seven (27) studies were excluded. Thirty (30) articles were therefore selected for this literature review.

LITERATURE REVIEW:

CONGENITAL HEART DISEASE - DEFINITIONS AND CLASSIFICATIONS:

In the studies by Narayen et al. (2016), it was observed that Congenital Heart Disease is any abnormality in the structure or function of the heart that arises in the first eight weeks of gestation when the baby's heart is formed. It occurs due to an alteration in the embryonic development of the heart structure, even if it is discovered at birth or years later. According to data from the Brazilian Society of Cardiology, approximately 28,000 children are born with heart problems every year in Brazil, i.e. 1 (one) out of every 100 babies born alive has a heart condition. Of these, around 80% will require heart surgery during their development (SBC, 2021). Congenital heart disease can produce symptoms at birth, during childhood or only in adulthood. In some cases, congenital heart disease causes no symptoms (RIEDE et. al, 2010).

For Khoh (2023), there are different types of heart disease, which can be mild and only discovered in adulthood, up to the most serious, which are cyanotic heart diseases, capable of causing altered blood flow to the body.

According to Schena (2017) congenital heart disease can be classified as; Cyanotic congenital heart disease. This type of heart disease is more serious, as the defect in the heart can significantly affect blood flow and the oxygenation capacity of the blood and, depending on its severity, can cause symptoms such as pallor, blue skin, shortness of breath, fainting and even seizures and death.

The main ones are Tetralogy of Fallot; Ebstein's anomaly; Pulmonary atresia; Acyanotic congenital heart disease; Atrial septal defect (ASD); Ventricular septal defect (VSD); Persistent ductus arteriosus (PDA); Atrioventricular septal defect (AVSD) (PLANA 2018; REICH, J. D. et al 2022; RIEDE et al 2010).

The signs and symptoms of congenital heart disease depend on the type and complexity of the heart defects. In newborns and babies, they can be: Cyanosis, which is the purple coloration of the fingertips or lips; Excessive sweating; Excessive tiredness during feedings; Pallor and apathy; Low weight and poor appetite; Rapid and short breathing even at rest; Irritation. In older children or adults, the symptoms can be: Rapid heartbeat and purple mouth after exertion; Frequent respiratory infections; Easily tired compared to other children of the same age; Does not develop or gain weight normally (REICH, J. D. et al 2022; RIEDE et al 2010).

IMPORTANCE OF EARLY DIAGNOSIS:

Khoh et.al (2023) state that in most neonatal units, the baby is discharged from hospital between 36 and 48 hours of life. At this stage, the clinical manifestation of critical heart disease may not yet have occurred, especially in heart disease with arterial channel-dependent systemic flow.

Searle et.al (2018) describe that cardiac auscultation can be apparently normal at this stage. The authors also point out that early diagnosis is essential, as it can prevent shock, acidosis, cardiac arrest or neurological deterioration before the heart disease is treated.

Early diagnosis can reduce the neonatal mortality rate. The ideal method for diagnosing congenital heart disease is echocardiography with color flow mapping, whether fetal or postnatal, but its use as a screening tool is unfeasible (SEARLE et .al 2018).

PULSE OXIMETRY TEST:

Pulse oximetry measurement should be carried out on all apparently healthy newborns with a gestational age > 34 weeks, before discharge from the Neonatal Unit. The site of measurement is the right upper limb and one of the lower limbs (THANGARATINAM et.al, 2012.

According to Tsao et al (2016), for proper measurement, the newborn must have warm extremities and the monitor (FIGURE 1) must show a homogeneous waveform. At the time of measurement, which takes place between 24 and 48 hours of life, before hospital discharge. The normal result is peripheral saturation greater than or equal to 95% in both measurements (right upper limb and lower limb) and a difference of less than 3% between the measurements of the right upper limb and lower limb (FIGURES 2 and 3).

Figure 1 - Portable G1B Neonate Pulse Oximeter with plethysmographic curve. Source: marcamedica.com

Figure 2 - Pulse Oximetry test on the neonate's foot. Source: centermedical.com

Figure 3 - Pulse Oximetry test performed on a neonate Source: centermedical.com

If any SpO2 measurement is lower than 95% or there is a difference of 3% or more between the measurements of the right upper limb and lower limb, a new measurement should be taken after 1 hour. If the result is confirmed, an echocardiogram should be performed within the following 24 hours (SHAHZAD et al, 2017). Studies by Studer et al (2014) show that the test has a sensitivity of 75% and a specificity of 99%. Therefore, some critical heart diseases may not be detected through this test, especially those of the aortic coarctation type. This test does not rule out the need for a thorough and detailed physical examination of every newborn before discharge from hospital (STUDER et al. 2014). Taksande (2013) describes that the routine measurement of pulse oximetry in newborns, between 24 and 48 hours of life, before hospital discharge has shown high sensitivity and specificity for the early detection of heart disease.

MANDATORY PULSE OXIMETRY TEST:

In 2013, the Brazilian Ministry of Health made it compulsory to incorporate the Pulse Oximetry - Little Heart Test, to be carried out universally as part of Neonatal Screening. Pulse oximetry - the little heart test - is now a universal part of neonatal screening in the Unified Health System - SUS (MINISTÉRIO DA SAÚDE 2013).

BENEFITS OF PULSE OXIMETRY MEASUREMENT:

Hamilçikan et.al (2018) describes in their study that pulse oximetry is the way to measure how much oxygen your blood is carrying. Using a small device called a pulse oximeter, your blood oxygen level can be measured without the need to puncture it with a needle. The oxygen level measured with an oximeter is called the oxygen saturation level (abbreviated as O2sat or SaO2). SaO2 is the percentage of oxygen your blood is carrying compared to its maximum carrying capacity. Ideally, more than 89% of your red blood cells should be carrying oxygen. If the newborn has a lung disease, their blood oxygen level may be lower than normal. It is important to know if and when this occurs, because when your oxygen level is low, the cells in your body may have difficulty working properly (ZUHLKE 2013). According to Oakley et al (2015), most people need a saturation level of at least 89% to keep their cells healthy. It is believed that a level lower than this for a short time does not cause damage. However, your cells can be attacked and suffer damage if low oxygen levels occur too often. If your oxygen level is low in room air, you may be asked to use supplementary (extra) oxygen. The oximeter can help assess how much oxygen you need and when you might need it. For example, some people need more oxygen when asleep than when awake. Others need more oxygen during activity than at rest.

HOW THE PULSE OXIMETER WORKS:

A pulse oximeter comes as a small unit to be placed on the finger, or a small portable device that connected to a wire can be attached or adapted to your finger or earlobe. The smaller devices are cheaper and more practical for home use (JAWIN 2015). For Hamilçikan et.al (2018), the device's light beams pass through the blood in your finger (or earlobe) to measure your oxygen. You won't feel it happen. The light beams are "read" to calculate the percentage of oxygen transport. This method also provides a reading of your heart rate (pulse). To make sure the oximeter is giving you a good reading, count your pulse for a minute and compare it with the number obtained by the oximeter. If they are similar, you are getting a good signal.

DIFFERENCE BETWEEN THE OXYGEN INFORMATION SHOWN BY THE OXIMETER AND THAT OBTAINED BY ARTERIAL BLOOD GAS ANALYSIS:

According to Engel & Kochilas (2016), an oximeter indirectly measures the amount of oxygen carried by your blood. Arterial blood gas directly measures both the amount of oxygen carried by your blood and the amount of carbon dioxide. To obtain an arterial blood gas, blood is taken directly from your artery (usually your wrist), which can be painful. Oximetry is painless, but not as accurate as arterial blood gas. In addition, the pulse oximeter does not measure your carbon dioxide level.

PULSE OXIMETER ACCURACY:

The oxygen level measured by a pulse oximeter is reasonably accurate. Most oximeters give a reading 2% above or 2% below the saturation that could be obtained by arterial blood gas. For example, if your oxygen saturation is 92% on the pulse oximeter, it could actually be anything between 90 and 94%. The oximeter reading may be less accurate if the patient wears nail polish, has cold hands, or has poor circulation. The pulse oximeter may also be less accurate in the case of very low oxygen saturation levels (below 80%) or very dark skin (ENGEL & KOCHILAS, 2016). This test has a sensitivity of 75% and a specificity of 99%. Therefore, some critical heart diseases may not be detected through this test, especially those of the aortic coarctation type. Performing this test does not rule out the need for a thorough and detailed physical examination of every newborn before discharge from hospital (AMORIM, 2017).

FINAL CONSIDERATIONS:

This literature review study showed that the importance of routinely measuring pulse oximetry in newborns between 24 and 48 hours of life before hospital discharge has shown high sensitivity and specificity for the early detection of heart disease.

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