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Performance of pulse oximetry screening for detection of congenital heart diseases in neonates at two health facilities in Yaounde, Cameroon

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Abstract: *Background:* Early detection of congenital heart diseases (CHD) remains challenging in resource-limited settings. This study aimed to determine the diagnostic performance of pulse oximetry screening in detecting congenital heart diseases in neonates.
Methods: This was a test validity study conducted over 8 months at two referral hospitals in Yaoundé. Newborns with gestational age >35 weeks underwent pulse oximetry screening after 24 hours of life. Oxygen saturation (SpO_2) was measured at four limbs, to determine whether there is a difference in saturation between the upper and lower limbs. The test was considered positive if SpO_2 <95% or if the difference between preductal (right hand) and post-ductal (lower limb) measurements >3%. All newborns subsequently underwent echocardiography.
Results: Fifty newborns were included in the study. The prevalence of CHD was 22% (11/50). Among newborns with SpO_2 <95%, 6 out of 7 had CHD confirmed by echocardiography. The identified cardiac malformations included atrial septal defects (n=2), ventricular septal defect (n=1), atrioventricular canal defect (n=1), bicuspid aortic valve (n=3), pulmonary valve stenosis (n=3), and combined pulmonary valve stenosis with bicuspid aortic valve (n=1). Pulse oximetry demonstrated a sensitivity of 54.54%, specificity of 97.43%, positive predictive value of 85.71%, and negative predictive value of 83.37%. There was a statistically significant relationship between oxygen saturation <95% and the presence of CHD (OR 20.5, 95% CI: 5.30-79.21; p<0.001).
Conclusion: Pulse oximetry is a valuable, non-invasive screening tool for detecting CHD in neonates. Its high specificity and positive predictive value support its systematic implementation in resource-limited settings to improve early diagnosis and management of CHD.

Keywords: Pulse oximetry, congenital heart disease, neonatal screening, Cameroon

Résumé: *Contexte:* Le dépistage précoce des cardiopathies congénitales (CC) reste difficile dans les milieux à ressources limitées. Cette étude visait à déterminer la performance diagnostique de l'oxymétrie de pouls dans la détection des CC chez les nouveau-nés.
Méthode: Il s'agissait d'une étude de validité pendant 8 mois dans deux hôpitaux de référence à Yaoundé. L'oxymétrie de pouls après 24 heures de vie, fut faite chez les nouveau-nés d'âge gestationnel > 35 semaines. La saturation en oxygène (SpO_2) a été mesurée au niveau des quatre membres afin de déterminer s'il existe une différence de saturation entre les membres supérieurs et inférieurs. Le test était considéré comme positif si la SpO_2 < 95 % ou si la différence entre les mesures (main droite et membre inférieur droit) était > à 3 %. Tous les nouveau-nés ont eu une échocardiographie.
Résultats: Cinquante nouveau-nés ont été inclus dans l'étude. La prévalence des CC était de 22 % (11/50). Parmi les nouveau-nés présentant une SpO_2 < 95 %, 6 sur

7 avaient une CCconfirmée par échocardiographie. Les malformations cardiaques identifiées comprenaient des communications interauriculaires (n = 2), communication interventriculaire (n = 1), canal atrioventriculaire (n = 1), bicuspidie aortique (n = 3), sténose pulmonaire (n = 3) et association sténose pulmonaire -bicuspidie aortique (n = 1). L'oxymétrie de pouls a démontré une sensibilité de 54,54 %, une spécificité de 97,43 %, une valeur prédictive positive de 85,71 % et une valeur prédictive négative de 83,37 %. Il existait une relation statistiquement significative entre une saturation en oxygène < 95 % et la présence d'une CC (OR 20,5, IC à 95 % : 5,30-79,21 ; p < 0,001).

Conclusion: L'oxymétrie de pouls est un outil de dépistage non invasif précieux pour détecter les cardiopathies congénitales chez les nouveau-nés. Sa spécificité et sa valeur prédictive positive élevées justifient son utilisation systématique dans les milieux aux ressources limitées afin d'améliorer le diagnostic et la prise en charge précoces des cardiopathies congénitales.

Mots clés: Oxymétrie de pouls, cardiopathie congénitale, dépistage néonatal, Cameroun

Introduction

Congenital heart diseases (CHD) are structural abnormalities of the heart and/or great vessels present at birth, resulting from developmental anomalies. They represent the most common congenital malformations, with a global prevalence of 8 to 10 per 1,000 live births.[1,2]. CHD constitute a major cause of perinatal mortality, accounting for half of infant mortality related to congenital malformations[3,4].

In sub-Saharan Africa, including Cameroon, CHD is a significant public health challenge. A previous study in Cameroon reported a prevalence of 4.3% among children attending a cardiac referral centre[5]. However, true population-based prevalence may be higher due to underdiagnosis, particularly in asymptomatic cases.

Early detection of CHD is essential as delayed diagnosis worsens prognosis, increases morbidity, and negatively impacts neurological outcomes and post-operative recovery[6,7]. Despite advances in prenatal ultrasound, approximately 25% of newborns with CHD remain undiagnosed before maternity discharge[8]. The sensitivity of prenatal echocardiography varies significantly depending on regional expertise and resources, with detection rates of only 50% reported in some developed countries [9].

Clinical examination has limited sensitivity for detecting asymptomatic CHD in the early neonatal period. Many critical heart defects present without obvious clinical signs such as cyanosis, murmurs, tachypnoea, or respiratory distress in the first days of life[10]. Visible cyanosis typically becomes apparent only when oxygen saturation falls below 85% in the absence of anaemia[11].

Pulse oximetry has emerged as a simple, non-invasive, and cost-effective screening tool that can detect subclinical hypoxemia indicative of critical CHD. The method uses spectrophotometry with two wavelengths (660 nm red and 940 nm infrared) to measure the proportion of oxygenated haemoglobin in peripheral blood[12]. Several international studies have demonstrated its effectiveness in improving CHD detection rates when added to routine physical examination[13-15.]

Despite growing international evidence supporting pulse oximetry screening for CHD, data from sub-Saharan Africa remain limited. In resource-constrained settings where access to prenatal screening and echocardiography is limited, implementing a systematic pulse oximetry protocol could significantly improve CHD detection rates.

This study aimed to evaluate the diagnostic performance of pulse oximetry screening in detecting congenital heart diseases among apparently healthy newborns in two referral hospitals in Yaoundé, Cameroon.

Methods

Study Design and Setting

This was a test validity study conducted over 8 months from February to September 2023. The study took place at two major referral hospitals in Yaoundé: the Yaounde-Gyneco-Obstetric and Paediatric Hospital (YGOPH) and the Yaoundé Central Hospital (YCH). Both facilities are first- and second-category institutions in Cameroon's healthcare pyramid, serving as referral centres for pregnancy monitoring and delivery, with approximately 200 births per month. Standard practice includes a 3-day postpartum observation period and systematic physical examination of all newborns.

Study Population

The study population comprised mother-infant pairs admitted to the maternity wards of YGOPH and YCH during the study period. Inclusion criteria were all newborns with gestational age ≥35 weeks who underwent echocardiography after maternity discharge, with parental informed consent obtained. Exclusion criteria included newborns presenting signs of life-threatening emergencies such as severe sepsis, neonatal asphyxia, or severe anaemia.

Sampling and Procedures

We performed consecutive sampling during routine clinical examinations in the maternity ward. Clinical examination was conducted by the paediatrician on duty, supplemented by pulse oximetry performed by the principal investigator in the presence of the mother, after the 24th hour of life and before maternity discharge.

Following established protocols from the Canadian Cardiovascular Society and Canadian Paediatric Association

[16], oxygen saturation was measured using a portable pulse oximeter (Viatom P05 Baby02 version B) designed specifically for newborns. Measurements were taken at four sites: right hand (pre-ductal), left hand, right foot (post-ductal), and left foot.

The test was considered negative if SpO_2 ≥95% at all sites with difference between right hand and either foot<3%. Borderline results (SpO_2 90-94% or pre-post ductal difference >3%) were repeated twice at one-hour intervals. The test was considered positive if SpO_2 <90% at any site, or SpO_2 <95% on three consecutive measurements, or pre-post ductal difference >3%.

All newborns, regardless of pulse oximetry results, were scheduled for echocardiography which served as the gold standard for CHD diagnosis. Echocardiography was performed by a paediatric cardiologist after obtaining parental informed consent.

Statistical Analysis

Diagnostic performance was calculated using standard formulas for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Statistical significance was assessed using odds ratios with 95% confidence intervals. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Ethics Committee of the University of the Mountains (Authorisation N° 2023/076/UdM/PR/CEAQ). Permissions were obtained from the directors of YGOPH and YCH. Written informed consent was obtained from all mothers after explaining study objectives, procedures, potential benefits, and the right to withdraw. Confidentiality was maintained through data anonymization.

Results

Maternal Characteristics

Mother-infant paired participated in the study. The median maternal age was 27 years (interquartile range: 23-33 years), with extremes of 18 and 41 years. The majority of mothers (94%) were aged 20-40 years. The sociodemographic characteristics of mothers are presented in Table 1.

Table 1: Sociodemographic characteristics of mothers (n=50)

Characteristics	n (%)
Age (years)	
<20	2 (4.0)
20-40	47 (94.0)
>40	1 (2.0)
Educational level	
Primary	5 (10.0)
Secondary	9 (18.0)
University	36 (72.0)
Number of pregnancies	
<2	12 (24.0)
2-4	28 (56.0)
≥5	10 (20.0)

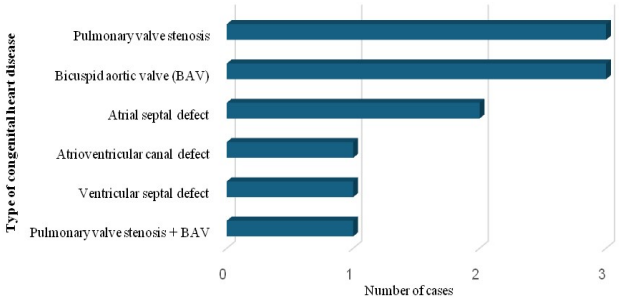
Newborn Characteristics

Among the 50 newborns studied, there was a male predominance with a sex ratio of 1.77 (64% male, 36% female). Three newborns presented with cardiac murmurs on auscultation, of which only one had a cardiac malformation confirmed by echocardiography. Among the seven newborns with SpO_2 <95%, six had congenital cardiac malformations confirmed by echocardiography.

Prevalence and Types of Congenital Heart Diseases

The overall prevalence of CHD was 22% (11/50). The distribution of cardiac malformations identified by echocardiography is shown in Fig 1. All identified malformations were acyanotic CHD.

Fig 1: Types of congenital heart diseases identified by echocardiography (n=11)



Diagnostic Performance of Pulse Oximetry

There was a statistically significant relationship between oxygen saturation and the presence of CHD. When oxygen saturation was <95%, the risk of having CHD was 20.5 times higher (OR 20.5, 95% CI: 5.30-79.21; p<0.001). The distribution of test results was: true positives 6 cases (12.0%), false positives 1 case (2.0%), false negatives 5 cases (10.0%), and true negatives 38 cases (76.0%) (Table 2).

Table 2: Relationship between pulse oximetry and congenital heart disease (n=50)

Pulse oximetry	CHD n (%)	OR (95% CI)
Abnormal (<95%)	6 (12.0)	20.5 (5.30-79.21)
Normal (≥95%)	5 (10.0)	0.05 (0.01-0.18)

The diagnostic performance parameters of pulse oximetry are summarized in Table 3. The test demonstrated high specificity (97.43%) and positive predictive value (85.71%), with moderate sensitivity (54.54%) and negative predictive value (83.37%).

Table 3: Diagnostic performance of pulse oximetry for etecting CHD

Diagnostic parameter	Value (%)
Sensitivity	54.54
Specificity	97.43
Positive predictive value	85.71
Negativepredictive value	83.37

Discussion

This study evaluated pulse oximetry as a screening tool for congenital heart diseases in apparently healthy newborns in two referral hospitals in Yaounde, Cameroon. The CHD prevalence of 22% in our study is higher than previously reported rates in Cameroon (4.3%)[5] and other international studies. This difference can be explained by our relatively small sample size, different study methodologies, and variations in prenatal screening programs between countries[17,18].

Study limitations included small sample size, loss to follow-up due to delayed echocardiography, and limited parental acceptance. Despite these limitations, our results demonstrate that pulse oximetry screening is feasible and can contribute to detecting undiagnosed CHD cases in resource-limited settings.

All CHD detected in our study were acyanotic lesions. This finding may be explained by prolonged transitional circulation in some newborns. Klausner et al. also reported detecting acyanotic CHD in newborns with SpO_2 <95%[19]. The absence of duct-dependent lesions could reflect survival bias or clinical exclusion criteria.

Sensitivity of 54.54% is comparable to the 50% reported by Arvind et al.[20] and falls within the range reported in other studies[13-15]. The moderate sensitivity reflects the limitation of pulse oximetry in detecting non-critical, acyanotic CHD that may not cause significant hypoxemia in the early neonatal period. The high specificity of 97.43% indicates that pulse oximetry rarely produces false positive results, making it a reliable tool for ruling out CHD when negative.

The positive predictive value of 85.71% suggests that when pulse oximetry is positive, there is a high probability that CHD is present. The negative predictive value of 83.37% is lower than some international studies, indicating that a normal pulse oximetry reading does not completely exclude CHD, particularly asymptomatic acyanotic lesions.

The high specificity and positive predictive value in our setting support the use of pulse oximetry as a screening tool, particularly in resource-limited environments where universal echocardiography is not feasible. However, the moderate sensitivity and NPV indicate that pulse oximetry should complement rather than replace clinical examination.

Conclusion

This study demonstrates that pulse oximetry is a valuable screening tool for detecting congenital heart diseases in neonates in a resource-limited setting in Cameroon. With a sensitivity of 54.54%, specificity of 97.43%, positive predictive value of 85.71%, and negative predictive value of 83.37%, pulse oximetry can identify a significant proportion of CHD cases that might otherwise go undetected before maternity discharge. The systematic implementation of pulse oximetry screening could improve early detection of CHD in settings with limited access to prenatal echocardiography. However, given its moderate sensitivity, pulse oximetry should complement rather than replace comprehensive clinical examination. Further research with larger sample sizes is needed to better characterize its performance in sub-Saharan African populations and evaluate its impact on clinical outcomes.

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