

Prevalence of Congenital Heart Disease Associated with Extracardiac Congenital Malformations in Paediatric Surgery

Yves N'da Kouakou N'goran^{1*}, Avoh Ami Echua Manzan¹, Traoré Fatoumata Epouse Diaby², Tano-Akoto Micesse¹, Camara Zenabou¹, Kouamé Yves Wilfried¹, Akoun Oboe Ange-Marie Christopher¹, Djibom Diana Viwassi¹, Eric Koutoua Katché³, Yoboua Aimé Kirioua-Kamenan³, Kramoh Kouadio Euloge¹

¹Department of Paediatric Cardiology, Abidjan Institute of Cardiology, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

²Department of Medicine, Abidjan Institute of Cardiology, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

³Department of Cardiovascular Surgery, Abidjan Institute of Cardiology, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

Email: *ngoran.yves@yahoo.fr

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Abstract

Background: Congenital heart defects (CHDs) are the most common congenital malformations. They are frequently associated with other extracardiac congenital malformations (ECCMs) and genetic syndromes. These ECCMs are a major cause of morbidity and mortality in CHDs. Despite its clinical significance, there are few publications on the association between CHD and ECCMs, particularly in sub-Saharan Africa. **Objective:** To analyse CHD associated with ECCMs. **Patients and Methods:** This was a prospective, cross-sectional, analytical study conducted among children aged 0 to 15 years attending paediatric surgery clinics over a six-month period (April to September 2024). The study was carried out in the paediatric cardiology department of the Abidjan Cardiology Institute (ICA). Patients were referred by the paediatric surgery departments of the Treichville and Cocody University Teaching Hospitals (CHU). **Results:** 79 children with extracardiac congenital malformations were recruited. Cleft lip and palate (CLP) was the most common cleft condition, with 35 cases. The prevalence of congenital heart defects (CHDs) associated with ECCMs was 35.44%, comprising 28 cases. The most common CHD was patent ductus arteriosus (PDA) (n = 6), followed by atrial septal defect (ASD) and ventricular septal defect (VSD) at rates of 17.86% (n = 5) and 14.28% (n = 4) respectively. The highest incidence of CHD was observed in children with FLP, at 32.15%. Multiple pregnancies, multiparity and miscarriage were associated with the occurrence of CHD and CHD-related compli-

cations. **Conclusion:** Miscarriage, gestation and parity have been linked to the occurrence of the combination of CHD and ECCM. The frequency of this combination necessitates systematic screening for CHD from birth, and even more so in cases where ECCM is present.

Keywords

Congenital Heart Defect, Extracardiac Malformation, Paediatric Surgery, Child, Cardiac Surgery

1. Introduction

Congenital heart defects (CHDs) are the most common congenital malformations, with a global incidence of 8 to 12 cases per 1000 births. They manifest in various forms and have diverse aetiologies [1] [2]. The course of a CHD depends on the type of heart defect, its severity and associated extracardiac abnormalities [3]. CHDs are often associated with major extracardiac congenital malformations (ECCMs), chromosomal abnormalities and genetic syndromes [4]. Previous studies have shown that ECCMs are present in 20% to 60% of live newborns with congenital heart disease [5]. ECCMs associated with CHD have a significant impact on their clinical course. Indeed, in the United States, R. D. Greenwood *et al.*, in their cohort, reported a prevalence of 23% of CHD in children with congenital diaphragmatic hernia, with a mortality rate of 73% in this group compared with 27% in those without CHD [6]. In Brazil, acute respiratory infections accounted for nearly 19% of deaths among children under one year of age in 2008, and were the second most common cause of death in this age group [5]. In Africa, A. Mourad, in his doctoral thesis in medicine in Algeria, found CHD in 11% of children with cleft lip and palate [7]. Ekure *et al.*, meanwhile, in their study of children with ECCMs in Lagos, reported the presence of CHD in 72.3% of patients [8]. In Côte d'Ivoire, although several studies have been carried out on CHD, the association between CHD and ECCMs has not been clearly defined. Given the limited number of studies focusing on the sub-Saharan African experience, the aim of our study is to provide a descriptive overview of the association between CHD and ECCMs in paediatric surgery, with the objective of analysing the CHD associated with ECCMs.

2. Patients and Methods

This was a prospective, analytical cross-sectional study conducted over a six-month period (from April to September 2024). The study was carried out in the paediatric cardiology department of the Abidjan Cardiology Institute (ICA). Patients were referred by the paediatric surgery departments of the Treichville and Cocody University Teaching Hospitals (CHU). These patients came in for a pre-operative assessment. We therefore proceeded to recruit patients sequentially in accordance with the questionnaire. We therefore recruited patients in stages in

accordance with the questionnaire. This study included all children aged 0 to 15 years who came for an echocardiogram: patients with ECCMs and CHD diagnosed by echocardiography by a paediatric cardiologist. Patients with isolated CHD or isolated ECCMs were excluded. The variables included in our study are age, sex, parental age, consanguinity, the mother's gestation and parity, miscarriage, antenatal assessment, high blood pressure, diabetes, alcohol and tobacco use among parents, the type of ECCMs, the type of CHD, and trisomic features. We highlighted the mean age, the frequency of sociodemographic data for children and parents (sex, age, occupation, medical history, consanguinity), and the frequencies associated with the combination of ECCMs and CHD. The data were entered into EpiInfo version 7.2 for Windows and analysed. For the statistical analysis, odds ratios (OR) and confidence intervals were calculated for the associated factors. Associations with $p < 0.05$ were considered statistically significant. The parents of the patients included in this study were all volunteers. They completed the questionnaire after giving informed consent. They were informed of the study protocol, which had been approved by the Scientific Committee of the Abidjan Institute of Cardiology.

3. Results

At the conclusion of our study (**Figure 1**), we identified 79 children with ECCMs (14.96%) out of a total of 528 patients who attended the clinic. The hospital admission rate for cleft-related conditions in our population was 5.30% ($n = 28$), whilst that for isolated CLP was 9.66% ($n = 51$). Of the 79 patients, cleft lip and palate (CLP) was the most common congenital malformation, accounting for 44.31% (35 patients), followed by omphalocele at 16.46% (13 patients). Umbilical hernia and hydrocephalus were found in 6.34% and 7.59% of cases, respectively (**Table 1**). In our cohort of 28 patients, the most frequently recorded congenital heart defects were patent ductus arteriosus (PDA), atrial septal defect (ASD) and double-outlet right ventricle (DORV), in proportions of 21.43% ($n = 06$), 17.86% ($n = 05$) and 14.28% ($n = 4$). We found an equal number of cases of pulmonary stenosis (PS) and atrioventricular septal defect (AVSD), namely 10.72% ($n = 3$). Only two cases of ventricular septal defect (VSD) were recorded, representing 7.14% (**Table 2**). The highest incidence of CHD was observed in children with FLP, at 32.15% (nine patients: three VDDI; two PDA; two AVSD; 1 ASD and 1 transposition of the great arteries (TGA)), followed by those with omphalocele, accounting for 21.44% (6 patients: 2 PDA; 1 VSD; 1 SP; 1 common arterial trunk (TAC) and 1 cardiac mass) (**Table 3**). Multiple pregnancies, multiparity and miscarriage were associated with the occurrence of CC and ECCMs (**Table 4**).

Table 1. Summary of extracardiac congenital malformations.

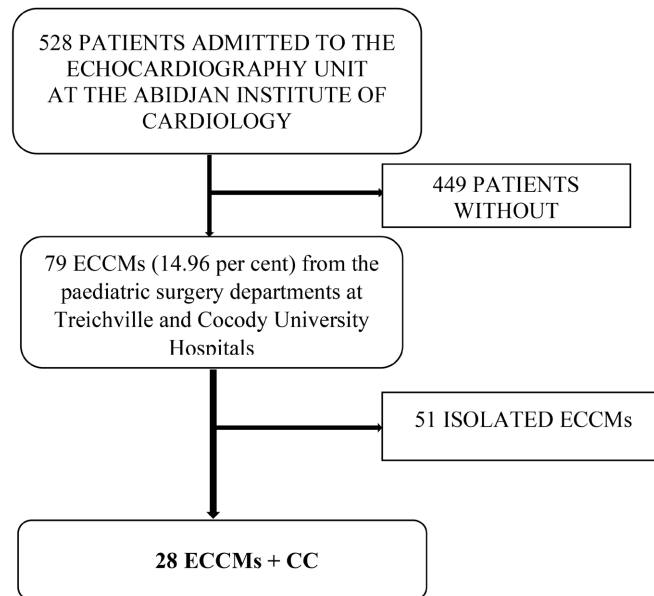
Malformations	Effective	Percentage (%)
Cleft Lip and Palate	35	44.31%

Continued

Omphalocele	13	16.46%
Hydrocephalus	06	07.59%
Umbilical hernia	05	06.34%
Polydactyly	04	05.07%
Spina bifida	04	05.07%
Cleft lip	02	02.54%
Hypospadie et épispadie	02	02.54%
Extrophie vésicale	01	01.26%
Clubfoot (varus equinus)	01	01.26%
Toe dysgenesis	01	01.26%
Anorectal atresia and stenosis	01	01.26%
Encephalocele	01	01.26%
Posterior urethral valve	01	01.26%
Testicular descent	01	01.26%
Vestibular fistula	01	01.26%
Total	79	100%

Table 2. Summary of congenital heart defects identified.

Congenitals Heart Diseases	Number	Percentage (%)
Patent ductus arterial	06	21.43%
Atrial septal defect	05	17.86%
Double outlet right ventricle	04	14.29%
Atrial ventricular septal defect	03	10.72%
Pulmonary stenosis	03	10.72%
Ventricular septal defect	02	07.14%
Cardiac mass	01	03.57%
Tetralogy of fallot	01	03.57%
Common arterial trunk	01	03.57%
Single atrial	01	03.57%
Transposition of the great vessels	01	03.57%
Total	28	100%

**Figure 1.** Flowchart.**Table 3.** Breakdown of CHD by ECCMs.

ECCMs \ CHD	PDA	DORV	AVSD	VSD	ASD	SP	CM	TOF	TAC	SA	TGVX
Clofted lip and palate	2	3	2	0	1	0	0	0	0	0	1
Omphalocele	2	1	0	0	0	1	1	0	1	0	0
Hernia umbilical	2	0	0	0	0	0	0	0	0	0	0
Hydrocephal	0	0	0	0	1	0	0	0	0	0	0
Polydactyly	0	0	1	0	1	0	0	0	0	0	0
Spina bifida	0	0	0	0	1	1	0	0	0	0	0
Vesical extrophy	0	0	0	0	0	1	0	0	0	0	0
Clubfoot	0	0	0	0	0	0	0	0	0	1	0
Toe dysgenesis	0	0	0	1	0	0	0	0	0	0	0
Hypospadiam and epispadiam	0	0	0	1	0	0	0	0	0	0	0
Testicular descension	0	0	0	0	0	0	0	1	0	0	0
Vestibular fistula	0	0	0	0	1	0	0	0	0	0	0
Total	6 (21.44%)	4 (14.28%)	3 (10.72%)	2 (7.14%)	5 (17.85%)	3 (10.72%)	1 (3.57%)	1 (3.57%)	1 (3.57%)	1 (3.57%)	1 (3.57%)

CHD: Congenital Heart Disease, ECCMs: Extracardiac Congenital Malformations, PDA: Patant Ductus Arteriosus, DORV: Double Outlet Right Ventricle, AVSD: Atrioventricular Septal Defect, VSD: Ventricular Septal Defect, ASD: Atrial Septal Defect, PS: Pulmonary Stenosis, CM: Cardiac Mass, TOF: Tetralogy Of Fallot, TAC: Troncus Arteriosus, SA: Single Atrial, TGVX: Transposition Greats Vessels.

Table 4. Analytical study.

	ECCMs + CHD	ECCMs	Odds Ratio	p-Value
Sex				
Male	15	23	1.40 [0.57 - 3.71]	0.30
Female	13	28		
Parents' age				
Mothers	29.6	28.66		0.51
Fathers	37.25	36.84		0.79
Multigeste				
Yes	26	45	1.73 [0.20 - 4.20]	0.001
No	02	06		
Multipare				
Yes	25	44	1.32 [0.31 - 5.50]	0.001
No	03	07		
Miscarriage				
Yes	07	13	1.07 [0.33 - 2.81]	0.001
No	21	38		
Alcohol				
Yes	02	06	0.57 [0.10 - 3.06]	0.06
No	26	45		
Folic acid				
Yes	19	38	1.38 [0.29 - 2.69]	0.13
No	09	13		
Trisomy faces				
Yes	04	01	8.33 [0.88 - 78.65]	2.78
No	24	50		
Consanguinity				
Yes	02	01	3.84 [0.33 - 44.4]	0.28
No	26	50		

CHD: Congenital Heart Disease, ECCMs: Extracardiac Congenital Malformations.

4. Discussion

4.1. Prevalence of CCs Associated with ECCMs

Congenital heart defects may occur in isolation or in conjunction with other types of congenital malformations, known as extracardiac malformations [8]. In our study, conducted over a six-month period in the Paediatric Cardiology Depart-

ment at the ICA, CHDs were found in 28 (35.44%) of the 79 patients with CHD. This prevalence is somewhat similar to that reported in several previous studies, such as that by Alvarado *et al.*, who, in their study conducted in Colombia, found a 30% prevalence of CHD in newborns [2], and Baltaxe and Zarante, who found a prevalence of 32.7% [9]. Other studies have reported higher prevalence rates, notably those by Gregor *et al.*, who found an association with CC in 56.6% of foetal cases [10]. The cases reported by Gregor were abnormalities diagnosed by magnetic resonance imaging prior to birth; consequently, these figures do not account for foetal deaths or terminations of pregnancy. In our study, cleft lip and palate (CLP) was the most common congenital anomaly, followed by omphalocele, umbilical hernia and hydrocephalus. The most frequently reported congenital anomalies in Latin America are genitourinary and gastrointestinal malformations [2] [5]. In the United States of America, the malformations reported were genitourinary, respiratory and gastrointestinal malformations [11] [12]. These results are also similar to those of Chang in South Korea [3]. In his study, facial anomalies ranked first, followed by genitourinary and gastrointestinal anomalies.

In our cohort, the most commonly recorded congenital heart defects were PDA, ASD and DORV. We found an equal number of SPs and AVSD. Tassinari in Colombia found VSD and ASD to be the most common congenital heart defects [13], as was also the case in South Korea and in previous studies [3] [14]. This contrasts with Alvarado, where complex heart defects were more prevalent [2]. This could be explained by access to more advanced technical facilities [15].

4.2. Multiple Pregnancies and Multiparity

In our study, 92.86% of mothers had been pregnant more than once, whilst 89% were multiparous. Our findings were higher than those reported by Firdaous JALAL in her thesis in Morocco, which found that 67% of mothers of newborns with congenital heart disease were multiparous [16]. These high proportions in Africa can be explained by a high fertility rate and a lack of awareness of family planning, particularly among populations with modest incomes and average educational levels. In our study, multiple gestation and multiparity represented a risk factor for the association of CHD with ECCMs. Saad, in his study, does not support this theory; it is multiple pregnancies that carry a high risk of congenital heart disease, though the mechanism is not clearly understood [17]. Furthermore, he suggests that it is advanced maternal age combined with primiparity that carries a risk of congenital malformations.

4.3. Miscarriage

In our study, a history of miscarriage was found in 25% ($n = 7$) of the mothers of children with CHD. The literature indicates that there is a known risk of congenital malformations in the offspring of mothers who have had miscarriages [18]. A previous meta-analysis demonstrated that children of women with a history of abortion (whether spontaneous or induced) had a higher risk of developing con-

genital heart disease (CHD) [19], a finding that was confirmed in the present study. Although the specific biological mechanism underlying the link between a history of abortion and the risk of congenital heart disease remains unclear, it has been suggested that such a history may cause psychological stress in mothers [17] [20].

4.4. Consanguinity

Consanguinity is a risk factor for the occurrence of chromosomal abnormalities and, consequently, congenital malformations in general. The prevalence of congenital heart disease is higher among children of consanguineous parents than among children of non-consanguineous parents [21]. In our study, no link was established between consanguinity and the occurrence of CHD and ECCMs.

5. Strengths and Limitations of the Study

Our study has a number of limitations that must be taken into account to ensure the results are interpreted correctly. A distinctive feature of our study is that it was the first of its kind to be conducted in sub-Saharan Africa, and specifically in the paediatric cardiology department of the ICA in Côte d'Ivoire.

➤ On sampling

The main limitation regarding patient recruitment was that patients were drawn from only one (Treichville University Hospital) of the three paediatric surgery departments. Furthermore, given the low to moderate socioeconomic status of the majority of our patients, those living far from Abidjan or the ICA were unable to travel there to take part in the survey. As a result, our sample was limited to 79 patients.

➤ On data quality

Data were collected using a questionnaire and by analysing the children's birth records. It should also be noted that some patient records were incomplete due to the unavailability of the birth record. Some records were compiled solely on the basis of interviews with the parents and are therefore likely to be subject to various forms of bias.

➤ Screening for chromosomal and genetic abnormalities

The lack of screening for chromosomal and genetic abnormalities is due to the fact that low-cost karyotype testing is not available in our country. Such screening would have provided a further explanation for the presence of certain congenital heart defects in our study. In the study by Tennstedt *et al.* [22], chromosomal abnormalities were observed in cases of VSD (62%), tetralogy of Fallot (50%), coarctation of the aorta (42.9%) and ASD (42%). Egbe *et al.* [11] found that ASD was most commonly observed in individuals with a genetic syndrome.

6. Conclusion

The aim of this study was to analyse CHDs associated with ECCMs. Our results showed that Cleft lip and palate was the most common ECCMs associated with

CHDs. Multiple pregnancies, multiparity and previous miscarriage have been linked to the occurrence of CHDs and ECCMs associations. These findings may be useful in the management of congenital anomalies. However, certain limitations, notably the sample size and the single-centre nature of the study, must be taken into account. Larger-scale prospective studies investigating chromosomal abnormalities are required to confirm these findings.

Author Contributions

N'goran Yves N'da Kouakou: Drafting and revising the manuscript. Traoré Fatoumata, wife of Diaby: Drafting and revising the manuscript. Kouamé Yves Wilfried: Analysis and literature review. Akoun Oboe Ange-Marie Christopher: Analysis and literature review. Djibom Diana Viwassi: Drafting and revising the manuscript. Avoh Ami Echua Manzan: Analysis and literature review, drafting and revising the manuscript. Tano-Akoto Micesse: Clinical management and diagnosis. Camara Zenabou: Clinical management and diagnosis. Eric Koutoua Katché: Clinical management and diagnosis. Yoboua Aimé Kirioua-Kamenan: Clinical management and diagnosis. Kramoh Kouadio Euloge: Scientific supervision of the study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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