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Epidemiological, Clinical, and Therapeutic Profile of Congenital Heart Disease in Children Admitted to a Pediatric Emergency Department in Marrakech, Morocco: A Three-Year Retrospective Study

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Abstract | **Original Research Article**

Background: Congenital heart disease (CHD) is the most common congenital malformation and a leading cause of infant morbidity and mortality, particularly in low- and middle-income countries, where diagnosis is often delayed. This study aimed to describe the epidemiological, clinical, echocardiographic, and therapeutic profile of children with CHD admitted to a pediatric emergency department in Morocco. ***Methods:*** We conducted a retrospective descriptive study of children younger than 15 years admitted to the pediatric emergency department of Mohammed VI University Hospital Center, Marrakech, Morocco, between January 1, 2019, and December 31, 2021, with CHD confirmed by echocardiography. Sociodemographic, maternal, clinical, radiological, echocardiographic, and therapeutic data were collected from medical records and analyzed descriptively. ***Results:*** A total of 200 children were included (102 girls, 51%). The mean age at diagnosis was 13.68 ± 15.82 months, and 167 patients (83.5%) were diagnosed after the neonatal period. Most patients lived in rural areas (53.5%) and had no health insurance (66.5%). Pregnancy follow-up was inadequate in 73.5% of mothers. Trisomy 21 was present in 13% of patients. Respiratory distress was the leading presenting feature (56%), and a heart murmur was heard in 79%. Ventricular septal defect was the most frequent lesion (47%), and left-to-right shunt lesions accounted for 74% of cases. Pulmonary hypertension was the most common complication, found in 30 of the 79 patients with complications (38%). Medical treatment was indicated in 157 patients (78.5%), mainly diuretics, and a surgical or interventional procedure was indicated in 121 (60.5%), most often pulmonary artery banding (49.6%). Intensive care was required in 27 patients (13.5%), mainly for sepsis. ***Conclusion:*** In this cohort, CHD was mostly diagnosed beyond the neonatal period in symptomatic children, frequently from rural and uninsured families, and pulmonary hypertension was already the leading complication at presentation. Strengthening prenatal follow-up, implementing neonatal pulse oximetry screening, and improving access to pediatric cardiac care are needed to allow earlier diagnosis and timely treatment.

Keywords: Congenital heart disease, Children, Pediatric emergency, Late diagnosis, Ventricular septal defect, Pulmonary hypertension, Pulse oximetry screening, Morocco.

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INTRODUCTION

Congenital heart disease (CHD) is defined as a structural abnormality of the heart or intrathoracic great vessels that is present at birth and results from abnormal cardiac development during fetal life. It is the most common group of congenital malformations, with a reported incidence ranging from four to 10 per 1,000 live births depending on the population studied and on the inclusion of minor lesions [1-3]. CHD accounts for more deaths than any other congenital anomaly and represents a major contributor to infant mortality worldwide [4].

The burden of CHD is unevenly distributed. While survival has improved considerably in high-income countries owing to prenatal diagnosis, neonatal screening, and access to pediatric cardiac surgery, most affected children are born in low- and middle-income countries, where diagnosis is frequently late and access to specialized care remains limited [4-6]. In North

Africa, data remain scarce; a Tunisian population-based study reported a birth prevalence of 6.8 per 1,000 live births with a high early mortality rate [7].

Routine neonatal clinical examination fails to detect a substantial proportion of critical CHD before hospital discharge, and missed diagnoses are associated with avoidable morbidity and death [8,9]. Pulse oximetry screening is a highly specific, moderately sensitive test that improves early detection of critical CHD and has been endorsed in several countries [10-13], whereas transthoracic echocardiography remains the reference diagnostic tool after birth. In Morocco, no national neonatal screening program for CHD exists, and recent hospital-based data on the profile of affected children are limited.

This study aimed to describe the epidemiological, clinical, echocardiographic, and therapeutic characteristics of children with CHD admitted to the pediatric emergency department of a tertiary university hospital in Marrakech, Morocco, and to discuss the factors that may contribute to late diagnosis in our setting.

Materials and Methods

Study design and setting

We conducted a retrospective, descriptive, single-center study at the pediatric emergency department of Mohammed VI University Hospital Center, Marrakech, Morocco, a tertiary referral center serving the Marrakech-Safi region and neighboring southern regions. The study period extended from January 1, 2019, to December 31, 2021.

Study population

We included all newborns and children younger than 15 years who were admitted to the pediatric emergency department during the study period with CHD confirmed by transthoracic echocardiography. We excluded patients with non-structural cardiac conditions, including cardiomyopathies, cardiac tumors, and isolated rhythm disorders, as well as patients with incomplete medical records.

Data collection

Data were retrieved from medical records using a standardized data collection form. The variables collected were sociodemographic data (age at diagnosis, sex, geographic origin, health insurance coverage, and month of admission); perinatal history (consanguinity, twin pregnancy, prematurity, intrauterine growth restriction, macrosomia, family history of CHD, and associated chromosomal anomalies); maternal data (age, parity, pregnancy follow-up, chronic diseases, infections, medication use, smoking, and alcohol consumption during pregnancy); clinical data (circumstances of diagnosis, history of recurrent respiratory infections, weight and height, heart rate, respiratory rate, oxygen saturation on room air, and cardiac auscultation); chest radiograph findings; echocardiographic diagnosis and complications; and therapeutic management (medical treatment, surgical or interventional procedures, and admission to intensive care).

Definitions

The neonatal period was defined as the first 28 days of life. Pregnancy follow-up was considered inadequate when the mother reported irregular or absent prenatal visits. For the purpose of this report, echocardiographic diagnoses were grouped according to their predominant hemodynamic consequence into left-to-right shunt lesions (ventricular septal defect, patent ductus arteriosus, atrioventricular septal defect, and atrial septal defect), obstructive lesions (pulmonary stenosis, coarctation of the aorta, aortic stenosis, and mitral stenosis), and other valvular anomalies (mitral regurgitation, tricuspid regurgitation, aortic regurgitation, and bicuspid aortic valve).

Statistical analysis

Data were entered and analyzed using IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, NY, USA). Categorical variables are presented as numbers and percentages, and continuous variables as mean ± standard deviation.

Ethical considerations

Patient anonymity and data confidentiality were maintained throughout data collection and analysis. Owing to the retrospective design and the use of anonymized data, individual informed consent was not required.

Results

Sociodemographic characteristics

A total of 200 children with CHD were included. There were 102 girls (51%) and 98 boys (49%), with a female-to-male ratio of 1.04. The mean age at diagnosis was 13.68 ± 15.82 months. Only 33 patients (16.5%) were diagnosed during the neonatal period, whereas 137 (68.5%) were diagnosed between 28 days and 24 months of age and 30 (15%) after 24 months. Overall, 107 patients (53.5%) came from rural areas, and 133 (66.5%) had no health insurance, while 59 (29.5%) were covered by the Moroccan medical assistance scheme for low-income populations (Régime d'Assistance Médicale, RAMED). Over the three study years, admissions peaked in December (44 cases, 22%) and were lowest in July (six cases, 3%). Sociodemographic, perinatal, and maternal characteristics are summarized in Table 1.

Perinatal and maternal characteristics

Parental consanguinity was reported in 19 patients (9.5%), a family history of CHD in 18 (9%), twin pregnancy in 16 (8%), prematurity in 13 (6.5%),

macrosomia in 12 (6%), and intrauterine growth restriction in two (1%). A chromosomal anomaly was identified in 29 patients (14.5%), including trisomy 21 in 26 (13%) and trisomy 13 in three (1.5%).

Maternal age was between 30 and 40 years in 88 cases (44%), between 20 and 30 years in 76 (38%), below 20 years in 23 (11.5%), and above 40 years in 13 (6.5%). Most mothers were multiparous (140, 70%), and pregnancy follow-up was inadequate in 147 (73.5%). A maternal chronic condition was reported in 29 mothers (14.5%): diabetes in 13 (6.5%), gestational hypertension in nine (4.5%), and both in seven (3.5%). Medication use during pregnancy was reported by 57 mothers (28.5%), including iron supplementation (29, 14.5%), amoxicillin-clavulanic acid (15, 7.5%), and insulin (13, 6.5%). Rubella during pregnancy was reported in two mothers (1%), recurrent genital infections in seven (3.5%), and chlamydial infection in one (0.5%). Five mothers (2.5%) smoked and three (1.5%) consumed alcohol during pregnancy.

Clinical and radiological findings

Respiratory distress was the most frequent circumstance of diagnosis (112 patients, 56%), followed by cyanosis (34 patients, 17%); other circumstances accounted for the remaining 54 cases (27%). A history of recurrent respiratory infections was reported in 47 patients (23.5%). Low weight for age was found in 78 patients (39%) and short stature in 105 (52.5%). On examination, tachycardia was present in 116 patients (58%), tachypnea in 131 (65.5%), and low oxygen saturation on room air in 32 (16%). A heart murmur was heard in 158 patients (79%). The chest radiograph was abnormal in 173 patients (86.5%), with cardiomegaly in 144 (72%), either isolated (93, 46.5%) or associated with a pulmonary opacity (51,25.5%). Clinical and radiological findings are detailed in Table 2.

Echocardiographic findings

Ventricular septal defect was the most frequent lesion (94 patients, 47%), followed by patent ductus arteriosus (25, 12.5%), pulmonary stenosis (25, 12.5%), atrioventricular septal defect (18, 9%), atrial septal defect (11, 5.5%), and coarctation of the aorta (10, 5%). Left-to-right shunt lesions accounted for 148 cases (74%), obstructive lesions for 40 (20%), and other valvular anomalies for 12 (6%) (Table 3).

At least one complication was identified in 79 patients (39.5%). Pulmonary hypertension was the most common (30 of 79, 38%), followed by right atrial dilatation (18, 22.8%), right ventricular dilatation (13, 16.5%), left ventricular dilatation (eight, 10.1%), left atrial dilatation (eight, 10.1%), and infective endocarditis (two, 2.5%).

Management

Medical treatment was indicated in 157 patients (78.5%). Among them, 71 (45.2%) received furosemide alone, 31 (19.7%) furosemide combined with digoxin, and 16 (10.2%) digoxin alone. Other treatments included ibuprofen (10, 6.4%), sildenafil (10, 6.4%), beta-blockers (eight, 5.1%), angiotensin-converting enzyme inhibitors (eight, 5.1%), amiodarone (two, 1.3%), and alprostadil (one, 0.6%). Antibiotic therapy with amoxicillin-clavulanic acid was administered to 161 patients (80.5%).

A surgical or interventional procedure was indicated in 121 patients (60.5%). Pulmonary artery banding was performed in 60 (49.6%), complete surgical repair in 45 (37.2%), balloon atrial septostomy (Rashkind procedure) in nine (7.4%), and a Blalock-Taussig shunt in seven (5.8%). Postoperative intensive care was required in 27 patients (13.5%), mainly for sepsis (11, 40.7%), cardiac arrhythmias (10, 37%), and respiratory distress (six, 22.2%) (Table 3).

Table 1: Sociodemographic, perinatal, and maternal characteristics of the study population (N = 200)

Characteristic	**n (%)**
Sex	
Female	102 (51)
Male	98 (49)
Age at diagnosis	
Mean ± SD, months	13.68 ± 15.82
< 28 days	33 (16.5)
28 days to 24 months	137 (68.5)
> 24 months	30 (15)
Characteristic	**n (%)**
Geographic origin	
Rural	107 (53.5)
Urban	93 (46.5)
Health insurance	
None	133 (66.5)
RAMED	59 (29.5)
Other	8 (4)

Perinatal history	
Parental consanguinity	19 (9.5)
Family history of CHD	18 (9)
Twin pregnancy	16 (8)
Prematurity	13 (6.5)
Macrosomia	12 (6)
Intrauterine growth restriction	2 (1)
Chromosomal anomaly	
Trisomy 21	26 (13)
Trisomy 13	3 (1.5)
Maternal age	
< 20 years	23 (11.5)
20-30 years	76 (38)
30-40 years	88 (44)
> 40 years	13 (6.5)
Pregnancy and maternal history	
Multiparity	140 (70)
Inadequate pregnancy follow-up	147 (73.5)
Diabetes	13 (6.5)
Gestational hypertension	9 (4.5)
Diabetes and gestational hypertension	7 (3.5)
Medication use during pregnancy	57 (28.5)
Rubella during pregnancy	2 (1)
Recurrent genital infections	7 (3.5)
Smoking during pregnancy	5 (2.5)
Alcohol during pregnancy	3 (1.5)

CHD: congenital heart disease; RAMED: Régime d'Assistance Médicale (Moroccan medical assistance scheme for low-income populations); SD: standard deviation

Table 2: Clinical and radiological findings at presentation (N = 200)

Finding	**n (%)**
Circumstances of diagnosis	
Respiratory distress	112 (56)
Cyanosis	34 (17)
Other	54 (27)
History	
Recurrent respiratory infections	47 (23.5)
Anthropometry	
Low weight for age	78 (39)
Finding	**n (%)**
Normal weight	110 (55)
Excess weight	12 (6)
Short stature	105 (52.5)
Normal height	93 (46.5)
Tall stature	2 (1)
Vital signs	
Tachycardia	116 (58)
Bradycardia	14 (7)
Tachypnea	131 (65.5)
Bradypnea	29 (14.5)
Low oxygen saturation on room air	32 (16)
Cardiac auscultation	
Heart murmur	158 (79)
Chest radiograph	
Normal	27 (13.5)
Isolated cardiomegaly	93 (46.5)

Cardiomegaly with pulmonary opacity	51 (25.5)
Isolated pulmonary opacity	3 (1.5)
Hyaline membrane disease	8 (4)
Other abnormalities	18 (9)

Table 3: Echocardiographic diagnoses, complications, and management

Variable	**n (%)**
Left-to-right shunt lesions (N = 200)	**148 (74)**
Ventricular septal defect	94 (47)
Patent ductus arteriosus	25 (12.5)
Atrioventricular septal defect	18 (9)
Atrial septal defect	11 (5.5)
Obstructive lesions (N = 200)	**40 (20)**
Pulmonary stenosis	25 (12.5)
Coarctation of the aorta	10 (5)
Mitral stenosis	4 (2)
Aortic stenosis	1 (0.5)
Other valvular anomalies (N = 200)	**12 (6)**
Mitral regurgitation	6 (3)
Bicuspid aortic valve	3 (1.5)
Tricuspid regurgitation	2 (1)
Aortic regurgitation	1 (0.5)
Complications (n = 79)	
Pulmonary hypertension	30 (38)
Right atrial dilatation	18 (22.8)
Right ventricular dilatation	13 (16.5)
Left ventricular dilatation	8 (10.1)
Left atrial dilatation	8 (10.1)
Infective endocarditis	2 (2.5)
Medical treatment (n = 157)	
Variable	**n (%)**
Furosemide alone	71 (45.2)
Furosemide and digoxin	31 (19.7)
Digoxin alone	16 (10.2)
Ibuprofen	10 (6.4)
Sildenafil	10 (6.4)
Beta-blocker	8 (5.1)
Angiotensin-converting enzyme inhibitor	8 (5.1)
Amiodarone	2 (1.3)
Alprostadil	1 (0.6)
Surgical or interventional procedure (n = 121)	
Pulmonary artery banding	60 (49.6)
Complete surgical repair	45 (37.2)
Balloon atrial septostomy	9 (7.4)
Blalock-Taussig shunt	7 (5.8)
Indications for intensive care (n = 27)	
Sepsis	11 (40.7)
Cardiac arrhythmia	10 (37)
Respiratory distress	6 (22.2)

Percentages for complications, medical treatment, procedures, and intensive care are calculated within each subgroup.

DISCUSSION

This study describes a three-year series of 200 children with CHD admitted to a pediatric emergency department in southern Morocco. Its main findings are the predominance of late diagnosis, with more than four in five children diagnosed after the neonatal period, the high proportion of patients from rural and uninsured families, the predominance of left-to-right shunt lesions led by ventricular septal defect, and the frequency of pulmonary hypertension and growth failure at presentation.

Age at diagnosis and access to care

Only 16.5% of our patients were diagnosed during the neonatal period, and the mean age at diagnosis exceeded one year. This contrasts with settings that combine prenatal ultrasound, systematic neonatal examination, and pulse oximetry screening, in which most critical lesions are identified before discharge from the maternity ward [10-12]. Delayed diagnosis of CHD has been repeatedly associated with avoidable morbidity and mortality [8,9]. Several factors identified in our cohort may explain this delay: nearly three-quarters of mothers had inadequate pregnancy follow-up, more than half of the families lived in rural areas, and two-thirds had no health insurance at the time of admission. Similar barriers, including geographic distance from referral centers, financial constraints, and a shortage of pediatric cardiologists and cardiac surgeons, have been described across Africa and in other low- and middle-income regions [5,6,14]. Pulse oximetry screening, which is inexpensive and has a specificity of 99.9% for critical CHD [10], could be particularly relevant in our context, especially when combined with clinical examination, which improves its sensitivity [12,13].

Sex distribution and associated conditions

The sex distribution in our series was almost balanced, with a slight female predominance, consistent with the literature, in which the overall sex ratio of CHD is close to one and sex differences mainly depend on the lesion type [2]. Genetic factors, including chromosomal anomalies, account for a substantial proportion of CHD [15]. In our series, chromosomal anomalies were found in 14.5% of patients, mainly trisomy 21 (13%). CHD occurs in approximately 40% to 50% of children with Down syndrome, most commonly as atrioventricular septal defect or ventricular septal defect [16], and a Moroccan series confirmed this association in our population [17]. The proportion of trisomy 21 in our cohort may be underestimated, as karyotyping is not systematically available because of its cost and limited access.

Parental consanguinity was reported in 9.5% of our patients. Consanguinity has been associated with an increased risk of CHD, particularly in populations where consanguineous marriage is common [18,19]. The relatively low rate observed here may reflect underreporting in medical records rather than a true absence of association. Similarly, prematurity (6.5%) was less frequent than might be expected, since preterm birth is about twice as common among infants with CHD as in the general population [20].

Maternal factors

Maternal diabetes was present in 10% of our patients' mothers when isolated and combined forms were considered together. Pregestational diabetes is a well-established risk factor for CHD, and large population-based studies have confirmed a severalfold increase in risk among exposed offspring [21,22]. Hypertensive disorders of pregnancy, reported in 8% of mothers, have also been associated with fetal CHD, particularly early-onset preeclampsia [23]. Maternal smoking and alcohol consumption were rare in our cohort; maternal smoking is associated with a modest increase in the risk of septal defects [24], whereas the evidence for alcohol is less consistent [21]. These findings support preconception counseling, optimal glycemic control before and during pregnancy, and the referral of high-risk pregnancies for fetal echocardiography.

Clinical presentation

Respiratory distress was the leading presentation, and tachypnea, tachycardia, and cardiomegaly on chest radiograph were present in most patients, reflecting the hemodynamic consequences of large left-to-right shunts with pulmonary overcirculation and heart failure. The peak of admissions in December is consistent with the seasonal circulation of respiratory viruses, which cause frequent and severe lower respiratory tract infections in children with hemodynamically significant CHD [25]. Growth failure was common, with low weight in 39% and short stature in 52.5% of patients. Malnutrition is highly prevalent in children with unrepaired CHD in resource-limited settings and is associated with poorer surgical outcomes [26]; early nutritional support should therefore be integrated into their management.

Distribution of lesions

Ventricular septal defect was the most frequent lesion (47%), followed by patent ductus arteriosus and pulmonary stenosis, which is in agreement with global meta-analyses identifying ventricular septal defect as the most common form of CHD [2,3] and with series from other African countries [6,14]. In the Tunisian population-based study by Abid *et al.,*, ventricular septal defect was also the predominant lesion [7]. The predominance of left-to-right shunt lesions (74%) in an emergency department cohort is consistent with their typical presentation, after the fall in pulmonary vascular resistance in the first weeks of life, with heart failure and respiratory infections.

Complications

Pulmonary hypertension was the most common complication, affecting 15% of the entire cohort. In the absence of early diagnosis and timely surgical correction, large left-to-right shunts expose children to progressive pulmonary vascular disease, which may eventually render the defect inoperable [5,14]. The high rate of pulmonary artery banding in our series, a palliative procedure that protects the pulmonary circulation while delaying complete repair, illustrates the clinical consequences of late referral and limited access to early complete repair. Infective endocarditis was rare, but its

occurrence underlines the importance of oral hygiene and prevention in this population.

MANAGEMENT AND OUTCOMES

Medical treatment was dominated by loop diuretics and digoxin, used to control heart failure while awaiting surgery. A surgical or interventional procedure was indicated in 60.5% of patients, of whom 37.2% underwent complete repair. Access to pediatric cardiac surgery remains a major challenge in many low- and middle-income countries, where most children who need surgery do not receive it in time [4,6]. Sepsis was the leading reason for intensive care admission in our series. Infants with CHD are at increased risk of sepsis, which is associated with higher mortality in this population [27]. The widespread empirical use of amoxicillin-clavulanic acid observed in our cohort, mostly in the context of respiratory distress and suspected lower respiratory tract infection, highlights the need for antimicrobial stewardship protocols adapted to children with heart disease.

LIMITATIONS

This study has several limitations. First, its retrospective single-center design exposes it to missing data and selection bias, and the exclusion of incomplete records may have affected the distribution of the lesions. Second, because patients were recruited in an emergency department, the cohort over-represents symptomatic children and does not reflect the true prevalence of CHD in the population. Third, the echocardiographic categories did not capture complex cyanotic malformations separately, although palliative procedures typically used in such lesions, such as balloon atrial septostomy and Blalock-Taussig shunt, were performed, suggesting that these malformations were underrepresented in the diagnostic categories. Fourth, the study period overlapped with the coronavirus disease 2019 (COVID-19) pandemic, which may have affected health care access and admission patterns. Finally, long-term outcomes and mortality after transfer to other departments could not be assessed. Prospective multicenter studies with standardized lesion classification and follow-up are needed.

CONCLUSION

In this cohort of children admitted to a pediatric emergency department in Marrakech, congenital heart disease was predominantly diagnosed beyond the neonatal period, in symptomatic children who frequently came from rural areas and lacked health insurance. Left-to-right shunt lesions, led by ventricular septal defect, were the most common, and pulmonary hypertension and growth failure were already frequent at presentation, reflecting the consequences of late diagnosis.

Improving the prognosis of these children requires a coordinated strategy that includes better prenatal follow-up and access to fetal echocardiography for high-risk pregnancies, systematic neonatal examination combined with pulse oximetry screening before maternity discharge, genetic counseling, and the development of a regional network for pediatric cardiology and cardiac surgery to ensure early referral and timely treatment.

Declarations

Ethical approval: Patient anonymity and data confidentiality were maintained throughout data collection and analysis. Owing to the retrospective design and the use of anonymized data, individual informed consent was not required.

Conflict of interest: The authors declare that they have no conflict of interest.

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Authors' contributions: Asma Ouaziz: conception and design, data acquisition, analysis and interpretation, drafting of the manuscript. Youssef Kourima: data interpretation, critical revision of the manuscript. Mounir Bourrous: study supervision, critical revision of the manuscript. All authors read and approved the final version.

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