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Research Article

Congenital Heart Disease: Diagnostic and Therapeutic Challenges in Clinical Practice

F Tahiri[1*], L Kadiri[1], K Danaoui[1], K Ettoini[1], A El Mahedaoui[1], M Zouine[1], A Oulmaati[1]

[1]Neonatal Intensive Care Unit, Mohammed VI University Hospital, Tangier, Morocco

***Corresponding author:** Tahiri Fatima Ezzahra, Neonatal Intensive Care Unit, Mohammed VI University Hospital, Tangier, Morocco;
E-mail: fatimaezzahratahiri29@gmail.com

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Abstract

Congenital heart disease can be defined as malformations of the heart and/or blood vessels present at birth, related to a developmental abnormality. It also includes malformations linked to the abnormal persistence after birth of structures normally present during fetal life. Our study is retrospective, descriptive and non-analytical, focusing on 100 newborns hospitalized in the neonatal intensive care unit at Mohammed VI University Hospital in Tangier between April 26, 2023 and January 26, 2025. It focuses on the epidemiological characteristics and etiological factors of congenital heart disease. The hospital prevalence of congenital heart disease was 3.33%. The average age at diagnosis was 3.28 days and the sex ratio was 1.38 (42% female, 58% male). Most patients had no social security coverage (53%) and 47% of newborns were from Tangier. At birth, nearly 50% of cases had an Apgar score of 10 at the 5th minute and the rate of prematurity was 49% of patients. Thirty-four percent of newborns were born to consanguineous parents. The average maternal age was 25 years and pregnancy monitoring was noted in 44% of mothers. Medication used during pregnancy was observed in 34% of mothers. Respiratory distress was the most common symptom (45%). Hypotrophy was observed in 44% of newborns. Non-cyanotic congenital heart disease accounted for 71% of cases, while cyanotic heart disease accounted for 29%. Ventricular septal defect is the most common non-cyanotic heart disease and tetralogy of Fallot is the most common cyanotic congenital heart disease. Thirty-five percent of newborns were indicated for medical treatment and 45% were indicated for surgery. Mortality was 51%, secondary in more than 50% of cases to the progression of their underlying heart disease. In light of this work, we emphasize the importance of implementing a strategy for screening and managing congenital heart disease.

Keywords: Prenatal Diagnosis; Pre and Post-Ductal Saturation; Cardiac Ultrasound; Genetic Counseling

Introduction

Congenital heart disease refers to structural abnormalities of the heart and/or large vessels resulting from atypical development during embryonic or fetal life. It also includes certain malformations related to the abnormal persistence, after birth, of structures normally present during the fetal period. Over time, the prevalence of congenital heart disease has increased significantly, accounting for approximately 33% of congenital malformations. This incidence varies across different regions of the world, with a predominance in Asia, where it is estimated at between 9 and 10 cases per 1,000 live births. In contrast, Africa has the lowest prevalence, with 3 cases per 1,000 live births, although these figures may be underestimated due to insufficient screening.

Critical congenital heart disease is a major cause of infant morbidity and mortality. One in ten children with these conditions dies within the first year of life, while one in four dies within the first week, often due to a lack of early diagnosis.

With this in mind, the World Health Organization (WHO) has adopted a resolution aimed at strengthening primary prevention of congenital malformations through a three-step screening process:

- Before conception, by identifying individuals at increased risk of passing on certain abnormalities to their offspring
- During pregnancy, through prenatal ultrasound to detect possible fetal malformations
- At birth, through neonatal screening that includes clinical examination and testing for metabolic, hormonal and hematological disorders, in addition to screening for deafness and congenital heart disease
- Early diagnosis of these abnormalities facilitates their management, improves survival rates and reduces the risk of complications leading to physical, intellectual, hearing or visual impairments
- In the context of neonatal screening, pulse oximetry is an effective method for the early identification of congenital heart disease by detecting possible hypoxemia. This rapid, non-invasive test should be routinely included in the clinical examination of newborns. However, the sensitivity and specificity of this technique vary according to different studies
- Hypoxemia can also result from other conditions, particularly pulmonary, infectious or malformative disorders. When oxygen saturation (SaO_2) does not normalize after a hyperoxia test, a cyanogenic cardiac cause should be suspected
- In Morocco, congenital heart disease is particularly common, with an incidence of between 6 and 8 cases per 1,000 live births. It is the second leading cause of infant mortality after infectious diseases. Early diagnosis would significantly reduce this mortality rate by ensuring appropriate care, as any delay in detection can be life-threatening during the neonatal period

Objective

The objective of our study was to examine the epidemiological, clinical and evolutionary profile of congenital heart disease and to analyze the predictive factors for the severity of congenital heart disease.

Results

Our study included 100 cases of congenital heart disease over a one-year period, from January 26, 2023, to January 26, 2025, in the neonatal intensive care unit at Mohammed VI University Hospital in Tangier. The average age at diagnosis was 3.28 days and the sex ratio was 1.38 (42% female, 58% male). Most patients had no social security coverage (53%) and 47% of newborns were from Tangier. At birth, nearly 50% of cases had an Apgar score of 10 at the 5th minute and the rate of prematurity was 49% of patients. Thirty-four percent of newborns were born to consanguineous parents. The average maternal age was 25 years and pregnancy monitoring was noted in 44% of mothers. Medication use during pregnancy was observed in 34% of mothers, dominated by martial treatment in 12% of mothers. We noted that 39% of parturients had no known illness during pregnancy, 13% had preeclampsia, 12% had gestational diabetes, 9% had anemia or even a urinary tract infection, with a percentage of <5% having gestational hypertension, rubella, toxoplasmosis and finally chickenpox.

In our series, the circumstances of discovery varied, with respiratory distress predominating in 41% of cases, followed by signs of heart failure in 14% of cases, persistent cyanosis in 12% of cases, fatigue during feeding in 11% of cases, incidental discovery in 11% of cases, pulmonary infections in 6% of cases and heart disease as part of a malformation syndrome in 5% of cases.

Clinical examination on admission of our patients noted normal weight in 37% of cases, with a normal heart rate ranging from 120 to 160 beats per minute in 48% of cases.

The majority of newborns (72%) had polypnea, 20% had a normal respiratory rate and 8% had bradypnea. Oxygen saturation measured at the right hand and right or left foot was normal in 67% of cases.

For paraclinical investigations, chest X-rays were performed as a first-line test in all our newborns, revealing various abnormalities, predominantly cardiomegaly in 38% of cases (Fig. 1).

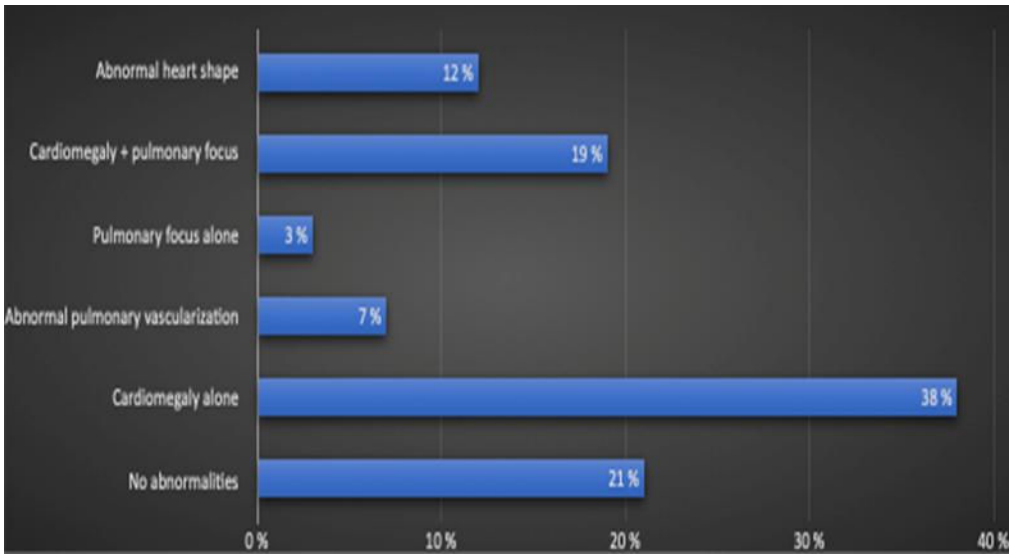

Figure 1: Interpretation of chest X-ray.

Cardiac echocardiography confirmed the presence of a shunt in 89% of newborns, 62% had a left-to-right shunt, while 27% of newborns had a right-to-left shunt. The remaining 11% of newborns had no shunt. 71% of newborns had cyanotic heart disease, while 29% had non-cyanotic heart disease. Isolated membranous-type ventricular septal defect was the most common heart defect in our series, occurring in 16% of cases, followed by ostium secundum-type atrial septal defect, occurring in 12% of cases (Fig. 2).

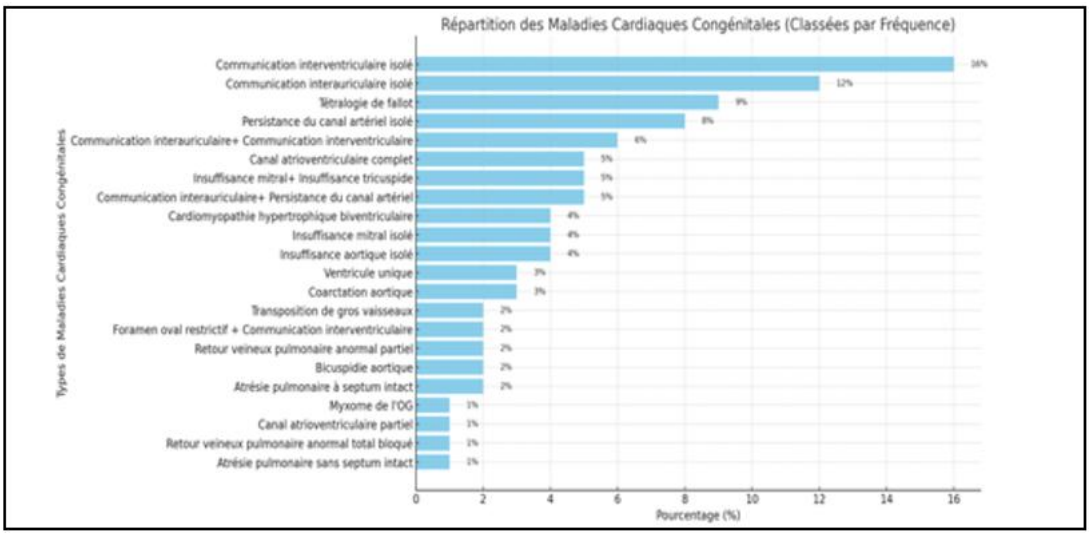

Figure 2: Distribution of congenital heart diseases.

Regarding therapeutic management, non-invasive ventilation was indicated in 68% of cases.

We noted that 68% of newborns required hemodynamic management, with 39.7% receiving vascular filling; 22.05% received vasoactive drugs (dobutamine, norepinephrine), while 38.23% received vascular filling with vasoactive drugs (Fig. 3).

Regarding the outcome of our patients, 51% of patients died. In 56.8% of cases, death was secondary to the progression of their underlying heart disease; in 23.5% of cases, it was secondary to septic shock; in 13.7% of cases, it was related to problems associated with prematurity (electrolyte imbalance, glycemic dysregulation, neonatal hemorrhagic syndrome, etc.) and finally, death secondary to associated congenital malformations. The outcome was favorable in 47% of cases and 2% were transferred to other hospitals for further treatment (Fig. 4).

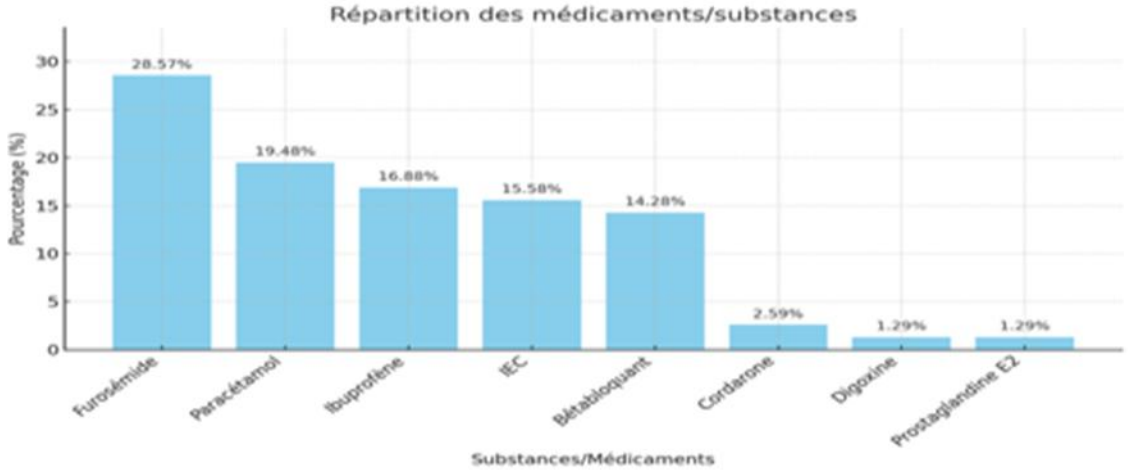

Figure 3: Distribution of drugs and substances.

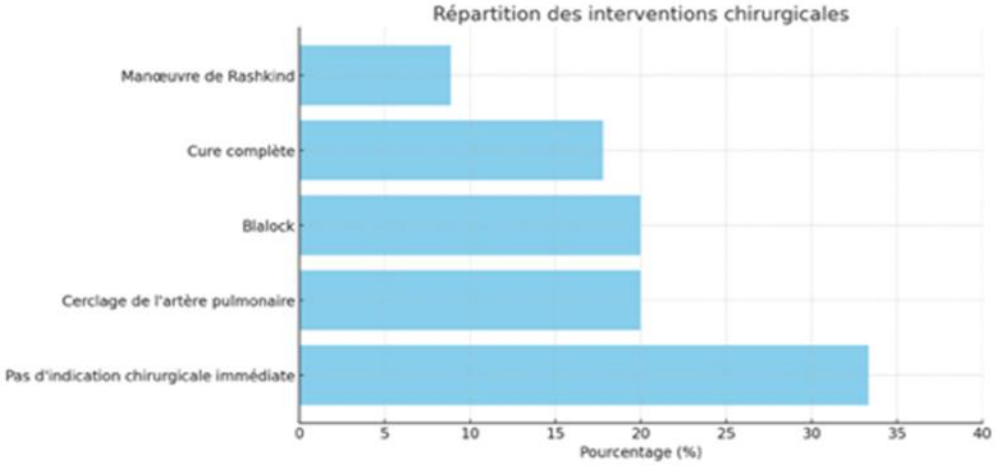

Figure 4: Distribution of newborns according to the interventional procedures indicated.

Discussion

Congenital heart disease is the most common congenital malformation worldwide. Its incidence varies according to region and available studies. In industrialized countries, it is estimated to occur in between 5.2% and 12.5% of live births [3]. In the United States, the incidence is 10.8%, while in Spain it is estimated at 8.96. In Asia, in the People's Republic of China, Qu, et al., report an incidence of 11.1% and in Palestine it is around 10 [3]. In Africa, data show variability between countries. For example, in Congo, the incidence is estimated at 5%, while in Tunisia, Dorra et al. report a frequency of 6.8% [4]. In Morocco, a study conducted at the Rabat hospital indicates that congenital heart disease accounts for 7.8% of children hospitalized over a four-year period [4]. The prevalence of congenital heart disease also varies between studies. It has increased over time, reaching a stable estimate of 9 per 1,000 live births over the last 15 years [5]. Internationally, the generally accepted prevalence is approximately 0.8% of live births and trends suggest relative stability over time [6]. In our series, the hospital prevalence is 7.51%, which is in line with the 7.7% result found by the team from the neonatal department of the mother and child center at the Mohammed VI University Hospital in Marrakech [6]. However, in the neonatal intensive care unit at the Mother and Child Specialized Hospital in Tlemcen, Algeria, between 2005 and 2009, congenital heart disease accounted for 2% of hospitalizations.

Our results can be explained by the inclusion of small interventricular communications, interatrial communications and patent ductus arteriosus linked to prematurity. Physiopathological classification is the most commonly used method in the analysis of congenital heart disease. It provides a better understanding of the clinical and radiological implications, as well as the prognosis of the various cardiac abnormalities. In fact, heart diseases with similar hemodynamic alterations often manifest themselves in comparable clinical presentations and require similar surgical management.

Congenital heart disease is therefore classified into four main groups [9,10]:

1. Left-to-right shunts, characterized by excessive pulmonary circulation
2. Obstructive malformations, involving an obstruction to blood flow
3. Cyanotic heart disease, causing hypoxemia due to abnormal blood mixing
4. Complex heart defects, which do not fit into the previous three groups and include rarer and often associated malformations

In our series, non-cyanotic congenital heart disease was the most common, accounting for 71% of cases. In contrast, cyanotic congenital heart disease accounted for only 29%. Our results were consistent with those in the table below [3,12,13].

Study	Location	Non-Cyanotic Congenital Heart Disease	Cyanotic Congenital Heart Disease
SY Cho, et al.,	Korea Saudi Arabia	81.2	18.6
Al Mawazini, et al.,	Spain Morocco	88.5	11.5
Martinez, et al.,	Morocco	62.1	13
Diani	Morocco	83	17
Study at Marrakech		86	14
University Hospital		71	29
Our study			

Table 1: Frequency of congenital heart disease according to several studies.

The male predominance in our series was consistent with the results reported in the literature. The age at which congenital heart disease is detected varies and depends on several factors, including the degree of hemodynamic adaptation to extrauterine life, but also the type and severity of the cardiac malformation. Some anomalies, particularly those associated with a left-to-right shunt, may be clinically silent during the first few days of life [22-24].

In fact, these malformations may not cause any obvious clinical signs in the neonatal period and it is only after a certain interval once pulmonary vascular resistance has decreased that they become symptomatic. The distribution of cases according to age at diagnosis varies between studies, largely due to the inclusion criteria chosen by the authors. In our study, the analysis focused exclusively on the neonatal population, i.e., patients aged 0 to 28 days [25,26]. The mean age at diagnosis was 3.28 days, with a standard deviation of 6.09 and extremes ranging from the day of birth to 27 days.

This result highlights the relatively early detection of cardiac malformations in our population, which is crucial for the prognosis of these patients. For maternal age, our data were consistent with those of the study by Ewer, et al., and those of D. Janjua, et al., since all three studies noted a predominance of congenital heart disease in newborns whose mothers were between 20 and 30 years of age [27,28]. In particular, there is a higher proportion of people over the age of 30 in the United Arab Emirates. A retrospective analysis of the Metropolitan Atlanta Congenital Defects Program found an association between advanced maternal age (between 35 and 40 years) and an increased risk of congenital heart disease. Maternal age under 20 has also been associated with an increased risk of congenital heart disease in a study by the Baltimore-Washington Infant Study.

Regarding the parity of mothers, our data do not match the percentages of the study by Ewer, et al., and the study by Marrakech University Hospital [27,29]. Consanguinity is one of the factors significantly associated with congenital heart disease and most studies support a relationship between parental consanguinity and congenital heart disease [29]. In our study, we found a consanguinity rate of 34%, which is consistent with the data in the literature.

A study conducted by the American Heart Association (AHA) on non-hereditary risk factors for congenital heart disease concluded that iron supplementation is not associated with an increased risk of developing congenital heart disease.[30-36]. On the other hand, a study published in the American Journal of Epidemiology by researchers at Johns Hopkins University indicates that iron supplementation may reduce the risk of congenital heart disease by 25% [37]. In our study, iron supplementation was most commonly used during pregnancy, with a rate of 12%. Prenatal screening for most congenital heart defects is possible using echocardiography. Detecting these malformations antenatally allows for optimized perinatal care.

In our study, no cases were diagnosed antenatally; this is explained by the lack of pregnancy monitoring, which reached a rate of 56%. A history of heart disease in a first-degree relative increases the risk. This history may concern one or both parents or a previous child. Overall, the risk is approximately 4% if the mother is the carrier of the heart disease and 2% if it is the father. When a previous child is affected, the risk of recurrence for the couple is 2 to 3%, but it can reach 10% if two of the children have had a heart defect [38,39,40].

In our study, no mothers were being monitored for congenital heart disease. The association between nuchal translucency and congenital heart disease has been reported in trisomic fetuses, but also in cases with a normal karyotype. The abnormalities described are mainly hypoplasia of the left heart and abnormalities of the great vessels [42]. Studies conducted in this area confirm that for nuchal translucency values greater than 3.5 mm, regardless of the craniocaudal length, the prevalence of congenital heart disease was approximately 5%. These data therefore justify performing a reference echocardiogram when nuchal translucency is greater than 3.5 mm.

In our study, no information concerning nuchal translucency was revealed. The development of high-resolution echocardiography now provides image quality that allows the anatomy of the fetal heart to be studied as early as 15-16 weeks of amenorrhea. Examination of the large vessels at the base and the four chambers is possible in nearly 90% to 98% of cases after 13 weeks of amenorrhea via the vaginal route. The limitations of the first trimester are obvious, particularly for abnormalities that are more difficult to identify, even later in pregnancy (such as interventricular communications) [43].

A general clinical examination may draw attention to a possible associated heart condition, as is the case with dysmorphic syndrome or a chromosomal abnormality. In addition to children with dysmorphic syndrome, premature babies and children with intrauterine growth retardation are two at-risk categories, as the incidence of heart disease is higher in these groups than in the normal population [43].

The neonatal unit at the Tangier University Hospital provides all newborns in the postnatal ward with a pediatrician who examines them before they are discharged. Birth weight is determined by maternal and fetal genotype and environmental factors. Yerushalmy, reported in "Study on Child Health and Development in California" that malformations, particularly those of the cardiovascular system, were more common in children with low birth weight [44]. Levin, et al., found a high prevalence of congenital heart disease in low-weight children.

Low birth weights have been reported in children with various septal defects, tetralogy of Fallot and coarctation of the aorta. Conversely, children with transposition of the great arteries generally have normal or sometimes higher birth weights [45]. In our study, hypotrophy was found in 44% of newborns. For screening at birth, pulse oximetry was developed in the early 1970s based on the different absorption spectra between oxygenated and deoxygenated hemoglobin. It is widely used in all hospitals, highly reliable and inexpensive.

Meberg, et al., concluded that pulse oximetry is useful for screening for congenital heart disease. Newborns who have not had their saturation measured are 17 times more likely to have congenital heart disease than newborns who have had their saturation measured. However, approximately 60% of newborns with congenital heart disease had normal saturation values and most of these congenital heart diseases were diagnosed during routine clinical examinations, which highlights its importance [46]. Several recent studies have demonstrated the value of using this test to screen for cyanotic congenital heart disease.

The hyperoxia test remains useful in differentiating the cause of cyanosis. Preductal saturation was measured systematically in all hospitalized newborns and was low, with values between 60% and 85% in 33% of newborns with congenital heart disease. Cardiac examination should be performed systematically and includes, in addition to vital signs and abdominal palpation for hepatomegaly, cardiac inspection and palpation, auscultation, peripheral pulse palpation and examination for signs of heart failure.

Hallidie-Smith, examined 230 newborns every day for 8 days and found that the number of auscultated murmurs increased from 33% on the first day to 77% on the eighth day [48]. Siemsen, found that the number of auscultated murmurs increased from 12% after a single clinical examination to 37% after three clinical examinations [48].

Newborns with significant heart disease may be asymptomatic: the absence of a heart murmur does not rule out the possibility of heart disease. Palpating peripheral pulses can be difficult in newborns, especially if they are vigorous or agitated. In the presence of weak femoral pulses and simultaneously good brachial pulses, heart disease with canal-dependent systemic perfusion should be considered, the most classic example being coarctation of the aorta [47]. On the other hand, it should be noted that normal femoral pulses do not rule out such heart disease, as they are palpable as long as a right-to-left shunt at the ductus arteriosus ensures good systemic perfusion of the lower half of the body. In our study, all newborns had palpable femoral pulses except for three newborns who had aortic coarctation. The clinical examination in our study found that 13% of newborns had heart failure, which is consistent with the results of Cloarec, who estimated the rate of heart failure to be 14% [48]. In some countries, chest X-rays are part of routine investigations for any suspected congenital heart disease or even for any child with a heart murmur. However, several studies have shown that the sensitivity and specificity of this investigation is insufficient to detect cardiac lesions in children, as a normal X-ray does not rule out congenital heart disease. On the other hand, this method of additional investigation is generally part the assessment performed when congenital heart disease has been diagnosed. Because chest X-rays do not increase the chances of diagnosis, this additional test cannot be recommended systematically [49]. In our study, chest X-rays were very useful, revealing cardiomegaly in 57% of cases, abnormalities in the shape of the heart in 12% of cases and abnormalities in pulmonary vascularization in 7% of cases. Some radiological features suggestive of congenital heart disease (Fig. 5-16) [50].

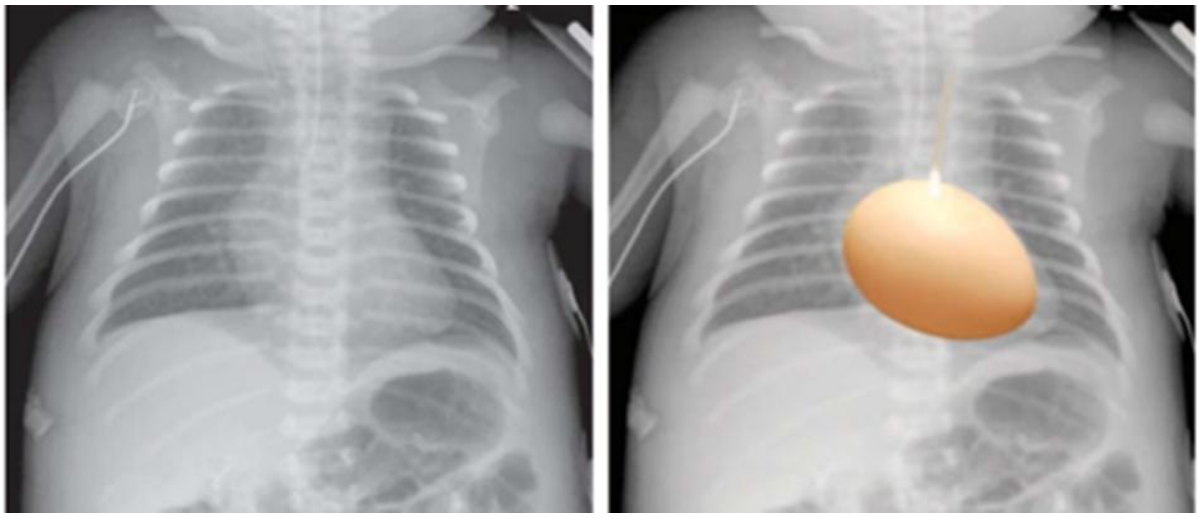

Figure 5: Ovoid heart, "lying on the diaphragm" = transposition of the great vessels.

In our series, there were two cases of transposition of the great vessels, but they did not have this typical radiological appearance.

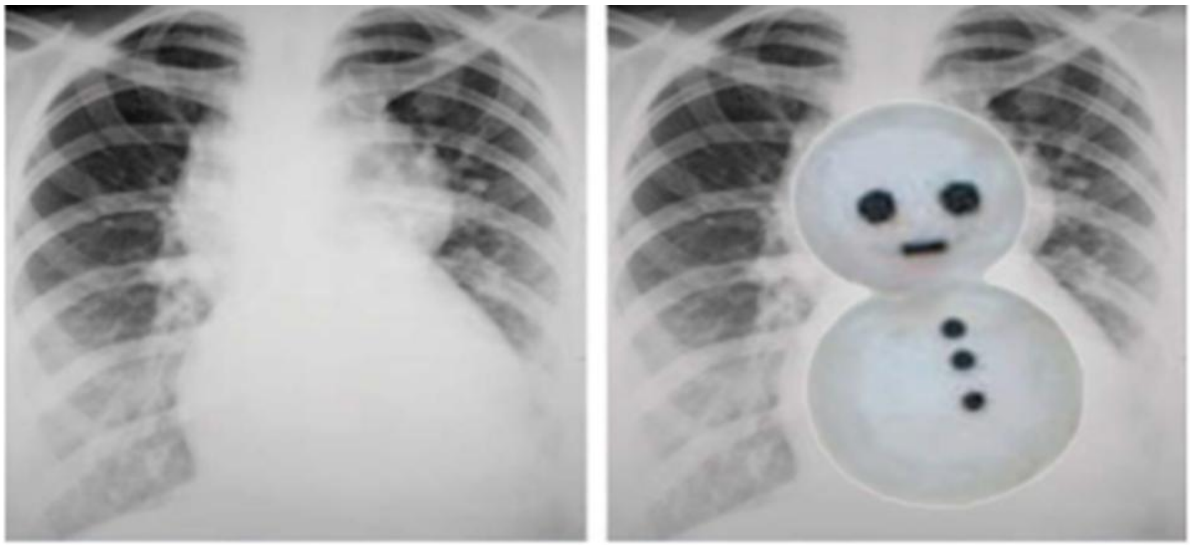

Figure 6: "Snowman" image = total abnormal pulmonary venous return.

In our training, this appearance was found in only one patient with total abnormal pulmonary venous return.

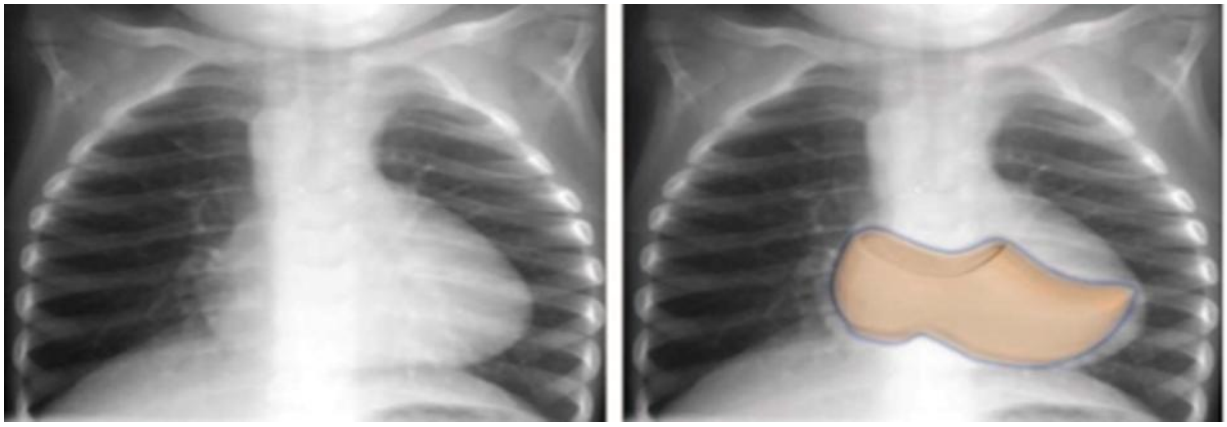

Figure 7: "Hoof-shaped heart" = tetralogy of Fallot.

This appearance was found in seven patients in our series with tetralogy of Fallot.

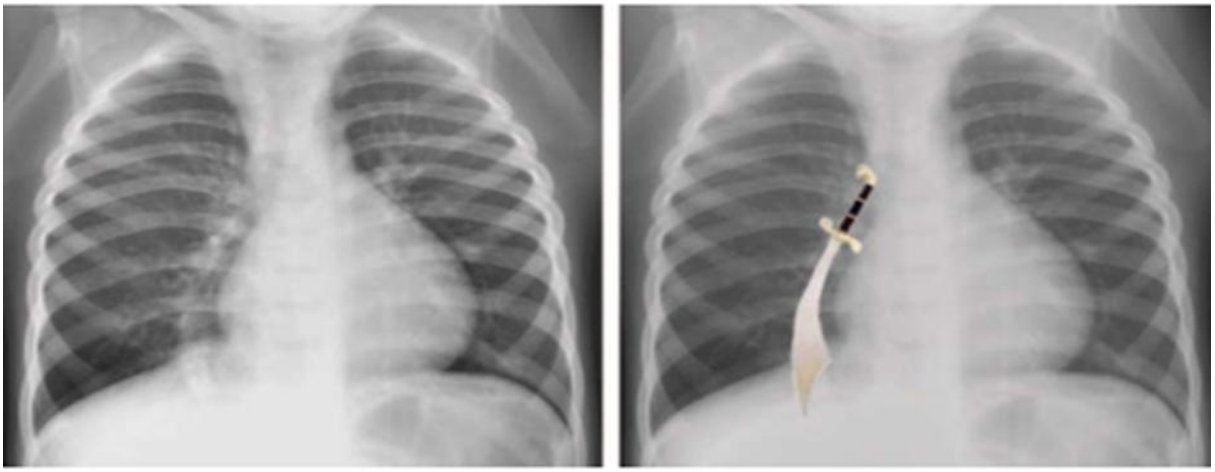

Figure 8: "Cimeterra sign" = partial abnormal pulmonary venous return.

In our series, this finding was not observed in patients with partial abnormal pulmonary venous return.

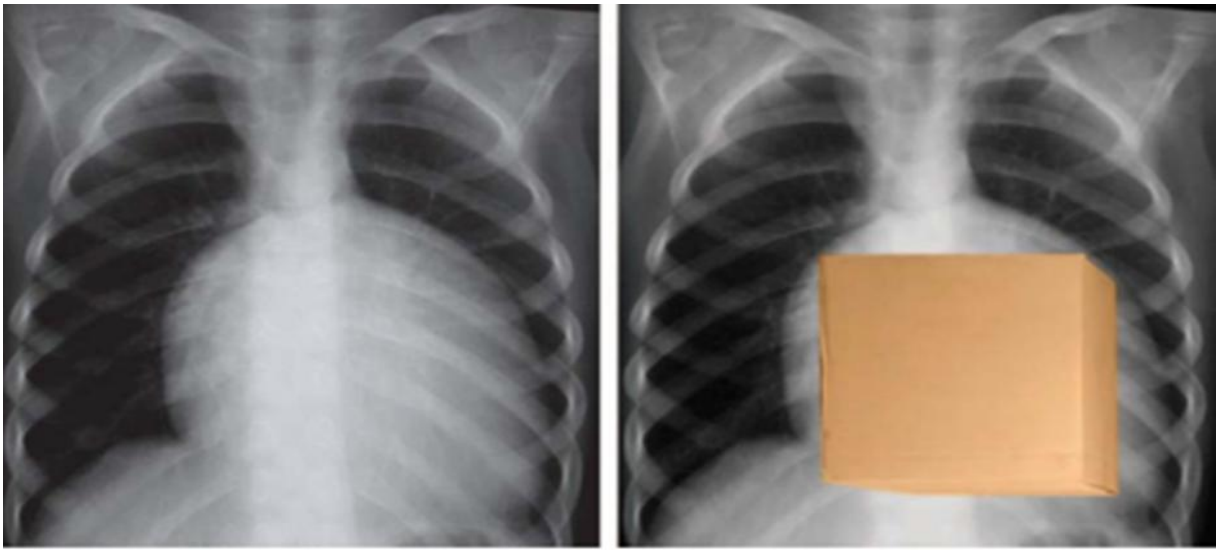

Figure 9: "Box-shaped heart" = Ebstein's anomaly.

No cases of Ebstein's disease were reported in our series. Two-dimensional echocardiography with pulsed Doppler and color Doppler has very high sensitivity and specificity and is the complementary investigation of choice in the diagnosis of congenital heart disease. This technique is painless and non-invasive, but requires a significant investment in time and personnel. Furthermore, the high costs do not justify its use as a neonatal screening tool for congenital heart disease.

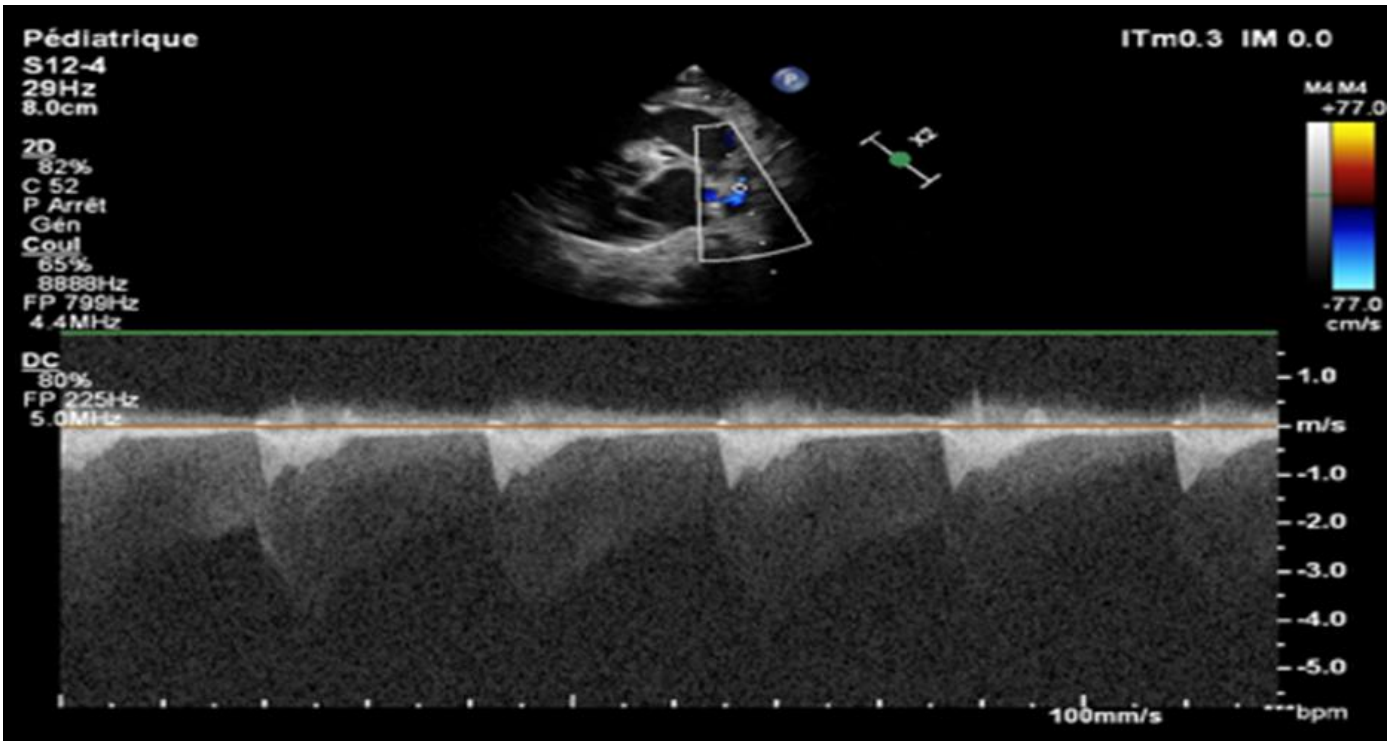

Figure 10: Ultrasound image of blood flow in aortic coarctation using continuous Doppler.

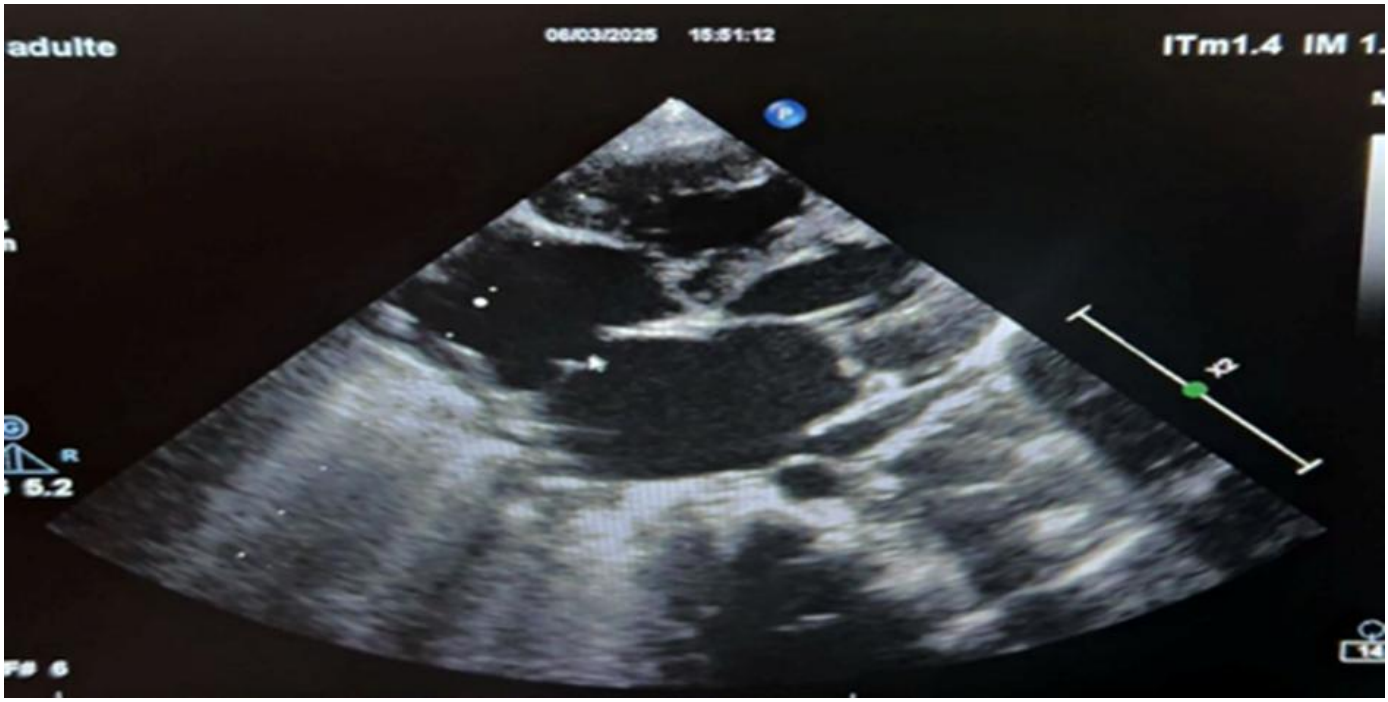

Figure 11: Appearance of an ostium secundum atrial septal defect in 2D mode.

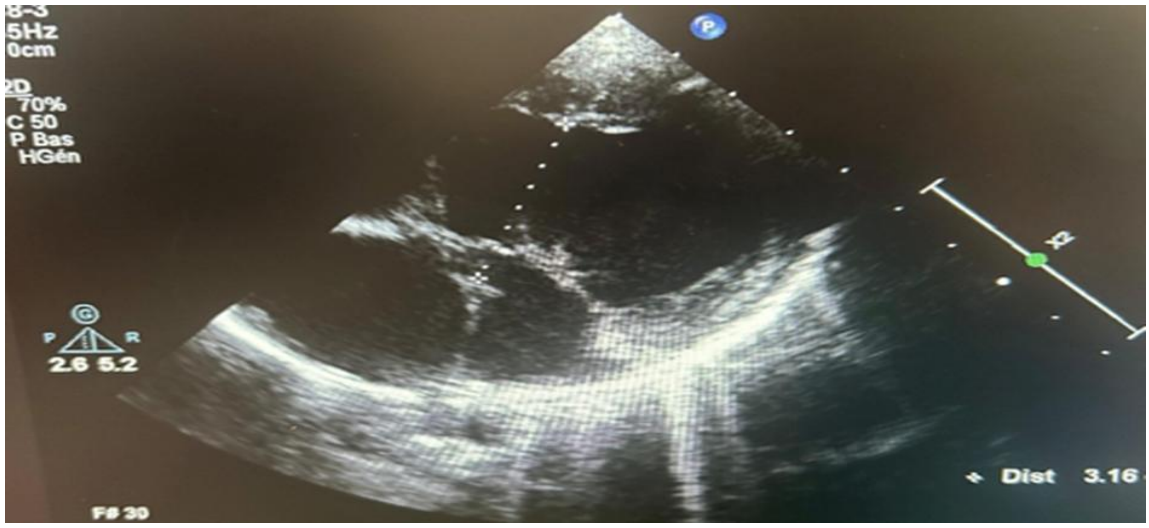

Figure 12: Appearance of a complete atrioventricular canal defect in 2D mode.

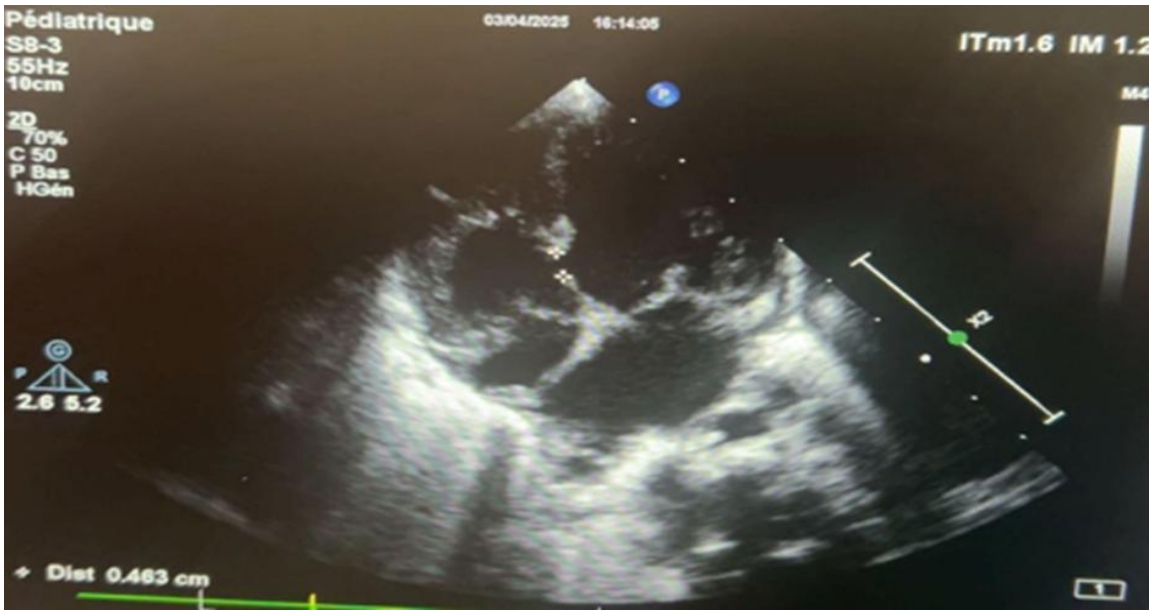

Figure 13: Appearance of a single perimembranous ventricular septal defect in 2D mode.

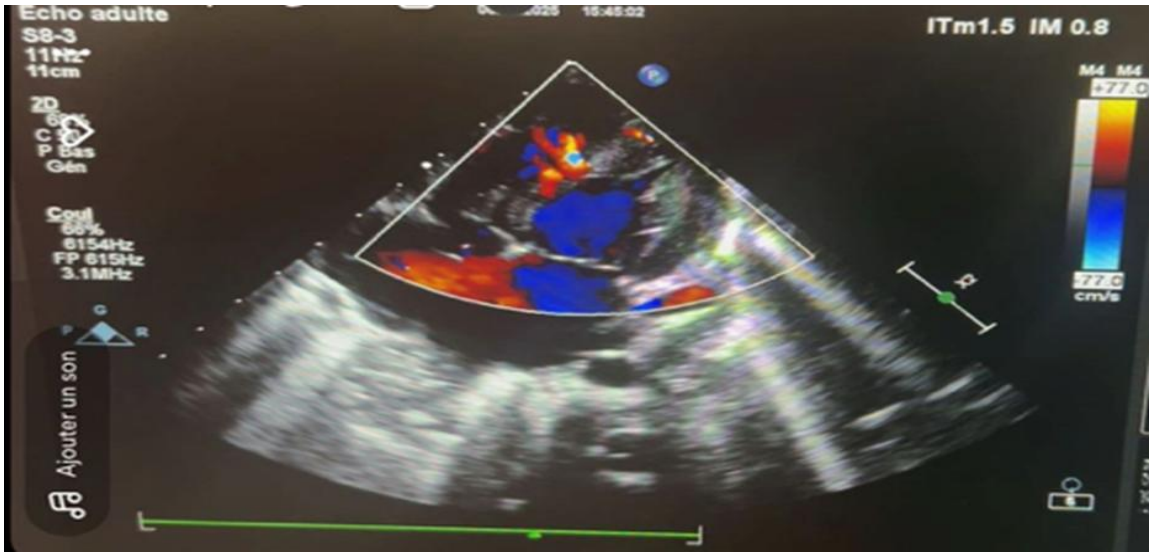

Figure 14: Appearance of three ventricular septal defects in color Doppler mode (note the left-to-right shunt).

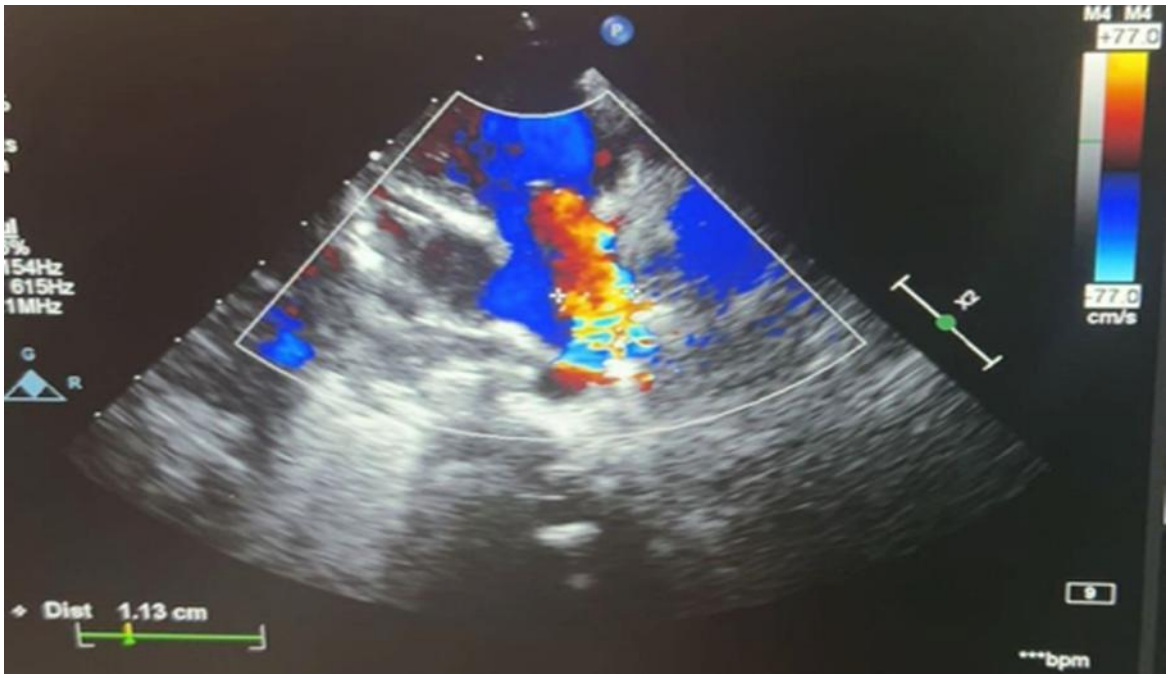

Figure 15: Patent ductus arteriosus in color Doppler mode in a one-week-old newborn.

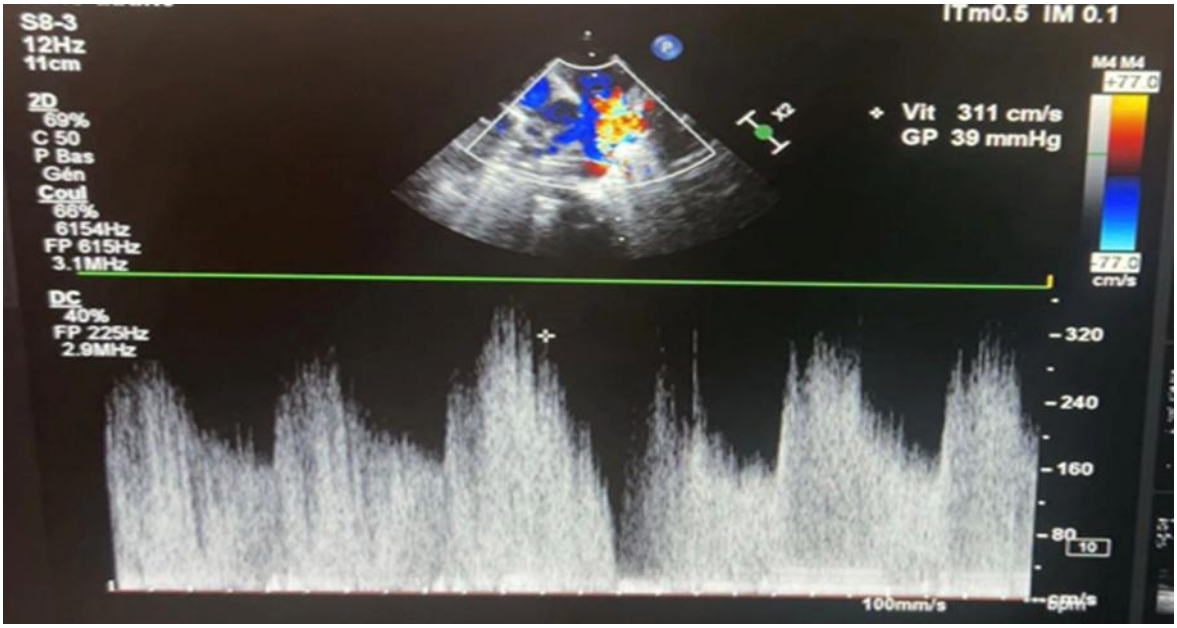

Figure 16: Flow from patent ductus arteriosus in continuous Doppler.

For therapeutic management, initial resuscitation is symptomatic with the initiation of assisted ventilation to reduce cardiac workload [52]. Oxygen supplementation aims to prevent anoxic damage but without seeking normal oxygenation, given the risks of untimely closure of the ductus arteriosus at this stage. A PaO_2 between 40 and 50 mmHg or a saturation between 80% and 85% can be considered sufficient. It will then be adjusted according to the type of heart disease. The establishment of a good-quality central and/or peripheral vascular access is an essential part of management. In newborns, umbilical access can be used to overcome any difficulties in establishing access.

Vascular filling in cases of hypovolemia and correction of metabolic acidosis will optimize cardiac output and tissue perfusion. Initial management must not neglect glycemic and calcium homeostasis. Similarly, analgesia and sedation must be ensured. If necessary, antibiotic treatment will be started after a complete infectious assessment.

Prostaglandins

The aim of treatment with prostaglandins is to keep the ductus arteriosus open and, depending on the type of heart disease, to improve pulmonary perfusion, systemic perfusion or intracardiac mixing. This leads to a reduction in hypoxemia and, therefore, also in metabolic acidosis. The initial dosage is 0.025 to 0.1μg/kg/min, with a reduction to 0.025μg/kg/min without loss of efficacy as soon as the therapeutic effect is achieved. If the patient's hemodynamic status deteriorates under prostaglandin, there is a high risk that this is due to obstruction of pulmonary venous return or left atrial obstruction.

Inotropic Drugs

The inotropic drugs commonly used in cases of congenital heart disease are dobutamine for heart failure and dopamine for vascular purposes to improve blood pressure. In more serious situations, continuous adrenaline infusion may also be used, but its visceral side effects limit its use and it is preferable to use phosphodiesterase inhibitors in such cases.

Ibuprofen

The first clinical trial was conducted by Patel, in 1995, who found that intravenous ibuprofen could close the patent ductus arteriosus in 55% of premature infants [53]. This figure did not predict a long future for ibuprofen until Van Overmeire, published a clinical trial in which ibuprofen was effective in closing the duct in 80% of cases [54]. In our study, ibuprofen was administered to approximately 16% of newborns. Indomethacin is also used for the same therapeutic purpose, but it is responsible for significant side effects.

Diuretics

Diuretics are essential in the management of congestive heart failure in newborns with congenital heart disease involving volume overload, such as large Ventricular Septal Defects (VSDs) or Patent Ductus Arteriosus (PDA). They reduce preload by decreasing fluid retention, thereby improving clinical symptoms and weight gain [58].

Conversion Enzyme Inhibitor

ACE inhibitors, such as captopril and enalapril, reduce afterload by inhibiting the renin-angiotensin-aldosterone system, which improves left ventricular function [59]. They are indicated in heart disease with ventricular dysfunction or pressure overload. ACE inhibitors should be used with caution in newborns, with monitoring of blood pressure and renal function.

Beta-Blockers

Beta-blockers, such as propranolol and bisoprolol, reduce excessive sympathetic activity, thereby improving cardiac function and reducing heart rate. They are used in hypertrophic cardiomyopathy, arrhythmias and certain forms of heart failure [60]. Beta blockers should be introduced gradually, with dose titration based on clinical tolerance and cardiac function and reducing the target heart rate.

One study showed that bisoprolol was well tolerated in newborns with hypoplastic left heart syndrome, with no notable side effects.

With regard to surgical treatment, [55] congenital heart disease was the subject of the first surgical attempts more than 60 years ago: ligation of the ductus arteriosus (Gross) in 1938, resection-anastomosis of isthmic coarctation (Crafoord) and palliation of tetralogy of Fallot (Blalock) in 1944, pulmonary valvulotomy (Brock) in 1948, and, most notably, the first intracardiac corrections in 1954 by Lillehei, under cross-circulation, then in 1955 by Kirklin, under extracorporeal circulation developed by Gibbon in 1953.

Constant technological advances (heart-lung machines, biomaterials, homografts, sutures, synthetic tubes), technical innovations, advances in pre- and postoperative pathophysiological knowledge and the sophistication of resuscitation techniques in terms of ventilation, monitoring and pharmacology have made it possible to treat most complex malformations with increasing safety and at an increasingly early stage. The current goal of this surgery is not only to transform the immediate prognosis, but also and above all, to interrupt the harmful pathophysiological consequences as early as possible, insofar as they can be optimally corrected, in order to allow normal somatic and neuropsychological development in the long term.

Surgical treatment in the neonatal period in our context remains a challenge for cardiovascular surgeons, given the lack of suitable post-operative follow-up facilities.

For the future of newborns with congenital heart disease, trends in congenital heart disease vary from country to country. Mortality from congenital heart disease has declined in recent years in Canada and 16 European countries, particularly for children under 1 year of age. A decrease in mortality from congenital heart disease was also observed in the United States between 1970 and 1997, contributing to a 59% reduction in infant mortality during this period.

In contrast, the overall mortality rate from congenital heart disease in China increased by 62% between 2003 and 2010. In 2013 in Mexico, Torres-Cosme, et al., reported that congenital anomalies were responsible for 24% of infant mortality and congenital heart disease accounted for 55% of total deaths from congenital anomalies in children under one year of age [56]. Dorra, et al., found that, in Tunisia over a one-year period, 23.5% of children with congenital heart disease died. Chaabouni M, et al., at the Sfax University Hospital Center, found that over a five-year period, 59.5% of children with congenital heart disease who did not undergo surgery died [57]. In a 2017 study at the Marrakech University Hospital, 42% of newborns died over a three-year period.

Conclusion

Despite progress and major advances in the diagnosis and management of congenital heart disease, these conditions are still associated with a significant mortality rate and high morbidity, especially in Morocco. This highlights the importance of prenatal screening to ensure early management and improve the prognosis for these heart conditions.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement

Not applicable.

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement

Informed consent was taken for this study.

Authors' Contributions

All authors contributed equally to this paper.

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