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Short term outcomes of the first pediatric cardiac surgery program in Rwanda

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Abstract

Background While the number of cardiac surgery programs in sub-Saharan Africa are increasing, it is still insufficient. With only 0.08 pediatric cardiac surgeons per million people, few cardiac centers routinely perform pediatric cardiac surgery. This has led to reliance on humanitarian medical missions or referral abroad for most African nations. This study outlines the outcomes of Rwanda's first sustainable pediatric cardiac surgery program.

Methods A retrospective chart review was performed for all pediatric patients who received cardiac surgery between October 2022 and April 2024. Patient demographics, procedures, operative times, length of stay, complications, and 30-day mortality were synthesized. Perioperative factors associated with complications and prolonged intensive care unit length of stay were evaluated using logistic and linear regression analysis, respectively.

Results 207 patients received 240 cardiac procedures. At time of surgery, 45% of patients were 1–5 years old ($n=95$). The top five procedures were repair of Ventricular Septal Defect, Patent Ductus Arteriosus, Atrial Septal Defect, Tetralogy of Fallot and Coarctation of the Aorta. 30-day mortality was 1.9% ($n=4$) and 6.3% ($n=13$) experienced a major complication. Additionally, 24% ($n=50$) experienced minor complications, most commonly, pneumonia. The linear combination of surgery duration, cross clamp and bypass time was significantly associated with having complications (aOR = 0.67, $p=0.01$). Younger age, longer operative times, number of inotropes and the presence of complications were associated with an increased intensive care unit stay.

Conclusions The 30-day surgical outcomes are favorable compared to programs with a similar case mix, showing that pediatric cardiac surgery can be safely performed in developing countries with local cardiac teams. Prolonged bypass and cross clamp times were associated with higher complication rates and increased inotrope use was associated with longer intensive care unit stay.

Keywords Cardiac surgery, Outcomes, Sub-Saharan Africa, Congenital

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Background

Congenital Heart Disease (CHD) is the most lethal congenital anomaly, with 69% of children dying before their first birthday [1]. CHD occurs in 17.9 per 1000 children globally [1]. In the past twenty years, advancement in diagnostic capabilities and surgical techniques facilitated a 60% decrease in mortality from CHD in high income countries [1]. Large cohort studies in North America demonstrate that 88% of children are still alive 25 years after surgery [2]. In contrast, the prevalence of CHD in sub-Saharan Africa is higher than the global average, with 20.1–26.7 per 1000 children born with congenital abnormalities [1]. Lamentably, this region has not experienced comparable gains in survival owing to a shortage of comprehensive cardiac centers. As a result, 90% of children do not have access to cardiac services [3].

While the number of cardiac surgery programs in sub-Saharan Africa are increasing, it is still insufficient. With only 0.08 pediatric cardiac surgeons per million people, few cardiac centers routinely perform pediatric cardiac surgery [4, 5]. This has led to reliance on humanitarian medical missions or referral abroad for most African nations [6]. While necessary to prevent mortality, fly-in mission services minimally address CHD burden as they operate at low surgical volumes and do not always transfer skills to local teams [5]. Similarly, referrals abroad are not financially sustainable for families who must pay out of pocket or for governments who sponsor this care from limited healthcare budgets [7].

In Rwanda, local pediatric cardiac surgery used to solely rely on international humanitarian missions who performed surgeries, usually for 2 weeks at a time. While these missions were important in developing the basic infrastructure for cardiac surgery and initiating skills transfer to local staff, the leadership recognized that establishing an independent pediatric cardiac surgery center would be imperative to truly address the burden of CHD in the country. As a result, Rwanda transitioned to a locally run pediatric cardiac surgery program in 2022 to increase access to pediatric surgical care. Meanwhile the role of surgical missions transitioned to performing more complex lesions, involving and training the local staff.

The program is hosted at King Faisal Hospital Rwanda (KFH), a tertiary level teaching hospital in the capital city. The program is supported by a full-time pediatric cardiac surgeon from Ethiopia, who was hired to support the program and build local team capacity. In an initial training period, a south-to-south partnership was developed through integration of Ethiopian cardiologists, perfusionists, cardiac theater nurses, cardiac anesthesiologist, critical care specialists and critical care nurses to transfer practical knowledge to the Rwandan team. This partnership was developed through an agreement between KFH, the Children's Cardiac Center of Ethiopia and St. Paul's Millennium Medical College, owing to the mutual benefits for staff development this opportunity could provide. The program scaled up its operations, starting with RACHS-1 cases in the first 6 months. After the first 6 months, operations transitioned to RACHS categories 2 and 3. International pediatric cardiac missions are limited to a maximum of twice per year for highly complex cases and always directed by the local team.

Given the significant investment in establishing this local pediatric cardiac surgery program, the aims are to evaluate case volumes and early surgical outcomes. We also assess whether there are modifiable risk factors associated with complications. The results from this study will expand the limited literature in pediatric cardiac surgery for sub-Saharan Africa and establish regional benchmarks for independent models of care delivery. Additionally, outcomes data is the first step in performing future cost-effectiveness evaluations that will be instrumental in lobbying for ongoing investments into the definitive care of children with cardiac anomalies in low-income settings.

Methods

Study setting

The study was conducted at King Faisal Hospital Rwanda, a quaternary-level teaching hospital located in Kigali, Rwanda, providing specialized clinical care, research, education, and training. The hospital has hosted the country's only pediatric cardiac surgery program since October 2022.

Study population

The study population included patients up to 18 years of age who received cardiac surgery between 8 October 2022 and 15 April 2024. Patients over 18 years with CHD and all patients operated in partnership with visiting teams were also included. Patients over 18 years were included to capture the prevalence of all congenital cardiac conditions that the program has treated, and adult patients with any other conditions were excluded. Patients who had a non-cardiac indication for referral were excluded.

Data collection

A retrospective chart review was performed using paper charts. All data was recorded in a pediatric cardiac surgery registry on an online, secure database called RedCap. Data collected included patient demographics, syndromic features based on clinical assessment, patterns of lesions and procedures, operative summaries, length of stay, in-hospital mortality, in-hospital complications, and 30-day mortality. Operative data included surgery duration, bypass time, cross clamp time and blood product utilization. In-hospital complications were

defined in accordance with the Society of Thoracic Surgery (STS) Congenital Heart Surgery Database. After surgery, patients were followed by doctors at district hospitals who are in close contact with King Faisal Hospital and reported mortality if it occurred. Patients' families were also contacted to confirm 30-day survival. The study was approved by the King Faisal Hospital Rwanda Institutional Review Board, and the need for consent was waived (Protocol No. KFH/2023/112/IRB, approved September 21, 2023).

Statistical analysis

De-identified data from RedCap was exported into RStudio (Version 2023.12.1) for analysis. Categorical variables were summarized as counts or percentages, and numerical variables were summarized as mean ± standard deviation if normally distributed or median with observed range if non-normal as determined by the Shapiro-Wilk test for normality. Univariate and multivariate logistic and linear regression analysis was performed with complications and intensive care unit (ICU) length of stay as outcome variables, respectively. Perioperative factors for the regression analysis were selected based on clinical relevance and published studies. Variables of interest included age, sex, weight less than 5th percentile for age as an indicator of malnutrition, risk score determined by Risk Adjustment for Congenital Heart Surgery (RACHS-1) category, surgery duration, bypass time, cross clamp time and number of inotropes. Since operative times were highly correlated, we used principal component analysis to create a linear combination of these variables for the regression analysis to prevent multicollinearity. In addition to age, only significant variables in the univariate analysis were included in the multivariate analysis starting with the most significant variables in the process of forward selection. The significance level was set at alpha = 0.05.

Results

Pre-operative characteristics

From 8 October 2022 to 15 April 2024, 207 patients underwent 240 cardiac procedures. Three patients had two cardiac operations within the same hospitalization resulting in 210 unique operations. Fifty-eight patients were operated on in the presence of visiting teams but led by the local team. The visiting surgeon was primary for 9 patients.

The proportion of male (n = 102) and female (n = 107) patients was similar. Age at time of surgery was most commonly 1–5 years for 45% (n = 95) of the operations (Table 1) and 17.7% (n = 37) were less than 1 year old. In terms of pre-operative characteristics, 13% (n = 27) had morphological features suggestive of genetic syndromes, most commonly Down's Syndrome. Additionally, 32%

Table 1 Pre-operative characteristics

Parameter	No. of patients	(%) *N* = 207*
Sex		
Male	102	49.4
Female	105	50.7
Age at Time of Surgery (N = 210)		
Neonate (0–28 days)	10	4.8
Infants (1 month – 1 year)	27	12.9
1–5 years	95	45.2
5–10 years	46	21.9
10–18 years	29	13.8
18 + years	3	1.4
Syndromic Features		
Down Syndrome	23	11.1
Noonan Syndrome	1	0.5
Holt-Oram Syndrome	1	0.5
DiGeorge Syndrome	1	0.5
Turner Syndrome	1	0.5
Less Than 5th Percentile for Weight**	66	31.9
Taking Medication on Admission	86	41.5
RACHS-1 Score		
1	66	31.9
2	99	47.8
3	32	15.5
4	7	3.4
Not Applicable	3	1.4
Diagnoses (N = 237)		
Ventricular Septal Defect	59	24.9
Isolated Patent Ductus Arteriosus	37	15.6
Tetralogy of Fallot	28	11.8
Atrial Septal Defect	20	8.4
Coarctation of the Aorta	13	5.5
Subaortic Membrane	11	4.6
Double-chambered right ventricle	9	3.8
Complete Atrioventricular Canal Defect	8	3.4
Pulmonary Valve Stenosis	8	3.4
Transposition of the Great Arteries	7	3.0
Partial Atrioventricular Canal Defect	6	2.5
Partial Anomalous Pulmonary Venous Drainage	4	1.7
Aortic Valve Regurgitation	3	1.3
Constrictive Pericarditis	3	1.3
Mitral Valve Regurgitation	3	1.3
Pericardial Effusion	3	1.3
Interrupted Aortic Arch	2	0.8
Prior Pulmonary Artery Banding	2	0.8
Pulmonary Artery Stenosis	2	0.8
Truncus Arteriosus	2	0.8
Aortopulmonary Window	1	0.4

Table 1 (continued)

Parameter	No. of patients	(%) *N* = 207*
Total Anomalous Pulmonary Venous Drainage	1	0.4
Other	5	2.1

*N = 207 unless otherwise indicated

** Calculated using WHO Growth Chart standards for children with no syndromic features. For children with suspected syndromes, published growth charts in the "Anthropometric Calculator for children with Turner, Noonan, Russell–Silver, Prader–Willi, and Down syndromes" tool provided by Boston's Children's Hospital were used: http://www.bcchildrens.ca/health-professionals/clinical-resources/endocrinology-diabetes/tools-calculators#Anthro--calculators

(*n* = 66) had a weight less than 5th percentile for age and 42% (*n* = 87) were taking cardiac medications prior to admission. RACHS-1 category 2 was the most common risk category with 48% (*n* = 99) of patients. There were no patients in RACHS-1 categories 5 and 6.

Diagnoses and procedures

The top 5 diagnoses were Ventricular Septal Defects (VSD), Patent Ductus Arteriosus (PDA),

Tetralogy of Fallot (ToF), Atrial Septal Defect (ASD), and Coarctation of the Aorta (CoA) (Table 1). As a result, repair of these lesions were the most common procedures. However, there was a large spectrum of procedures performed (Table 2). On average, patients were intubated for 2.5 h in the ICU and only 8% (*n* = 17) were mechanically ventilated for more than 24 h (Table 3). Inotropes and blood products were used in 72% (*n* = 152) and 56% (*n* = 116) of patients respectively.

Complications

The 30-day mortality in this cohort was 1.9% (*n* = 4) (Table 4). Two of these deaths were ToF patients and the other two had VSDs as their primary lesion (Table 5). Notably, cyanotic lesions accounted for 6 out of the 13 major complications. There were 24% (*n* = 50) of patients who experienced minor complications, with pneumonia being the most common (Table 4).

In the univariate analysis, higher RACHS-1 score, surgery duration, bypass time, cross clamp time and inotropic support were significantly associated with having a major or minor complication (Table 5). There were 197/207 patients with complete data for the multivariate analysis. In the multivariate analysis, only the linear combination of surgery duration, cross clamp and bypass time was significantly associated with having complications (aOR = 0.67, 95% CI 0.49–0.90, $p = 0.01$). Since the principal component used in the regression analysis is inversely associated with operative times, this indicates that longer operative times increase the odds of experiencing a complication (Table 6).

Length of stay

Patients stayed a median of 2 days in the ICU and a 6 day total hospital stay. In the univariate analysis age, RACHS-1 category 2 and 4, surgery duration, bypass time, cross clamp time, inotropic support and complications were significantly associated with length of ICU stay. There were 188 patients with complete data for the multivariate analysis. The overall regression was statistically significant (Adjusted $R^2 = 0.33$, $F(7, 180) = 14.41$, $p < 0.01$). RACHS-1 category 3 was associated with a decreased ICU stay while younger age, operative times, number of inotropes and complications were associated with prolonged ICU stays (Table 7).

Discussion

This study expands the scarce literature on pediatric cardiac surgery outcomes in sub-Saharan Africa and in low to middle income countries more generally. It shows that an independent cardiac surgery model in East Africa can perform a wide variety of procedures on children across the age spectrum, ranging from ASD repair to arterial switch operations with a low mortality and major complication rate of 1.9% and 6.3%, respectively. It also highlights risk factors associated with complications that can be targeted to improve outcomes and decrease costs.

Pediatric cardiac surgery programs in sub-Saharan African countries such as Ethiopia, Angola, Ivory Coast and Uganda report overall 30-day mortality rates and major cardiac complication rates between 3.2 −4.2% and 8.1 −12.9%, respectively [8–11]. In developing countries more generally, 30-day mortality rates range between 2.6 −13.6% [12–16]. In comparison, the STS database for North American programs reports a 30-day mortality of 0.6–3.5% for procedures of comparable risk [17]. This demonstrates that mortality and morbidity in this study are at the lower bound achieved by centers globally. These outcomes are rooted in careful patient selection, effective south-to-south medical mentorship, and a stepwise approach to advancing complexity and case volume over time.

The next frontier is ensuring continuous professional development of the local team to further elevate the quality of care for common procedures as well as develop the capacity to perform more advanced surgeries on younger children. Continued national investment and targeted collaboration with experienced international centers can help circumvent suboptimal postoperative outcomes observed with cases of this complexity in new cardiac centers [5, 6]. Scaling up the program also involves the mitigation of challenges experienced over the first years of the programs. Specifically, this includes strengthening the supply chain system, where consumables are readily available on the local market. Secondly, ensuring timely patient referrals is critical, and the local team is engaging

Table 2 Pediatric cardiac procedures performed

Procedure	No. of patients	(%) *N* = 240
Ventricular Septal Defect Repair	59	24.6
Patent Ductus Arteriosus Repair	37	15.4
Tetralogy of Fallot Repair	28	11.7
Atrial Septal Defect Repair	20	8.3
Coarctation of the Aorta Repair	13	5.4
Subaortic Membrane Resection	11	4.6
Double Chambered Right Ventricle Resection	9	3.8
Complete Atrioventricular Canal Defect Repair	8	3.3
Partial Atrioventricular Canal Defect Repair	6	2.5
Arterial Switch Operation	5	2.1
Mitral Valve Repair	5	2.1
Pulmonary Valve Repair	5	2.1
Partial Anomalous Pulmonary Venous Drainage Repair	4	1.7
Pericardial Window	4	1.7
Right Ventricular Outflow Tract Obstruction Relief	4	1.7
Aortic Valve Repair/Replacement	3	1.3
Pulmonary Artery Banding	3	1.3
Pulmonary Artery Debanding	3	1.3
Pulmonary Artery Plasty	3	1.3
Atrial Septectomy	2	0.8
Pericardiectomy	2	0.8
Aorto-pulmonary Window Repair	1	0.4
Truncus Arteriosus Repair	1	0.4
Total Anomalous Pulmonary Venous Drainage Repair	1	0.4
Other	3	1.3

Table 3 Operative times and resource utilization

Parameter	
Surgery Duration (median hours, min - max)	3 (0.6–8)
Bypass Time (median minutes, min - max)	92 (18–251)
Cross Clamp Time (median minutes, min - max)	60 (6–217)
Duration of Intubation (median hours, min - max)	2.5 (0–792)
Hospital Stay (median days, min - max)	6 (1–36)
ICU Stay (median days, min - max)	2 (1–33)
Prolonged Ventilation > 24 h (n %)	17 (8.1)
Inotropes Used (n %)	152 (72.4)
Blood Products Used (%)	116 (56.0)
PRBCs (median units, min - max)	1 (1–6)
FFP (median units, min - max)	1 (1–4)
Platelets (median units, min - max)	1 (0.5–4)

Table 4 In-hospital complications and 30-day mortality

Complications	No. of Patients	(%) *N* = 207
Major Adverse Cardiac Events	*13*	*6.3*
Death	4	1.9
Bleeding Requiring Re-operation	5	2.4
Cardiac Arrest	2	1.0
Unplanned Cardiac Re-operation	2	1.0
Minor Complications	*50*	*24.2*
Pneumonia	20	9.7
Arrhythmia Requiring Intervention	8	3.9
Pleural Effusion Requiring Intervention	5	2.4
Respiratory Insufficiency Requiring Re-intubation	5	2.4
Pneumothorax Requiring Intervention	3	1.4
Sepsis	3	1.4
Chylothorax	2	1.0
Systemic Inflammatory Response Syndrome	2	1.0
New Onset Seizures	1	0.5
Deep Wound Infection	1	0.5
None	155	74.9
Unknown	5	2.4

Table 5 Diagnoses associated with major complications

Diagnoses	No. of Patients	(%) *N* = 13
Tetralogy of Fallot	4	30.8
Transposition of the Great Arteries	2	15.4
VSD	2	15.4
VSD + Right Ventricular Outflow Obstruction	1	7.7
VSD + ASD + Pulmonary Stenosis	1	7.7
PDA + Cortriatrium	1	7.7
PDA + VSD	1	7.7
PDA + ASD + Pulmonary Stenosis + Subaortic Membrane	1	7.7

with national leadership to streamline this process at the national level across the health system. Mitigating these challenges will allow the team to perform a higher volume of cases on patients who present while they are still eligible for surgery.

While the frequencies of procedures are correlated with the prevalence of the most common conditions seen in Rwanda and other sub-Saharan African countries, there are still infants with severe CHD that die before receiving surgery [18–20]. Training healthcare professionals in rural hospitals to perform basic screening for CHD and antenatal evaluations can decrease this disparity and ensure patients are referred early to cardiologists for preoperative management until surgery [21].

Pneumonia was the most common complication in this cohort. Patients are often admitted with a history of repeated chest infections, and while efforts are made to rule out active infections pre-operatively, indolent infections may persist, increasing the risk of postoperative pneumonia. Early extubation and rigorous pulmonary hygiene will help reduce this complication. The regression analysis identified additional perioperative risk factors. Surgery duration, bypass, and cross clamp time were significantly associated with both complications and increased ICU length of stay. This has been reported in a systematic review and is likely due to microscopic ischemic-reperfusion injury [13, 22]. Operative times

Table 6 Logistic regression analysis for complications

Parameter	Bivariate			Multivariable		
	OR	95% CI	*P* value	OR	95% CI	*P* Value
Age	0.95	0.87–1.02	0.163	0.93	0.84–1.02	0.137
Sex						
Female	Reference					
Male	0.84	0.44–1.60	0.587			
Underweight (Less Than 5th Percentile Weight for Age)						
No	Reference					
Yes	0.61	0.26–1.37	0.233			
RACHS-1						
1	Reference			Reference		
2	5.56	2.19–17.09	< 0.001*	1.45	0.43–5.45	0.559
3	4.77	1.49–17.00	0.010*	1.00	0.26–4.55	0.995
4	16.27	2.88–105.80	0.002*	3.87	0.35–46.6	0.265
Surgery Duration + Cross Clamp + Bypass Time	0.64	0.52–0.78	< 0.001*	0.67	0.49–0.90	0.01*
Surgery Duration	1.72	1.36–2.22	< 0.001*			
Bypass Time	1.01	1.00–1.02	0.006*			
Cross Clamp Time	1.01	1.00–1.02	0.005*			
Number of Inotropes	2.05	1.48–2.94	< 0.001*	1.39	0.90–2.17	0.138

*Indicates significance at alpha = 0.05 level

Table 7 Linear regression analysis for ICU stay

Parameter	Bivariate			Multivariable		
	Coefficient	95% CI	*P* value	Coefficient	95% CI	*P* Value
Age	-0.19	(-0.34) - (-0.05)	0.007*	-0.19	(-0.33) - (-0.05)	0.007*
Sex						
Female	Reference					
Male	1.04	(-0.27) - (2.36)	0.120			
Underweight (Less Than 5th Percentile Weight for Age)						
No	Reference					
Yes	0.11	(-1.08) – 1.31	0.857			
RACHS-1						
1	Reference			Reference		
2	2.67	1.22–4.13	< 0.001*	-1.25	(-2.98) – 0.49	0.157
3	1.52	(-0.49) – 3.54	0.138	-2.54	(-4.71) - (-0.36)	0.022*
4	7.78	3.93–11.62	< 0.001*	-0.12	(-4.21) – 3.98	0.955
Surgery Duration + Cross Clamp + Bypass Time	-1.03	(-1.41) - (-0.66)	< 0.001*	-0.80	(-1.32) - (-0.27)	0.003*
Surgery Duration	1.01	0.60–1.41	< 0.001*			
Bypass Time	0.04	0.02–0.05	< 0.001*			
Cross Clamp Time	0.04	0.02–0.06	< 0.001*			
Number of Inotropes	1.82	1.24–2.41	< 0.001*	0.97	0.26–1.67	0.007*
Complications	5.27	3.91–6.62	< 0.001*	3.66	2.21–5.11	< 0.001*

*Indicates significance at alpha = 0.05 level

may be prolonged due to complexity of the procedure or unexpected events during surgery. RACHS-1 score as an indicator of complexity was not associated with complications in the multivariate analysis. While there are limitations to this score, the results suggest that regardless of the procedure, the priority should be to keep operative times to safe minimum to limit complications [23].

Number of inotropes was also associated with increased ICU stay, which was similarly observed by a CHD cohort in Indonesia [13]. Inotrope use reflects attempts to correct unstable hemodynamics in tenuous patients after surgery, which would warrant longer observation in the ICU. However, judicious use and timing of inotropes in line with available evidence can help ensure effective stabilization of postoperative cardiac function and decreased ICU stay [24, 25]. Paradoxically, a RACHS category 3 was associated with a decreased ICU stay. The procedures in this category for our cohort were predominantly double chambered right ventricle repair with VSD repair and atrioventricular canal defect repair. Given that

there were only 13% of the cohort in this category, this is likely a chance association due to the idiosyncrasies of these patients.

Limitations

This study has a few limitations. First, there is the risk of selection bias, as patients that survive to receive surgery in this setting may represent those with a diagnosis that is less severe and more likely to experience favorable post-operative outcomes. However, the program frequently operates on patients with complex and late presenting lesions, suggesting that this potential bias does not fully account for the positive results reported in this study. Secondly, we were limited to data available in paper medical charts which varied in their completeness. However, we were able to use alternative methods to confirm missing data for key endpoints such as 30-day mortality by contacting patients' families. Due to limited sample size, we were unable to assess if any diagnoses were more likely to be associated with complications. Since 6 out of the 13 complications were seen in children with cyanotic lesions, this may be a risk factor to explore as the program performs more of these cases. Although we aimed to incorporate major variables of interest and address known confounding factors in our regression analysis, it is possible that they were unknown confounding variables or other explanatory variables that we could not account for.

Conclusion

The locally run pediatric cardiac surgery program in Rwanda is poised to provide safe and timely intervention for children with CHD. It is achieving outcomes comparable or better than its peers with few major complications, highlighting the untapped potential of locally directed pediatric cardiac centers in sub-Saharan Africa. Factors that have facilitated these excellent results include political willingness to invest in pediatric cardiac surgery, strong regional training collaborations and thoughtful working relationships with international partners. Complications and excess resource use may be further reduced by ensuring safe minimum operative times and carefully managing inotropes during ICU stay. Sustained growth will ensure that the youngest and sickest patients will have access to high quality cardiac surgery close to home.

Abbreviations

CHD	Congenital Heart Disease
STS	Society of Thoracic Surgery
ICU	Intensive Care Unit
RACHS-1	Risk Adjustment for Congenital Heart Surgery
VSD	Ventricular Septal defect
PDA	Patent Ductus Arteriosus
ASD	Atrial septal defect
ToF	Tetralogy of Fallot
CoA	Coarctation of the Aorta
TGA	Transposition of the Great Arteries

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Author contributions

Y.E. conceptualized the paper. V.M., R.W., and M.G. analyzed the data. V.M., Y.E., and K.N. wrote the initial manuscript. All authors reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by King Faisal Hospital Institutional Review Board (Protocol No. KFH/2023/112/IRB, approved September 21, 2023). The need for consent was waived. The IRB norms were followed.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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