E-ISSN: 2616-3470
P-ISSN: 2616-3462

www.surgeryscience.com
2024; 8(4): 26-32
Received: 02-08-2024
Accepted: 07-09-2024

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Outcome of paediatric cardiac surgery in a tertiary care hospital of Bangladesh

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DOI: https://doi.org/10.33545/surgery.2024.v8.i4a.1116

Abstract
Background: Paediatric cardiac surgery is a specialized field addressing congenital and acquired heart diseases in children. Congenital heart disease (CHD), the most common congenital disability, affects approximately 8 per 1,000 live births. Surgical intervention is often necessary, with 25% of infants with CHD requiring surgery in their first year. Advances in surgery, anesthetics, and critical care have improved survival rates, but morbidity remains high in resource-limited settings.
Aim of the study: The present study aims to evaluate the outcomes of paediatric cardiac surgery in a tertiary care hospital.
Methods: This prospective analytical study was conducted at the Department of Obstetrics & Gynaecology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, over one year. Purposive sampling selected 445 pediatric patients with cardiac issues aged one month to 16 years. Exclusions included neonates and children without parental consent. Informed consent was obtained, and data were kept confidential. Ethical approval was granted. Daily monitoring identified postoperative complications. Data included age, sex, diagnosis, outcomes, and complications. Risk factors for major complications were analyzed using the RACHS-1 category and statistical methods. Results were presented using SPSS software, version 26.
Result: The study involved 445 children with an average age of 49.32 months, nearly evenly split between genders. Notably, 42.02% were undernourished, 20.90% had failed to thrive, and 6.07% had syndromic conditions. The most common cardiac diagnosis was ventricular septal defect (28.99%). Most patients (83.82%) were in the RACHS-1 category two surgical risk. Post-surgery, 78.88% required cardiopulmonary bypass, with a mean ICU stay of 34.91 hours. General complications were prevalent (77.98%), with endocrine issues being most common (80.00%). Major complications included death (14.16%). Predictors of complications included congestive heart failure, cyanotic CHD, long CPB duration, and increased lactate postoperatively.
Conclusion: The study found a 14.16% in-hospital mortality rate for pediatric cardiac surgery. Key predictors of major complications include cyanotic congenital heart disease, prolonged bypass duration, high inotropic support, and elevated lactate levels. High complication rates highlight the need for better surgical techniques and postoperative care.

Keywords: Paediatric cardiac surgery, general and major complication

Introduction
Paediatric cardiac surgery is a critical and highly specialized field within cardiac care, addressing congenital and acquired heart diseases in children [1, 2]. Acquired heart disease develops after birth, often due to factors such as infections, illnesses, or other medical conditions [3]. Congenital heart disease (CHD) is a structural abnormality of the heart or intrathoracic great vessels occurring during fetal development. CHD is the most common type of birth defect and the leading type of heart disease in children [1, 2, 4]. It occurs in approximately 8 out of every 1,000 live births, with higher rates observed in stillbirths, spontaneous abortions, and premature births [5, 6]. According to the World Health Organization (WHO), the incidence of congenital heart disease among all cardiovascular diseases is 6% in Bangladesh, 15% in India, 6% in Burma, and 10% in Sri Lanka [7]. The management of these conditions often requires surgical intervention, which is crucial for correcting structural abnormalities and improving the quality of life for affected children [8]. The need for surgical intervention arises in a significant proportion of these cases, with studies indicating that about 25% of infants diagnosed with CHD require surgery within the first year of life [9]. Though the survival rates of children have improved

dramatically due to advancements in paediatric cardiac surgery, anaesthetic, extracorporeal circulation, ultrasonography, and critical care technology, there is still a considerable amount of morbidity, particularly in resource-limited settings such as tertiary care hospitals in developing countries [10]. Outcomes of paediatric cardiac surgery are well-documented in high-income nations; however, data from low-to-middle-income countries remain scarce. In low-to-middle-income countries, the lack of human resources and adequate facilities for cardiac surgery and postoperative care may negatively impact the results of paediatric cardiac procedures [11, 12]. According to national benchmark data, the majority of institutions have an overall death rate of less than 4% following congenital heart surgery [13-15]. Risk models currently incorporate factors such as age, weight, preoperative status, comorbidities and surgical complexity, which are associated with increased morbidity and mortality. The complications and the factors contributing to these complications are more challenging targets to measure, and interinstitutional comparisons are less easily made. Postoperative cardiac and extracardiac complications in paediatric cardiac surgery have been inconsistently reported but contribute importantly to mortality, hospital stay, cost, and quality of life after paediatric cardiac surgery [16, 17]. It is crucial to analyse the data to identify the factors contributing to successful outcomes and areas for improvement. The present study aims to evaluate the outcomes of paediatric cardiac surgery in a tertiary care hospital.

Methodology & Materials

This prospective analytical study was conducted in the Department of Obstetrics & Gynaecology at Bangabandhu Sheikh Mujib Medical University (BSMMU) in Dhaka, Bangladesh. The research lasted one year from February 2021 to August 2024. Participants were selected using purposive sampling according to predefined inclusion and exclusion criteria. The study involved 445 paediatric patients who were experiencing cardiac issues.

Inclusion criteria

- Pediatric patients aged one month to 16 years
- Patients who absconded were referred elsewhere and left against medical advice (LAMA).
- Patients have other related circumstances and an unknown diagnosis.

Exclusion criteria

- Participants aged 1 to 28 days (neonates).
- Children whose parents declined to provide consent.

Following the explanation of the study's aims, objectives, and procedures, written informed consent was obtained from each participant's parents. Baseline patient demographic information was then collected, with all data maintained under strict confidentiality. The study received ethical approval from the institutional ethics committee.

Each child was monitored daily from the day of surgery until discharge or death to identify any postoperative complications. Data from the records included patient age, sex, diagnosis, and outcomes. The outcomes were categorized into transfers to paediatric wards, discharges, patients who left against medical advice (LAMA), and deaths. Complications were defined according to the criteria established by the Multi-societal Database Committee for Paediatric and Congenital Heart Disease [18]. Factors contributing to the development of major complications were also identified. Data were collected using a standardized form to document significant complications, including death, multiorgan dysfunction, cardiac arrest, and the need for emergency chest reopening. We also recorded patients' baseline characteristics, clinical signs and symptoms, surgical outcomes, and potential predictors of major postoperative complications. The Risk Adjustment for Congenital Heart Surgery-1 (RACHS-1) category was utilized to compare outcomes among children undergoing cardiac surgery. Five potential predictors were analyzed: preoperative congestive heart failure, cyanotic congenital heart disease, prolonged cardiopulmonary bypass (CPB) time (>120 minutes), high inotropic drug requirements upon leaving the operating room, and an increase in blood lactate levels (>0.75 mmol/L/h or more within the first 24 hours post-surgery) [19, 20]. The 30-day mortality was defined as any death occurring within 30 days after cardiac surgery, even if the patient had been discharged from the hospital. A complication was characterized as any deviation from the expected postoperative course following cardiac surgery [21].

Statistical analysis

Data entry commenced immediately after the data collection process was completed. The collected is described in line with the study's objectives using SPSS software version 26. The data were then organized into appropriate tables or graphs based on their relationships. Continuous variables were presented as mean±SD, while categorical variables were expressed as frequencies and percentages.

Results

The study population, as outlined in Table 1, comprised 445 children with an average age of 49.32±11.61 months, highlighting a relatively young cohort. The gender distribution showed a nearly equal split, with 213 males (47.87%) and 232 females (52.13%). A noteworthy proportion of the participants faced nutritional challenges, with 42.02% categorized as undernourished, indicating a significant prevalence of malnutrition. In contrast, 28.31% of the children had a normal nutritional status, while 2.70% were classified as overweight. Additionally, 20.90% of the population was diagnosed with failure to thrive, a concerning condition in pediatric growth, and 6.07% presented with syndromic conditions, pointing to a subset of patients with more complex health issues. In Table 2, the distribution of cardiac diagnoses reveals that ventricular septal defect (VSD) was the most common condition, affecting 28.99% of the patients, followed by tetralogy of Fallot, which impacted 24.72% of the group. Other notable conditions included atrial septal defect (8.54%), mitral stenosis or regurgitation (6.29%), and double outlet right ventricle (DORV) (6.07%). A variety of rarer diagnoses were also present, such as single ventricle (4.94%), atrioventricular septal defect (3.82%), and truncus arteriosus (0.45%). Most patients were categorized into RACHS-1 category 2 (83.82%), signifying moderate surgical risk, while a smaller number were classified into higher-risk categories, such as category 4 (3.82%) and category 5 (1.12%). Table 3 presents the clinical outcomes of the patients who underwent pediatric cardiac surgery. An overwhelming majority (78.88%) required the use of cardiopulmonary bypass (CPB), with an average CPB time of 89.55±18.36 minutes. The mean aortic clamp time was 49.84±21.57 minutes. Postoperatively, 11.01% of patients required mechanical ventilation for more than seven days, indicating prolonged respiratory support. The average stay in the intensive care unit (ICU) was 34.91±12.48

hours, while the average duration of mechanical ventilation was 23.24±9.15 hours. The average hospital stay for the cohort was 8.43±3.61 days, reflecting the typical recovery period following pediatric cardiac surgery. Figure 1 shows the distribution of complication types following cardiac surgery in a sample of 445 cases. The chart indicates that 77.98% of the complications fall under the general category, while 22.02% are categorized as major. Table 4 outlines the incidence of general complications after pediatric cardiac surgery, indicating that endocrine complications are the most prevalent at 80.00%, followed by cardiac complications at 32.81% and lung complications at 29.89%. Other notable complications include renal complications at 25.84%, arrhythmia at 17.98%, and infections at 16.85%. Table 5 details the incidence of major complications, with death occurring in 14.16% of cases, cardiac arrest at 5.17%, and the necessity for reoperation and multiple organ dysfunction both at 4.04% and 6.97%, respectively. Table 6 presents a comparison of predictors associated with general and major complications following pediatric cardiac surgery. Of the 347 patients with general complications, 7.49% had preoperative congestive heart failure, while 12.24% of the 98 patients with major complications had this condition (P=0.008). Cyanotic congenital heart disease (CHD) was observed in 31.41% of patients with general complications but a striking 81.63% of those with major complications. Intraoperatively, 50% of patients with major complications had a cardiopulmonary bypass (CPB) duration exceeding 120 minutes, compared to 13.54% with general complications (P=0.009). High inotropic support was a significant predictor, seen in 51.02% of major complications but only 2.02% of general cases (P<0.001). Postoperatively, a lactate increases within 1 hour occurred in 93.88% of major complication cases, compared to 15.27% in the general complication group (P<0.0001), indicating it as a strong predictor.

Table 1: Demographic and nutritional characteristics of the study population

Characteristics	Frequency (n)	Percentage (%)
Age (in months)		
Mean±SD	49.32±11.61	
Gender		
Male	213	47.87
Female	232	52.13
Nutritional state		
Undernourished	187	42.02
Normal	126	28.31
Overweight	12	2.70
Failure to thrive	93	20.90
Syndrome	27	6.07

Table 2: Distribution of diagnoses and RACHS-1 categories in study patients

Diagnosis	Frequency (n)	Percentage (%)
Ventricular septal defect	129	28.99
Tetralogy of Fallot	110	24.72
Atrial septal defect	38	8.54
Mitral stenosis or regurgitation	28	6.29
DORV	27	6.07
Single ventricle	22	4.94
Atrioventricular septal defect	17	3.82
PA-VSD	13	2.92
PA-IVS	9	2.02
Patent ductus arteriosus	9	2.02
TGA-VSD	8	1.80
TGA-IVS	7	1.57
TAPVD or PAPVD	7	1.57
Tricuspid atresia	6	1.35
Ebstein's anomaly	4	0.90
Mitral atresia	3	0.67
Truncus arteriosus	2	0.45
Others	6	1.35
Definitive operation	347	77.98
RACHS-1		
Category 1	41	9.21
Category 2	373	83.82
Category 3	9	2.02
Category 4	17	3.82
Category 5	5	1.12

PA-VSD: Pulmonary atresia with ventricular septal defect, PA-IVS: Pulmonary atresia with intact ventricular septum, DORV: Double outlet right ventricular, TGA-VSD: Transposition of the great arteries with ventricular septal defect, TGA-IVS: Transposition of the great arteries with intact ventricular septum, TAPVD: Total anamolous pulmonary venous drainage, PAPVD: Partial anamolous pulmonary venous drainage, RACHS-1: Risk Adjustment for Congenital Heart Surgery-1.

Table 3: Clinical outcomes of patients undergoing pediatric cardiac surgery

Outcomes	Frequency (n)	Percentage (%)
Use of CPB	351	78.88
Use of ventilator >7 days	49	11.01
Mean±SD		
CPB time (min)	89.55±18.36	
Aortic clamp time (min)	49.84±21.57	
ICU stay (hour)	34.91±12.48	
Duration of mechanical ventilation (hour)	23.24±9.15	
Hospital stays (days)	8.43±3.61	

CPB: Cardiopulmonary bypass, ICU: Intensive care unit.

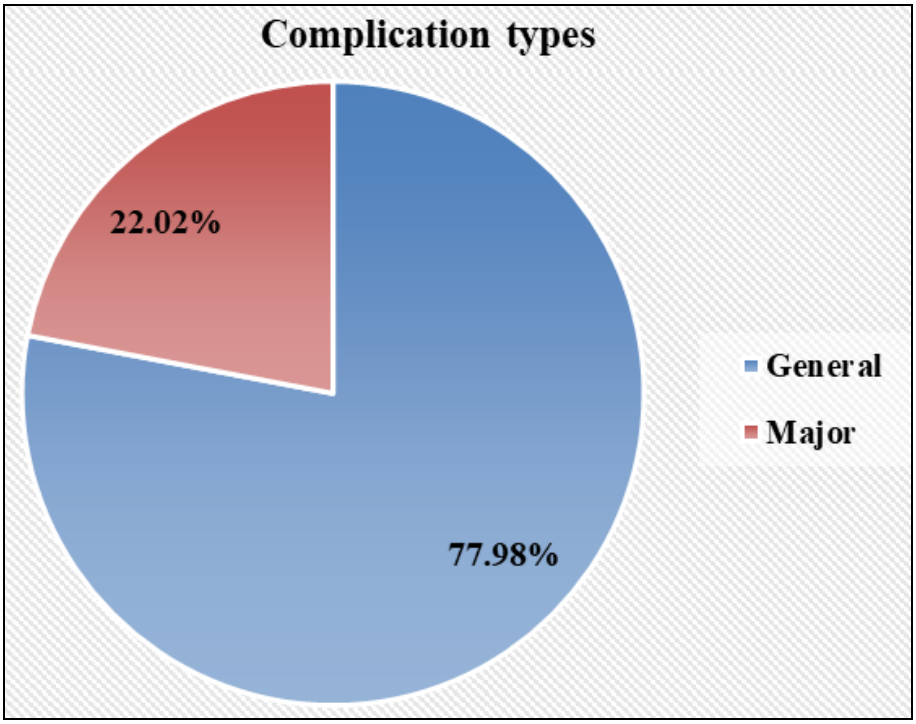

Fig 1: Prevalence of complication after cardiac surgery (N=445)

Table 4: Incidence of complications after pediatric cardiac surgery

General complications	Frequency (n)	Percentage (%)
Readmission	18	4.04
Multiple organ dysfunctions	31	6.97
Shock	9	2.02
Cardiac complications	146	32.81
Procedure complications	63	14.16
Arrhythmia	80	17.98
Lung complications	133	29.89
Renal complications	115	25.84
Infections	75	16.85
Systemic inflammatory response syndrome	84	18.88
Neurological complications	36	8.09
Gastrointestinal complications	18	4.04
Endocrine complications	356	80.00
Vascular complications	5	1.12

Table 5: Incidence of major complications post pediatric cardiac surgery

Major complication	Frequency (n)	Percentage (%)
Cardiac arrest	23	5.17
Re-operation	18	4.04
Multiple organ dysfunction	31	6.97
Death	63	14.16

Table 6: Predictors of major complications post-pediatric cardiac surgery

Predictors	General complications (n=347)		Major complication (n=98)		P-value
	n	%	n	%	
Preoperative					
Congestive heart failure	26	7.49	12	12.24	0.008
Cyanotic CHD	109	31.41	80	81.63	
Intra-operative					
Duration of CPB >120 min	47	13.54	49	50	0.009
High inotropic support	7	2.02	50	51.02	<0.001
Postoperative					
Increase in lactate in 1 hour	53	15.27	92	93.88	<0.0001

CHD: Congenital heart disease, CPB: Cardiopulmonary bypass, OR: Odds ratio, CI: Confidence interval.

Discussion

This study examined outcomes in pediatric patients following cardiac surgery, revealing an in-hospital mortality rate of 14.16%. Mortality rates vary significantly depending on case complexity, the presence of comorbidities (such as malnutrition and chronic infections), as well as the quality of surgical and postoperative care provided [18]. Comparable or lower mortality rates have been reported in other developing nations: 12.4% in Iran, 10.7% in Guatemala, 7.9% in India, and 5.5% in China [19-22]. In contrast, large pediatric cardiac centers in high-income countries report mortality rates of less than 5% [23]. There is an inverse relationship between the volume of surgeries performed and mortality rates. Units conducting over 300 surgeries annually tend to have lower mortality, while those performing around 101 surgeries per year face a threefold increase in mortality risk. Units with fewer than 10 surgeries annually experience an eightfold increase in mortality risk [24]. Additionally, surgeons face a learning curve when introducing new surgical techniques. Specialized training and expert guidance may help reduce this learning curve [25]. The highest mortality in our cohort was observed in patients undergoing an arterial switch operation for transposition of the great arteries (TGA) with ventricular septal defect (VSD) or intact ventricular septum. Pulmonary hypertension, often resulting from delayed surgeries due to late presentation, was the leading cause of mortality. Most deaths following the arterial switch procedure were associated with pulmonary hypertensive crises, which are particularly challenging to manage in resource-limited settings. Complications occurred in 77.98% of patients, a rate higher than previously reported studies, potentially due to different definitions of complications. Our study included endocrine complications, such as hypocalcemia, hyperglycemia, and hypoglycemia, which are often not accounted for in other studies. These endocrine issues occurred in 80% of our cases post-surgery. Lou *et al*. (2011) similarly reported endocrine complications (Hyperglycemia and hypocalcemia) in close to 60% of patients after cardiac surgery [26]. The most common complications in our cohort were low cardiac output syndrome (LCOS), arrhythmia, nosocomial sepsis, and pleural effusion. The incidence of LCOS in our study, ranging from 25% to 32%, was consistent with other studies [27]. Postoperative management should focus on avoiding factors that contribute to LCOS development, such as maintaining adequate preload, using vasoactive medications to enhance contractility, and regulating systemic and pulmonary vascular resistance [27, 28]. Nosocomial bloodstream infections or sepsis were observed in 16.85% of patients, a rate significantly higher than the 8.6% reported in a previous study [29]. In low- to middle-income countries, gram-negative sepsis is a common postoperative infection in children, leading to increased morbidity, mortality, and antibiotic resistance. Improvements in nutrition, early corrective surgery, and infection control measures could help mitigate this risk [30]. Our analysis identified several predictors for major complications after cardiac surgery, providing a basis for preventative strategies. These predictors included cyanotic congenital heart disease, prolonged cardiopulmonary bypass (CPB) duration, high inotropic support upon leaving the operating room, and elevated blood lactate levels. Patients with cyanotic congenital heart disease, especially those with complex heart lesions, often require longer surgeries and CPB times, increasing the risk of severe metabolic acidosis and tissue hypoxemia, which are associated with higher mortality [19]. Although the presence of cyanotic congenital heart disease is an intrinsic, uncontrollable factor, awareness of the associated risks can aid in mitigating adverse outcomes. High inotropic support upon leaving the operating room was linked to increased mortality and cardiac arrest in children following surgery. More severe hemodynamic instability and lower cardiac index require greater inotropic support [31]. Elevated blood lactate levels, reflecting anaerobic metabolism due to inadequate oxygenation or cellular hypoxia, were also identified as a risk factor. Blood lactate levels greater than 0.75 mmol/L can predict early outcomes in neonates after cardiac surgery, though with high specificity and low sensitivity. This elevation may be a physiological consequence of CPB and impaired lactate clearance [12, 32]. These findings underscore the urgent need for comprehensive interventions to enhance the quality of pediatric cardiac surgery and reduce mortality and major complications by addressing factors such as prolonged CPB duration, high inotropic requirements, and elevated blood lactate levels post-surgery.

Limitations of the study: This study faced several limitations. The lack of a control group also restricts the ability to draw comparative conclusions. Some data were self-reported, which may introduce bias. The study did not account for long-term postoperative outcomes or quality of life, focusing solely on short-term results. Additionally, resource constraints in a developing country setting may have influenced the study's outcomes and the ability to implement certain interventions.

Conclusion and Recommendations

The study on pediatric cardiac surgery outcomes at Bangabandhu Sheikh Mujib Medical University reveals significant findings. With a 14.16% in-hospital mortality rate, the study identifies key predictors for major complications, including cyanotic congenital heart disease, prolonged cardiopulmonary bypass duration, high inotropic support, and elevated blood lactate levels. The high complication rate (77.98%) is attributed to comprehensive inclusion criteria, including endocrine issues. Common complications were low cardiac output syndrome, arrhythmia, sepsis, and pleural

effusion. These findings emphasize the necessity for improved surgical techniques, early intervention, and better postoperative care to enhance outcomes in resource-limited settings.

Funding: No funding.

Conflict of interest: There is no conflict of interest.

Ethical approval: The study was approved by the ethics committee of the institution.

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How to Cite This Article
Ullah MA, Saha H, Mamun S, Zaher MA, Akhter S. Outcome of paediatric cardiac surgery in a tertiary care hospital of Bangladesh. International Journal of Surgery Science 2024; 8(4): 26-32.