The Outcome of Non-cardiac Surgery among Children with Congenital Heart Disease: A Single Institution-based Review of Cases in the Low-Resource Setting

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Abstract

Background: Over half of infants with congenital heart disease (CHD) need surgery for non-cardiac abnormalities during the first year of life. **Objective:** This study looked at the variables and surgical outcomes related to non-cardiac surgery in this specific patient population. **Methods:** We looked at and analyzed 152 case records using SPSS software version 27 (SPSS Inc., Chicago, IL, USA) in order to identify factors associated with post-operative mortality on the 7th and 30th days using a binary and multivariable logistic regression model. **Results:** Infants with CHD who had non-cardiac surgery for non-heart-related abnormalities had mortality rates of 28.9% on the 7th, and 45.4% on the 30th post-operative day. Preterm neonates had a 2.16-fold higher mortality rate than mature neonates. The death rate was 1.2 times higher in patients who underwent surgery after 24 hours of diagnosis than those who had before 24 hours. Death is also associated with severe CHDs, comorbidities, genetic diseases, operating room mishaps, and age <1 year. **Conclusion:** The study found that among CHD cases undergoing non-cardiac surgery, the mortality rate was quite high on the 7th and 30th post-operative days.

Keywords: Pediatric congenital heart surgery, Cardiopulmonary bypass (CPB), congenital heart disease (CHD), Non-cardiac surgery

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Introduction

Congenital heart disease (CHD) is the most common birth defect, affecting 9.41/1000 live births. Reports from LMIC showed that 13% of children with CHD were found to have additional extra-cardiac defects (1). However, this figure is higher according to reports from developed nations (2-4). Children with CHD may have non-cardiac issues, such as trachea–esophageal fistulas, anorectal abnormalities, cleft lip and palates, renal, and skeletal diseases. Eighty-five percent of these patients are predicted to live to adulthood in the United States (5-6). Children with CHD need both elective and emergency surgery at their local hospital because they are susceptible to the same childhood diseases as healthy children.

Generally speaking, children with CHD who have extracardiac surgery are more likely to experience morbidity, perioperative cardiac arrest, and a greater mortality rate on the 7th and 30th days after surgery (4-10). In developed nations, patients with CHD who underwent extra-cardiac surgery were divided into three risk groups: high, medium, and low risk groups (11). The low risk group includes patients with corrected CHD, receiving minor surgery and having no residual abnormalities. The moderate risk group includes patients with moderate problems, such as residual ventricular septal defects or pulmonary hypertension, and individuals undergoing intermediate-risk operations.

The high risk group includes patients undergoing major or emergency procedures for complex CHDs, such as single-ventricle physiology, severe cyanosis, or systemic ventricular dysfunction (12-14).

One study in the United States found that the overall death rate on the 7th and 30th days after non-cardiac surgery was 0% and 0.4%, respectively, with 1% mortality in the major CHD group and no mortality in the minor CHD group (7). Different studies have shown that children with cardiomyopathy, supra-systemic pulmonary hypertension, left ventricular blockage, and functional single ventricle had greater post-operative mortality rates (16).

According to yet another study conducted in the United States, children with moderate CHD had a considerably higher overall incidence of death (3.9%) and severe CHD (8.2%) than controls (1.7% [$p < 0.001$] and 1.2% [$p = 0.001$]), respectively (17).

Research involving sizable sample populations of children with and without CHD revealed that the total 30-day death rate following non-cardiac surgery was greater in the CHD group (6.0%) than in the non-CHD group (3.8%). Perioperative mortality was linked to the operation’s complexity and the severity of CHD (18). In a different study, 27% of patients undergoing non-cardiac operations had CHD, and the incidence of perioperative cardiac arrest was 2.9 per 10,000 anesthetic sessions (19).

A multi-center observational study conducted in Addis Ababa, Ethiopia revealed that 97 of the 271 (35.8%) congenital anomaly cases were due to CHD (5). Guidelines for classifying the risk of extracardiac surgery in individuals with CHD are lacking in developing countries. The purpose of this study is to determine the surgical outcome of non-cardiac surgery in children with CHD and to identify factors influencing the outcome as we were unable to locate published data in Ethiopia and other African countries regarding the challenges and outcomes of non-cardiac surgical issues in children with CHDs.

Methods

Study site and period

The study was carried out in a tertiary hospital, the biggest teaching hospital in our nation with over 700 beds that treats more than 5 million people a year. A retrospective cross-sectional survey was carried out in the hospital using secondary data.

Children with CHD who underwent non-cardiac surgery at the hospital between January 2015 and December 2020 comprised our source population.

A finite population adjustment and a single population proportion calculation were used to calculate the sample size.

Where n is the minimum sample size, P = the prevalence of non-cardiac surgery in CHD children, were taken as 0.13, using a study from low- and middle-income countries (1) d is the level of precision (margin of error), and Z is the value at 95% confidence level. After adding 10% to compensate for the non-response rate, the final sample size was 191 cases (Annex 1).

Charts of children with CHD aged 0–14 years who underwent non-cardiac surgery at the study site between January 2015 and January 2020 and had full information were included as part of the inclusion criteria. Exclusion criteria included cases of CHD and non-cardiac surgery during the aforementioned time frame where insufficient information was available.

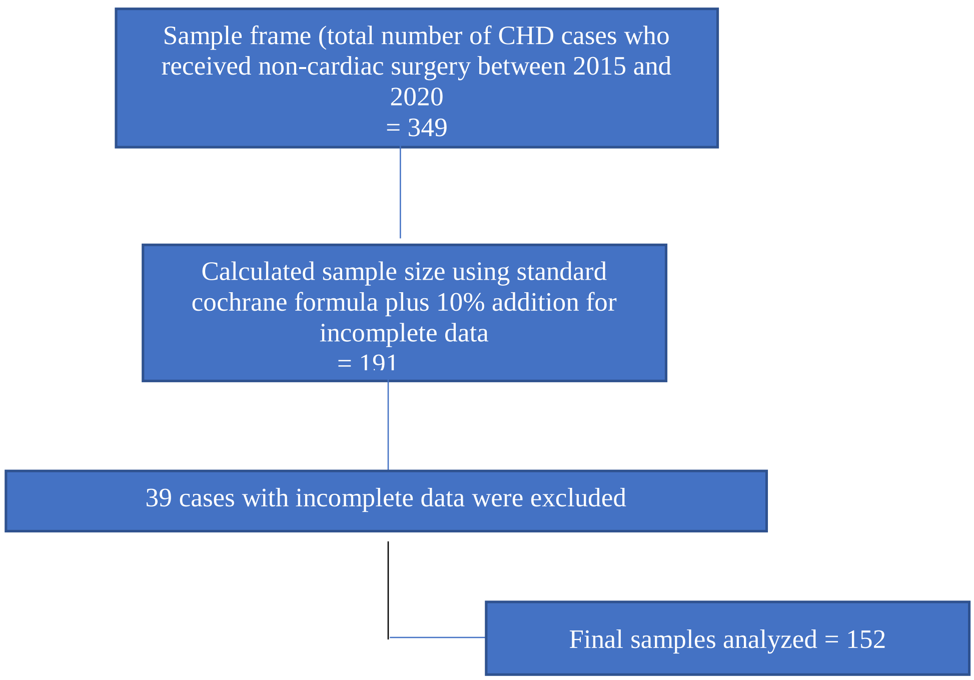
Variables

Our primary end variables were mortality on the 7th and 30th post-operative days, and our secondary outcome variables were factors associated with death. The following were the independent variables: length of surgery, non-cardiac comorbidities, operating room incidents, age, sex, birth weight, age at diagnosis, source of referral, clinical data, hospital stay, and CHD.

Data collection

Following the identification of non-cardiac surgery cases with CHD in the Health Management Information System logbook, the patient's chart was obtained, pertinent information was looked up, collected, and then entered into a semi-structured questionnaire instrument that was piloted before being utilized. The appropriateness of the tool was evaluated on a small sample of patients before data collection.

Annex 1: Flow chart



Prior to entering the data into the computer software program (IBM SPSS statstics 27, Chicago, IL, USA), the lead investigator collected, coded, and cleaned the data. Additionally, the lead investigator confirmed the accuracy and completeness of the data. To make sure it was correct, thorough, and consistent with the hard copy, the converted soft copy was once more closely inspected before the statistical analysis was conducted.

Data analysis

While frequencies and percentages were used to depict categorical data, the mean and standard deviation were used to display continuous variables. The chi-square test was used to ascertain the association between the independent factors and the outcome. The odds' ratio with a 95% confidence interval was calculated to assess the degree of association and statistical significance. The association between the independent factors and the post-operative outcome was investigated using a binary regression model, and all covariates that met the chi-square assumption and had p-values <0.2 in the univariate analysis were included in a multivariate logistic regression model. A p-value <0.05 was considered statistically significant. Thus, gestational age, age <1 year, types of extracardiac problems, types of CHD, non-cardiac comorbidity, length of surgery, time between diagnosis and surgical intervention, length of hospital stay, emergency cases, type of anesthesia used, and related syndromes were all considered in the multivariate analysis. Basic descriptive statistics, such as percentages, tables, and graphs, were used to display the variables. Figures were utilized to illustrate the examined data.

Operational definitions

A non-cardiac surgery is defined as a procedure performed in an operating room with a documented surgical procedure code. The intrinsic surgical risk is the risk of 30-day mortality associated with specific surgical procedures as defined by current procedural terminology (CPT) (6).

Surgical procedures with CPT risk quartiles 1 and 2 comprise the low-risk procedure category, and quartiles 3 and 4 comprise the high-risk procedures (6).

Table 1. Demographic characteristics of patients with congenital heart disease who have undergone non- cardiac surgery (N=152)

Variables	**Category**	**Frequency**	**Percentage**
Age	Neonates	116	76.3
	Infants	19	12.5
	Toddlers	12	7.9
	Preschool	1	.0.7
	School age	4	2.6
Sex	Male	73	48
	Female	79	52
Referral source	©TASH	44	28.9
	Health center	48	31.6
	Other hospital	60	39.5

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Table 2. Comorbid conditions in patients who have undergone extracardiac surgery

Variables	**Category**	**Frequency**	**Percentage**
Non-cardiac comorbidities	Sepsis	80	52.6
	Bleeding disorder	14	9.2
	Metabolic/electrolyte	10	6.6
	disorder		4.6
	Renal failure	7	3.9
	Other	6	23.1
	No comorbidities	35	
Dysmorphism	Down syndrome	17	11.2
	Charge syndromes	7	4.6
	Other	4	2.7
Without dysmorphism	Non-syndromic	124	81.6
Total		152	100

Intraoperative events were defined as an occurrence of the following incidents: cardiac arrest, significant arrhythmias, significant hypotension requiring inotropic support, pulmonary hypertensive crisis, difficult intubation, loss of airway requiring reintubation, bronchospasm, laryngospasm, desaturation, stroke, seizure, hemorrhage requiring transfusion, and difficult access (7).

Minor CHDs were identified in patients who had maintained good cardiac hemodynamics with or without medication and children with a repaired CHD. Major CHDs were identified in patients with a repaired CHD but with a residual abnormality in their hemodynamic status, patients with an unrepaired cyanotic CHD, pulmonary hypertension, and ventricular dysfunction (15).

Ethical approval

The ethics and review committee of the Department of Pediatrics and Child Health of the university approved the research on July18, 2023 (REC no-007/15).

Results

Socio-demographic characteristics

Of the patients, 78 (52%) were female, and the ages ranged from 4 days to 119 months, with a mean age of 4.8 ±14.6 months.

Table 3. Factors associated with post-operative mortality among CHD cases undergoing non-cardiac surgery

Variables	**Alive**	**Died**	**COR (95% CI)**	**AOR (95%)**	***p*-value**
Gestational age					
Term	61	19	1	1	0.12
Preterm	91	45	2.36 (1.95–4.27)	1.5 (1.08–10.87)	
Age of the patient					
<1 years	73	63	0.092 (0.12–0.79)	16.64 (1.127–240.84)	0.04
≥1 year	13	1			
Gap between dx and surgical procedure					
<24 hours	42	25	1	1	0.45
≥24 hours	49	39	1.23 (0.64–2.378	1.95 (0.39–18.95)	
Operation room incident					
Reintubation	7	14	1.946 (0.267–3.25)	3.935 (0.59–26.13)	<0.001
Blood transfusion	2	8	8 (1.127–56.25)	64.04 (4.92–83.23)	
Cardiac arrest	8	4	4 (0.88–18.09)	15.28 (1.74–133.66)	
No major incident	74	35	1	1	
Genetic syndrome					
Yes	8	18	3.1 (1.7–17.5.572)	4.67 (1.25–17.37)	<0.01
No	83	43	1	1	
Comorbidities					
Sepsis	42	50	1.91 (0.3–10.9)	0.719 (0.27–19.67)	0.008
Metabolic	11	5	1.3 (0.16–11.7)	0.53 (0.114–2.33)	
Bleeding disorder	7	3	1.1(0.45-1.7)	1.52(.310-7.58)	
No comorbidity	30	3	1	1	
Re-operation done			1.52 (0.7–2.67)	1.9 (1.125–39.25)	0.224
Yes	38	21	1	1	
No	53	40			
CHD risk					
Minor	40	20	1	1	<0.001
Major	20	19	1.561 (0.712–3.4)	1.12 (0.79–3.7)	
Severe	12	27	5.23 (2.2–12.21)	1.4 (1.15–3.12)	

AOR, adjusted odds ratio; CHD, congenital heart disease; CI, confidence interval; COR, crude odds ratio.

While school-age children made up 4 (2%) of the cases, neonates made up over 75% of the research patients (Table 1). Of all the patients, 44 (28.9%) were born at the research site; the remaining cases were referred from other hospitals and health facilities.

Comorbid conditions

According to Table 2, Down syndrome affected 11.2% of the patients, while sepsis and metabolic problems (hypoglycemia and electrolyte imbalance) affected roughly 53% and 7% of the patients, respectively.

Thirteen percent of the patients needed to be re-intubated, and in 23.7% of the cases, the surgical process took more than 4 hours. Table 3 shows that general anesthesia was used in 92.8% of the patients.

Patent ductus arteriosus (PDA), which accounted for 34.9% of cases, was the most prevalent congenital cardiac disease, followed by ventricular septal defect (VSD) (27%), as shown in Figure 1.

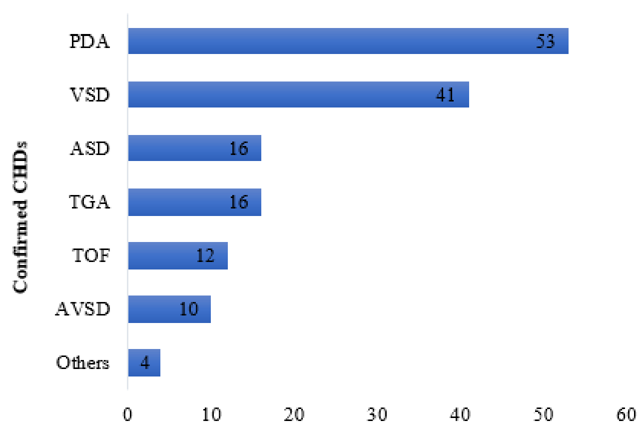

Figure 1. Frequency of congenital heart diseases among cases who received non-cardiac surgery. ASD, atrial septal defect; AVSD, atrioventricular septal defect; NB-PDA, patent ductus arteriosus; TGA, transposition of the great artery, Tetralogy of Fallot; VSD, ventricular septal defect.

With 62 occurrences, tracheoesophageal fistulas were the most prevalent non-cardiac surgical issue, while clubfoot was the least common. The kind of surgery used to fix non-cardiac surgical issues is depicted in Figure 2. While the average duration of hospitalization was 9.27 ± 4.85 days, with a range of 2–30 days, the average time between diagnosis and surgery was 2.74 ± 1.48 days. After the 7th post-operative day, 28.9% of the cases had died, and 45.4% had died after the 31st.

Table 3 shows a statistically significant correlation between the risk of post-operative death and age <1 year (adjusted odds' ratio [AOR] 16.64, 95% confidence interval [CI] 1.127–240.84, p = 0.04). In the same way, patients who experience blood transfusions, cardiac arrest, or reintubation in the operating room are more likely to die after surgery (AOR 3.935, 95% CI 0.59–26.13, p < 0.001).

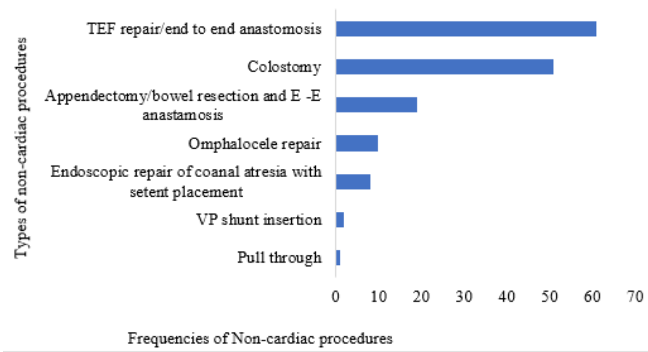

Figure 2. Types of non-cardiac surgeries performed on patients with CHD. TEF, tracheoesophageal fistula; VP-shunt, ventriculoperitoneal shunt.

There is also a 4.6-fold increased risk of death after surgery for those with the genetic syndrome (AOR 4.67, 95% CI 1.25–17.37, p < 0.01). AOR 1.5, 95% CI 0.310–7.58, p = 0.008 indicates that comorbidities such as intraoperative hemorrhage have a higher risk of death. In addition, children who have severe forms of CHD are 1.4 times more likely to die than children who do not (AOR 1.4, 95% CI 1.15–3.12, p < 0.001.

Discussion

According to the current study, children with CHD who underwent non-cardiac surgical procedures had increased mortality rates on the 7th and 31st post-operative days. Even while the number of non-cardiac surgeries performed on CHD patients has increased over time, research findings in other parts of the world have shown that mortality rates have significantly decreased (6). Along with the high post-operative mortality, the current study also revealed factors that contributed to the high mortality. For instance, the majority of our participants in this study included children younger than 2 years. Others also illustrate this age distribution (8-11). According to the current analysis, Hurshsprung's disease, anorectal malformation, and tracheoesophageal fistula were the most frequent extracardiac surgical issues.

Findings of post-non-cardiac surgery outcomes in children with CHD cases, according to Rebecca et al., indicated that younger age groups had a higher burden of non-cardiac surgery, including general, ear, nose, and throat surgery. Conversely, adolescents saw an increase in the number of orthodontic and dental operations. Patients with single ventricle physiology frequently experienced intraoperative events (7). The risk of non-cardiac surgery is significantly increased by single ventricle, parallel circulation, aortic stenosis, cardiomyopathy, heart failure, arrhythmias, cyanosis, pulmonary hypertension, age <2 years, and American Society of Anesthesiology (ASA) class 4 or higher, according to Kaitlin et al. (16-18). The majority of the CHDs in our research were straightforward lesions such as PDA, VSD, and atrial septal defect (ASD), which were not frequently known to have a high related mortality rate when non-cardiac surgery was performed. Nonetheless, even in instances with straightforward CHDs, a substantial death rate has been noted. Although the numbers are small, our study likewise showed higher mortality among significant and severe CHD risk groups. Because of the potential for bad results, surgeons are afraid to operate on complicated CHDs in our settings. There are other studies that are comparable (19).

According to a multicenter American study, children having non-cardiac surgical procedures were frequently diagnosed with ASD, PDA, and VSD. Cases with maintenance cardiac medicines and repaired cyanotic or complicated CHD were categorized as intermediate risk, while repaired ASD and VSD were deemed low risk. High-risk factors included congestive heart failure, hypertrophic cardiomyopathy with blockage, pulmonary hypertension, ventricular-assisted devices, Williams syndrome, ventricular heart disease with notable valvular gradients, unrepaired cardiac abnormalities, and congestive heart failure (18). In our investigation, there were not many of these complex lesions to compute significant analysis.

The high post-operative mortality seen in the current study is in contrast to studies conducted in the United States that revealed an overall 30-day mortality range between 9% and 11% (20-21).

Delays in surgery and a high likelihood of infection could be the causes. The mortality rate for preterm neonates was 2.16 times higher than that of term neonates in this study. Comorbid prematurity and congenital abnormalities have been proposed to impact brain growth in preterm infants; a number of disorders, such as esophageal atresia, diaphragmatic hernia, and abdominal wall deformities, also have an impact on maturity and neurodevelopmental outcomes (22).

Similarly, the cases having surgery after 24 hours of diagnosis had a 1.2 times higher mortality than those whose surgeries were performed within 24 hours of the diagnosis. It was reported that when critical CHD is detected early rather than later, mortality is said to decrease (23).

Cote and Lerman reported that the complexity of the operation and anesthesia-related arrest were identified as risk factors associated with increased post-operative mortality (17). Children in the major CHD risk group had higher mortality in the current study, and Cote and Lerman reported that major and severe CHD remained significant risk factors for perioperative cardiovascular events after controlling for ASA physical status, emergency cases, and surgical types (17). High mortality risk was observed in cases that had major incidents (eight times risk) during and after surgery. The intricacy of CHD, the length of the procedure, and the kind of anesthetic (local versus general) all have a detrimental impact on the results in the American studies (11, 7,16). In our results, we have not shown a statistically significant difference in mortality according to the type of anesthetic type.

Strength of the study

The strength of the study was the use of verified and standardized instruments. Numerous factors were taken into consideration. The largest teaching and referral hospital, which might be representative of the entire population, served as the site of the study.

Study limitations

The study may have omitted some crucial information because it was a retrospective chart-based evaluation of cases. The investigation was carried out in a single central referral hospital, which might be indicative of more complex situations. Data from resource-rich countries were compared, although reports from poorer countries were few. The representativeness of the data cannot be overstated because patients were referred from all around the nation. It is possible that the 7th- and 30th-day fatality rates were impacted by nearly one-fourth of the patients who were not included in the analysis.

Conclusion

The 7th and 30th post-operative day mortality was unacceptably high among commonly encountered simple CHD cases. Comorbid conditions, delayed surgery, and room operation incidents all increased mortality.

Recommendation

Healthcare providers are advised to prevent post-operative mortality by managing comorbid diseases as soon as possible, lowering the reintubation rate, and unintentionally delaying the surgical intervention. Future researchers should consider conducting a prospective multicenter study that covers all referral hospitals in the nation, as the current study is based on retrospective data analysis from a single institution.

Acknowledgment

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Author contributions

TM had incepted the research topic and mentored the proposal development. ZT wrote the proposal mentored by TM. ZT collected the data, cleaned, entered, and analyzed it. ZT wrote the manuscript while TM reviewed it. Both authors reviewed the manuscript before it was submitted for publication.

Ethical consideration

The study was approved by the departmental research review and publication committee of the university. It was also permitted by the departmental ethics committee to publish the manuscript.

Data availability

All the necessary data are included in the manuscript.

References

1. Jaiyesimi F, Antia AU. Extracardiac defects in children with congenital heart disease. British Heart Journal. 1979 Oct;42(4):475.
2. Liu Y, Chen S, Zühlke L, et al. Global birth prevalence of congenital heart defects 1970-2017: updated systematic review and meta-analysis of 260 studies. Int J Epidemiol 2019; 48(2): 455-63.
3. British Heart Foundation. Congenital heart disease statistics 2006. 2008. p. Available from www.heartstats.org, 2024.
4. Higashi H, ·Barendregt JJ, Vos T. The burden of congenital anomalies amenable to surgeries in low-income and middle-income countries: a modelled analysis. Lancet 2013; 381: S62.
5. Talargia F, Seum G, Moges T. Congenital heart defects and associated factors in children with congenital anomalies. Ethiop Med J 2018; 56(4): 335-42.
6. Nasr VG, Staffa SJ, Faraoni D, et al. Trends in mortality rate in patients with congenital heart disease undergoing noncardiac surgical procedures at children's hospitals. Sci Rep 2021; 11: 1543.
7. Hamilton ARL, Odegard KC, Yuki K. Exploring noncardiac surgical needs from infancy to adulthood in patients with congenital heart disease. J Cardiothorac Vasc Anesth 2022; 36(12): 4364-9.
8. Ezekwesili-Ofili JO, Ogbonna AO. African Traditional and Complementary Therapies. 2022. https://www.researchgate.net/publication/361964327_African_Traditional_and_Complementary_Therapies
9. White MC, Peyton JM. Anaesthetic management of children with congenital heart disease for non-cardiac surgery. BJA Educ. 2012; 12(1): 17-22.
10. Menghraj SJ. Anaesthetic considerations in children with congenital heart disease undergoing non-cardiac surgery. Indian J Anaesth. 2012; 56(5): 491-5.
11. Brown ML, DiNardo JA, Nasr VG. Anesthesia in pediatric patients with congenital heart disease undergoing noncardiac surgery: defining the risk. J Cardiothorac Vasc Anesth. 2020; 34: 470-8.
12. Nasr VG, Markham LW, Clay M, et al., American Heart Association Council on Lifelong Congenital Heart Disease and Heart Health in the Young and Council on

Cardiovascular Radiology and Intervention. Perioperative considerations for pediatric patients with congenital heart disease presenting for noncardiac procedures: a scientific statement from the American Heart Association. Circulation: Cardiovasc Qual Outcomes. 2023; 16(1): e000113.

13. Mossad EB. Risk assessment of the congenital heart disease patient for noncardiac surgery. Rev Mex Anestesiol. 2013; 36(S1): 39-42. https://www.medigraphic.com/pdfs/rma/cma-2013/cmas131l.pdf
14. Constantine A, Clift P. Non-cardiac surgery in congenital heart disease-associated pulmonary arterial hypertension: risk recognition and management. J Congenit Cardiol. 2020; 4: 1-5.
15. Hamilton ARL, Odegard KC, Yuki K. Exploring noncardiac surgical needs from infancy to adulthood in patients with congenital heart disease. J Cardiothorac Vasc Anesth 2022; 36(12): 4364-69.
16. Walker I. Anesthesia for non-cardiac surgery in children with congenital heart disease. Update in Anesthesia. 2008; 30: 46-51. Available from https://resources.wfsahq.org/wp-content/uploads/uia30-Anaesthesia-for-non-cardiac-surgery-in-children-with-congenital-heart-disease.pdf
17. Miller-Hance WC, Gertler R. Essentials of cardiology. In: Cote CJ, Lerman J, Anderson B (eds). *A practice of anesthesia for infants and children*. 6th ed. Elsevier. 2019: p. 355-92.
18. White MC, Peyton JM. Anesthetic management of children with congenital heart disease for noncardiac surgery. Contin Educ Anaesth Crit Care Pain 2012; 12: 17-22.
19. Kaitlin M. Flannery. Anaesthesia in children with congenital heart disease for noncardiac surgery. Pediatric Anesthesia Tutorial 467. 2022. Available from https://resources.wfsahq.org/wp-content/uploads/atow-467-00.pdf
20. Miller R, Tumin D, Tobias JD, et al. Estimating surgical risk in younger and older children with congenital heart disease. J Surg Res. 2018; 232: 298-307.
21. Lee S RE, Koutsogiannaki S, Hernandez MR, et al. Incidence and risk factors for perioperative cardiovascular and respiratory adverse events in pediatric patients with congenital heart disease undergoing noncardiac procedures. Anesth Analg. 2018; 127: 724-9.
22. Gunn-Charlton JK. Impact of comorbid prematurity and congenital anomalies: a review. Front Physiol. 2022; 13: 880891.1(3): 880891.
23. Eckersley L, Sadler L, Parry E, et al. Timing of diagnosis affects mortality in critical congenital heart disease. Arch Dis Child. 2016; 101(6): 516-20.