

# Predictors of postoperative complications in pediatric cardiac surgery

**RESUMO** | Objetivo: Identificar preditores de complicação no pós-operatório de cirurgia cardíaca pediátrica. Método: Estudo quantitativo que analisou retrospectivamente 88 prontuários de pacientes submetidos a procedimento cirúrgico no ano de 2018. Para análise dos dados foi aplicado o teste exato de Fisher e o modelo logístico univariado. Os resultados foram expressos pelo odds ratio (OR) com nível de significância de 5%. Resultados: observou-se idade média de 3,61 anos com predominância do sexo feminino. Complicações circulatórias, metabólicas, renais, respiratórias e cardiovasculares foram identificadas intra e pós-operatória. Foi identificada correlação estatística preditiva de complicações em: uso de diuréticos, hipertensão arterial, insuficiência de valva atrioventricular, hipertrofia de ventrículo direito, trissomia do cromossomo 21, leucócitos alterados nos pré-operatórios, sangramento intraoperatório, derrame pericárdico e alterações no ecocardiograma pós-operatório. Conclusão: Variáveis de condições clínicas, medicações em uso, defeitos congênitos e intercorrências intraoperatórias quando associadas às complicações encontradas no pós-operatório de cirurgias cardiopediátricas mostram-se como preditivos de risco.

**Descritores:** Cuidados de Enfermagem; Cirurgia Torácica; Cardiopatias congênitas; Complicações pós-operatórias; Unidades de Terapia Intensiva.

**ABSTRACT** | Objective: To identify predictors of complications in the postoperative period of pediatric cardiac surgery. Method: Quantitative study that retrospectively analyzed 88 medical records of patients undergoing surgical procedure in 2018. Fisher's exact test and the univariate logistic model were applied to analyze the data. The results were expressed by odds ratio (OR) with a significance level of 5%. Results: A mean age of 3.61 years was observed, with a predominance of females. Circulatory, metabolic, renal, respiratory and cardiovascular complications were identified intra- and postoperatively. A predictive statistical correlation of complications was identified in: use of diuretics, hypertension, atrioventricular valve insufficiency, right ventricular hypertrophy, trisomy 21, altered WBCs preoperatively, intraoperative bleeding, pericardial effusion, and postoperative echocardiogram changes. Conclusion: Variables of clinical conditions, medications in use, congenital defects and intraoperative complications when associated with complications found in the postoperative period of cardiopediatric surgeries are shown to be predictive of risk.

**Keywords:** Nursing Care; Thoracic Surgery; Congenital Heart Disease; Postoperative Complications; Intensive Care Units.

**RESUMEN** | Objetivo: Identificar los predictores de complicaciones en el postoperatorio de la cirugía cardíaca pediátrica. Método: Estudio cuantitativo retrospectivo de 88 historias clínicas de pacientes operados en 2018. Se aplicó la prueba exacta de Fisher y el modelo logístico univariante. Los resultados se expresaron mediante odds ratio (OR) con una significación del 5%. Resultados: La edad media era de 3,61 años con mayoría de mujeres. Se identificaron complicaciones circulatorias, metabólicas, renales, respiratorias y cardiovasculares intra y postoperatorias. Se identificó una correlación estadística predictiva de complicaciones en: el uso de diuréticos, la hipertensión arterial, la insuficiencia valvular auriculoventricular, la hipertrofia ventricular derecha, la trisomía 21, la alteración de los leucocitos preoperatorios, la hemorragia intraoperatoria, el derrame pericárdico y las alteraciones en el ecocardiograma postoperatorio. Conclusión: Las variables del estado clínico, los medicamentos en uso, los defectos congénitos y las complicaciones intraoperatorias cuando se asocian a las complicaciones encontradas en el postoperatorio de las cirugías cardiopediátricas se muestran como predictoras de riesgo.

**Palabras claves:** Cuidados de Enfermería; Cirugía Torácica; Cardiopatías Congénitas; Complicaciones Postoperatorias; Unidades de Cuidados Intensivos.

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Recebido em: 15/02/2022

Aprovado em: 30/03/2022

## INTRODUCTION

Congenital heart disease is determined by the presence of malformations in the structure or function of the heart existing from the moment of birth resulting from an alteration in the embryonic development of the cardiac structure. It may be accompanied by clinical signs such as cardiac arrhythmias,

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tachypnea, cyanosis, among others.<sup>(1)</sup>

In the last decades, the mortality of children and adolescents related to congenital heart diseases has been progressively reduced thanks to advances in diagnosis and early treatment. Congenital heart diseases account for 25,757 new cases/year in Brazil. The most common congenital heart diseases are ventricular septal defect (VSD), atrial septal defect (ASD), patent ductus arteriosus (PDA), pulmonary stenosis (PS), coarctation of the aorta (CoAo), tetralogy of Fallot (T4F) and transposition of the great arteries (TGA). Of these, 30% need some intervention in the first 12 months of life.<sup>(2-3)</sup>

The Ministry of Health Ordinance No. 1,727 of July 11th, 2017 points out that approximately 10% of infant deaths and 20% to 40% of deaths resulting from malformations are due to congenital heart disease. It also states that congenital heart diseases represent the third leading cause of neonatal mortality in the country.<sup>(4)</sup> Data updated in 2020 estimate that, for every 1,000 live births in Brazil, ten have some congenital heart disease. Every year, 29,000 babies are affected in the country, with 6% of these dying in the first year of life. In the severe forms of the disease, mortality is even higher, reaching 30% in the neonatal period.<sup>(5)</sup>

Patients with complex congenital heart diseases that rarely reached adulthood today can be active members of society. Surgical corrections performed during childhood can be classified as palliative or corrective, taking into account the cardiac anatomy and hemodynamic repercussions on the child/adolescent. The sooner the surgical intervention is performed, the less future hemodynamic repercussions these heart diseases can bring to patients.<sup>(3,6)</sup>

After undergoing surgical procedures, patients are referred to the Intensive Care Unit (ICU) under nursing care due to the complexity of the intervention performed, thus, specific care is

necessary. These include inspection, evaluation and continuous hemodynamic monitoring of the patient's condition, loss control (drains and probes), dressing care, control of thermoregulatory conditions and sites of possible infection.<sup>(7-9)</sup>

The most common postoperative complications related to organ systems can be pulmonary, such as atelectasis, bronchoconstriction, hypoxemia, acute respiratory distress syndrome, pulmonary edema, intubation or prolonged ventilation; cardiovascular: low cardiac output syndrome, acute myocardial infarction, cardiac tamponade, changes in blood pressure; the neurological ones: lowering of the level of consciousness, stroke, sensory, motor or reflex alterations; renal: reduced renal function with increased creatinine, reduced urinary output and need for dialysis; and infections such as: urinary, pulmonary, surgical site and venous access.<sup>(9-10)</sup>

In view of the above, it is important for nurses to recognize which are the main predictors of complications for this patient profile in the postoperative period of pediatric cardiac surgery and to act to prevent their occurrence in the care provided. Therefore, the aim of this study is to identify predictors of cardiac surgery complications in the postoperative period of pediatric cardiac surgery.

## METHOD

A historical, retrospective and documentary cohort study with a quantitative approach carried out through a survey of the medical records of pediatric patients undergoing cardiac surgery from January to December 2018. It was carried out in a large public institution specialized in cardiology linked to the Health Department of the State of São Paulo, Brazil. Data collection took place from May 2019 to January 2020 as part of the completion of the residen-

cy in cardiovascular nursing. The data collected referred to the surgical procedures that took place between January and December 2018.

The institution has a data information management system, which is the Hospital Medical Archive Service (SAME - Serviço de Arquivo Médico Hospitalar). The selection of medical records was based on an electronic spreadsheet provided by the same with name, age, hospital record (HR), type of surgery and date of performance under the category "congenital".

Inclusion criteria were:  $\leq 17$  years 11 months and 29 days; both sexes; carrier of congenital heart disease; having undergone surgical procedures in 2018; have been admitted to the pediatric ICU in the postoperative period. The exclusion followed the criteria: ICU admission for clinical treatment, after catheterization/angioplasty or due to conditions not associated with the surgical procedure. Thus, 241 medical records met the inclusion and exclusion criteria and of these 88 were selected to compose the sample through sample calculation performed by a statistician. To perform the selection of 88 medical records among the 241, the Software R was used, which allows a random drawing (random) in a certain numerical set, in this case, using the HR numbers.

After the sample selection was defined, the medical records were requested from SAME for data collection. For this, a semi-structured instrument with closed questions was developed by the researchers. The information collected was transcribed and stored in a Microsoft Office Excel® 11 spreadsheet (2013 version). The variables collected included: sociodemographic data (age, weight, gender, ethnicity and education), clinical aspects of congenital heart disease, intraoperative and postoperative period up to 48 hours.

Quantitative variables were expressed as mean, standard deviation,

minimum and maximum. Qualitative variables were expressed as absolute frequency and percentage. To analyze the variables that were associated with complications, Fisher's exact test was applied to qualitative variables, and the univariate logistic model was applied to quantitative variables. Results were expressed by odds ratio (OR). The significance level adopted was 5%.

The study respected the ethical precepts of Resolution No. 466, of December 12th, 2012, of the National Health Council, and was approved by the Research Ethics Committee of Instituto Dante Pazzanese de Cardiologia, under opinion No. 3,297,771 of May 2nd, 2019 and CAAE: 11487519.9.0000.5462.

**RESULTS**

A total of 88 medical records that followed the eligibility criteria participated in this study. 51.1% were female, with a mean age of 3.61 years and a standard deviation (SD) of 3.887, white ethnicity was present in 62.5%, followed by browns (11.4%) and blacks (5.7%). Due to the mean age of the patients, 69.3% were of non-school age.

It was noted that the presence of congenital defects associated with each other was recurrent, a fact evidenced by the sum of defects being greater than the number of the sample. Acyanotic heart disease prevailed over cyanotic heart disease, with 88 patients studied, VSD represented 50% (44), ASD 38.6% (34); FOP 20.5% (18); AVSD 17% (15); PDA 14.8% (13); PS 10.2% (9); AoS 3.4% (3) and CoAo with only 1.1% (1) occurrence. The cyanotic ones found were: T4F 11.4% (10); TGA 3.4% (3); Tricuspid atresia 3.4% (3); APVD 3.4% (3); double outlet right ventricle (DORV) 3.4% (3); Pulmonary Atresia 1.1% (1) and lastly Ebstein's Anomaly 1.1% (1).

The presence of associated comorbidities is represented in order of frequency, as follows: arterial hypertension 62.1% (54); valve alteration 55.7%

(49); Pulmonary hypertension 27.9% (24); Chromosome 21 trisomy (Down syndrome) 24.4% (21); Heart failure 17.2% (15); Hypertrophic cardiomyopathy 5.7% (5); Malformation of vessels 5.7% (5); Hypothyroidism 4.7% (4); Liver disease 2.3% (2); Dilated cardiomyopathy 2.3% (2); Pulmonary trunk hypoplasia 2.3% (2).

Medications for continuous use by these patients fall into the following categories: antihypertensive 53 (62.4%); diuretic 48 (56.5); vitamin supplement 6 (7.1%); hormone replacement 3 (3.5%); corticosteroid 2 (2.4%); leukotriene 2 receptor antagonist (2.4%); antiarrhythmic 1 (1.2%); anticoagulant 1 (1.2%);

From admission to the day of the intervention, the mean time was 7.1 days (standard deviation of 7.580) with a minimum of 1 day and a maximum of 38 days of previous hospitalization. As for the preoperative temperature, 5.7%

(5) of the patients had hypothermia. The use of an intraoperative thermal blanket was recorded in the medical records in 78.4% (69) of the individuals, in 6.8% (6) of them it was not used and in the remaining 14.8% (13) there was no record of the information. Regarding the surgical procedure, Table 1 presents other variables considered.

The complications recorded in the operating room comprised arrhythmias 10.3% (9), of these, 5.7% (5) evolved with the need for pacemaker implantation, followed by bleeding 9.2% (8), desaturation 5.7% (5), bradycardia 5.7% (5), hypotension 4.6% (4), tube adhered to the sternum 1.1% (1), hypertension 1.1% (1), compensated metabolic acidosis 1.1% (1), fever (n=87) 1.1% (1), post cec petechiae 1.1% (1) and finally the occurrence of bronchospasm 1.1% (1).

Alterações no exame de ecocardiograma pós-procedimento estavam pre-

**Table 1 – Characteristics related to surgical intervention. São Paulo, SP, Brazil. (n=88)**

Description of the variable	n	%
<b>Duration of Surgery</b>		
Up to 2 hours	4	4,5
2 to 4 hours	44	50,0
4 to 6 hours	37	42,0
> 6 hours	3	3,4
<b>Use of ECC</b>		
No	5	5,7
Yes	83	94,3
<b>Intraoperative blood components</b>		
No	35	39,8
Yes	53	60,2
<b>Anoxia time</b>		
Mean (standard deviation)	58,94 (34, 319)	-
Minimum	0	-
Maximum	220	-
<b>T (°C) patient's intraoperative</b>		
Mean (standard deviation)	29,72 (2,193)	-
Minimum	19,0	-
Maximum	35,3	-

ECC: Extracorporeal Circulation; T: temperature.

Source: Prepared by the author (2020)

entes em 47,7%<sup>(42)</sup> do total avaliado, 14,8%<sup>(13)</sup> deles apresentavam achados compatíveis com as correções realizadas e em 37,5%<sup>(33)</sup> não foi possível encontrar o laudo do exame em prontuário. As alterações encontradas incluíam: dilatação de cavidades cardíacas, hipertrofia de ventrículo esquerdo e direito, derrame pleural, derrame pericárdico, artéria do tronco da pulmonar dilatado, tronco da pulmonar aumentado, refluxo pós plastia valvar, insuficiência valvar, trombose em prótese, coronária dilatada, retalho cirúrgico mal posicionado, retalho cirúrgico com shunt residual, estenose valvar, neoaorta com refluxo e forame oval patente bidirecional.

The reception electrocardiogram at the ICU showed changes in 21.5%<sup>(17)</sup> patients, characterized by tachycardia, junctional rhythm, irregular rhythm, right and left ventricular overload, left bundle branch block, axis deviation in relation to the preoperative axis, systolic biventricular dysfunction, ST depression in D2 and D3 and 1st degree atrioventricular block.

The intubation time calculated in hours presented an average of 34.51 (standard deviation = 105.218), with a minimum time of 4 hours and a maximum of 960 hours, which corresponds to 40 days. The mean number of days in the ICU was 4.46 (standard deviation of 5.564), with a minimum stay of 2 days and a maximum of 45 days. It was evidenced that 70.5%<sup>(62)</sup> of the patients studied had a length of stay considered long in the unit.

The complications presented in the postoperative period were organized according to the systems that were affected (figure 1). It was found that the complications coexisted and that none of them caused death to the patients.

Regarding the circulatory system, the presence of: hypertension; hypotension; thrombus; hemorrhage/bleeding; thrombocytopenia; hemodynamic instability; low output and drop

in hematocrit; Then, the occurrence of renal disorders was characterized by: oliguria; polyuria; anasarca; congestion; hematuria; acute insufficiency; hyperkalemia and hypokalemia. In the metabolic aspect, the following were noticed: hypoglycemia; hyperglycemia; respiratory acidosis; respiratory alkalosis; metabolic acidosis; mixed acidosis; post-cardiac arrest conditions. Respiratory complications were considered the occurrence of: accidental extubation; bronchospasm; dyspnea; pulmonary congestion; pneumothorax; pleural effusion; atelectasis; presence of secretion in the airway; pneumomediastinum and poorly positioned orotracheal cannula. The presence of cardiac arrest was considered a cardiovascular complication; arrhythmia; buffering; bradycardia and tachycardia. No records were found in the medical records of neurological alterations in the first 48 hours after surgery.

Intraoperative bleeding is statistically associated with an increased risk of cardiovascular complications with an odds ratio of 9.48 compared to patients who did not experience bleeding. The occurrence of pericardial effusion on the echocardiogram in the immediate postoperative period (OR=9.60) was also statistically significant. The presence of altered leukocytes in laboratory tests, below or above the reference values, presents a metabolic risk ratio

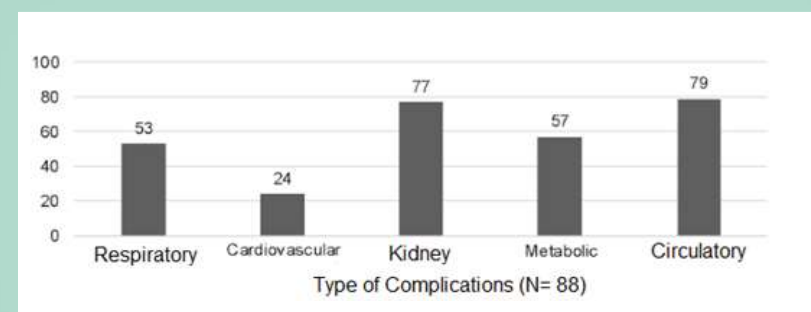
of 7.556.

The use of diuretics prior to surgical treatment was 6,345 (p=) times more likely to have postoperative renal events. Arterial hypertension stands out as a predictor of renal (OR=4.577) and respiratory (OR=2.850) risk. The presence of changes in the post-surgical echocardiogram is also a risk variable concomitant with the renal (OR 5.778) and respiratory (OR 5.019) systems.

Atrioventricular valve insufficiency showed an 11,050 (OR) times greater risk of having respiratory complications. The occurrence of right ventricular hypertrophy (OR 12.571) and syndromic conditions, such as trisomy of chromosome 21 (OR 9.212) also increase the risk of unwanted post-procedure events in this category. A perceived associated condition was that respiratory (OR 2.864) and cardiovascular (OR 4.217) complications cause a longer stay in the ICU than the protocol in the institution.

As predictors of protection for the circulatory system, the following were identified: IAC (OR 0.148) and Pulmonary Stenosis (OR 0.164). Tricuspid insufficiency (OR 0.217) was relevant in protecting against metabolic events. VSD (OR 0.185), TGA (OR 0.059) and DORV (OR 0.059) proved to be protective of the renal system. Concerning the quantitative variables, age (OR 0.892) decreases the chance of having respi-

Figure 1. Types of complications presented up to 48 hours after surgery. São Paulo, SP, Brazil.



Fonte: Elaborado pelo autor (2020)



ratory complications by 11% for each year of life and each centimeter of height (OR 0.978) decreases the occurrence of unwanted cardiovascular events by 2%.

The surgical size of the operation, even being related to the severity of the heart disease, did not show statistical significance (p=0.930) as a predictor of postoperative complications. The p-value of predictors of postoperative complications is highlighted in Table 2.

**DISCUSSION**

Complications are usually common in the postoperative period and may vary in terms of the risk to life they may present. In addition, risk factors for postoperative complications of pediatric cardiac surgery have not yet been fully elucidated.

Studies show that congenital heart disease associated with genetic syndro-

mes has a high risk of intraoperative and long-term mortality due to the presence of comorbidities in several systems. The main causes of death are related to the cardiovascular system, followed by the pulmonary system. Postoperative pulmonary complications increase the length of hospital stay, costs and the chances of developing nosocomial illnesses. (12-13) The results found confirm that syndromic patients are more likely to develop respiratory events and that the length of hospital stay is related to complications.

The incidence of Acute Renal Failure (ARF) after pediatric cardiac surgery is high and may be related to longer duration of mechanical ventilation, inotropic support, stay in the Intensive Care Unit (ICU), use of cardiopulmonary bypass (CPB), Renal Replacement Therapy (RRT) and prolonged hospital stay. Therefore, AKI makes the clinical course more complicated, with an

impact on the morbidity and mortality ratio. (14)

Authors describe that pediatric patients with cyanotic congenital heart disease are at high risk for developing AKI after cardiac surgery. Hydroelectrolytic, acid-base and glycemic complications are usually frequent in procedures associated with ECC due to tissue anoxia. (15-16) The renal and metabolic predictors when related to the use of CPB did not show statistical significance, differing from the literature.

In this study, patients evolved with the need for a pacemaker due to arrhythmias. The incidence of postoperative heart block requiring permanent pacemaker placement immediately after congenital heart surgery is usually low. However, postoperative ventricular arrhythmias have a twofold increased risk of in-hospital mortality. (17-18)

Bleeding is frequent during and after pediatric cardiac surgeries and he-

**Table 2 – Predictors of postoperative complications after association of variables. São Paulo, SP, Brazil. (n=88)**

	OR	p-value	OR	p-value	OR	p-value	OR	p-value	OR	p-value
Bleeding	9,480	0,006	-	-	-	-	-	-	-	-
Pericardial Effusion	9,602	0,041	-	-	-	-	-	-	-	-
Longer stay in the ICU	4,217	0,047	-	-	-	-	2,864	0,033	-	-
Height	0,978	0,032	-	-	-	-	-	-	-	-
Altered leukocytes	-	-	7,556	0,044	-	-	-	-	-	-
Tricuspid Insufficiency	-	-	0,027	0,022	-	-	-	-	-	-
Diuretics	-	-	-	-	6,345	0,018	-	-	-	-
Arterial hypertension	-	-	-	-	4,557	0,038	2,850	0,025	-	-
Echocardiogram changes PO	-	-	-	-	5,778	0,046	5,019	0,023	-	-
VSD	-	-	-	-	0,185	0,049	-	-	-	-
TGA	-	-	-	-	0,059	0,040	-	-	-	-
DORV	-	-	-	-	0,059	0,040	-	-	-	-
AVVI	-	-	-	-	-	-	11,050	0,007	-	-
RVH	-	-	-	-	-	-	12,571	0,008	-	-
Trisomy chromosome 21	-	-	-	-	-	-	9,212	0,002	-	-
Age	-	-	-	-	-	-	0,892	0,047	-	-
ASD	-	-	-	-	-	-	-	-	0,148	0,025
PS	-	-	-	-	-	-	-	-	0,164	0,046

\*PO= Postoperative; (-)= variables did not show statistical significance; AVVI= atrioventricular valve insufficiency; RVH = right ventricular hypertrophy.

Source: Prepared by the author (2020)

modynamic instability can be found associated with this factor. A frequent and expected physiological challenge after pediatric cardiac surgery that requires extremely diligent bedside monitoring and careful intervention is low output. The etiology is usually multifactorial and may be related to load change, injury and myocardial dysfunction.<sup>(19-20)</sup>

Some variables in this study were shown to be protective predictors. This fact can be explained by the treatment bias, showing that the best care provided to these patients reduces the risk of complications. This is because early detection and correct diagnosis allow the stabilization of the patient with severe heart disease and reduce the occurrence of complications, improving the results of the child's growth and

development.<sup>(21)</sup>

The findings of this research must be evaluated considering some limitations of the design of this study. First, as it is a documental study, secondary data from medical records were analyzed retrospectively, so there may be a failure to record information. Second, some information may have been misplaced because the institution's medical record is not electronic. Finally, the generalization of data may be limited because it is a single-center study.

#### CONCLUSION

Variables of clinical conditions, medications of continuous use, congenital defects, syndromes and intraoperative complications when associated

with cardiovascular, renal, pulmonary and circulatory complications found in the postoperative period of pediatric cardiology surgeries are shown to be clinical predictors of risk.

Early identification of predictors of protection and complications for pediatric congenital heart surgery can help improve patient care, decision making, treatment choice,

in reducing the length of stay and complications presented and, consequently, in reducing the cost of treatment. In view of the results, it is clear that nursing care aimed at preventing health problems in children with congenital heart disease directly reflects on their postoperative recovery.

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