RCMOS – Multidisciplinary Scientific Journal of Knowledge.
ISSN: 2675-9128. São Paulo-SP.
Year V, v.1 2025. | submission: 22/09/2025 | accepted: 24/09/2025 | publication: 26/09/2025

Profile of patients with acute kidney injury in the postoperative period of cardiac surgery in a referral hospital in Salvador – BA

Profile of patients with acute kidney injury in the postoperative period of cardiac surgery at a referral hospital in Salvador, Bahia

Anna Vitória Carvalho de Andrade – Bahian School of Medicine and Public Health
Maria Eduarda Carvalho de Andrade – Salvador University

SUMMARY

Introduction: Acute kidney injury is the second most common major complication in the postoperative period of cardiac surgery, accounting for longer hospital stays, the need for renal replacement therapy, and higher mortality rates. Its development is related to pre-, intra-, and postoperative risk factors, such as previous comorbidities, type of surgery performed, cardiopulmonary bypass time, need for blood component transfusions, and use of vasoactive drugs. **Objectives:** To describe the profile of patients with acute kidney injury in the postoperative period of cardiac surgery at Ana Nery Hospital, in Salvador, Bahia. **Methodology:** This is an observational, descriptive, cross-sectional study with a control group, using secondary data obtained from the electronic medical record system of Ana Nery Hospital, in Salvador, Bahia. **Results:** Among the 1,132 patients included in the study, 22 presented acute kidney injury in the postoperative period.

The main comorbidities in these patients were systemic arterial hypertension, with a prevalence of 77.7% among those affected, compared to 64.9% in the general population; type 2 diabetes mellitus, with a prevalence of 31.8% among those affected and 25.2% in the total population; and endocarditis, with a prevalence of 22.7% among those affected and 4% in the total population. Among the main intraoperative factors, a 59.1% prevalence of blood component transfusion was observed in the affected population, compared to 30.1% in the total population. Among the postoperative factors, the median creatinine was 2.85 mg/dL among affected patients, compared to 0.68 mg/dL in the general population. **Conclusion:** Identifying risk factors is essential, as it allows for patient profiling and developing strategies to prevent the onset of acute kidney injury, contributing to better surgical outcomes, shorter hospital stays, reduced renal replacement therapy and mortality rates, and reduced associated hospital costs.

Keywords: Acute kidney injury in the postoperative period of cardiac surgery. Acute kidney injury. Cardiac surgery.

ABSTRACT

Background: Acute kidney injury is the second most common major complication in the postoperative phase of cardiac surgeries, being responsible for longer hospital stays, the need for dialysis, and higher mortality rates. Its development is related to preoperative, intraoperative, and postoperative risk factors, such as patients' preexisting comorbidities, type of sur-gery, duration of cardiopulmonary bypass, need for blood transfusion, and use of vasopressor agents.

Objectives: To describe the profile of patients with cardiac surgery-associated acute kidney injury at Hospital Ana Nery, in Salvador, Bahia. **Methodology:** Observational, descriptive, cross-sectional study with a control group, using secondary data obtained from the electronic health records of Hospital Ana Nery, Salvador, Bahia. **Results:** Among the 1,132 patients included in the study, 22 developed postoperative acute kidney injury. The main comorbidities among these patients were systemic arterial hypertension, with a prevalence of 77.7% among the affected patients and 64.9% in the general population; type 2 diabetes mellitus, with a prevalence of 31.8% among the affected patients and 25.2% in the general population; and en-docarditis, with a prevalence of 22.7% among the affected patients and 4% in the general population. Among intraoperative factors, 59.1% of the affected patients required blood transfusion, compared to 30.1% of the general population. Regarding postoperative factors, the median postoperative creatinine level was 2.85 mg/dL in the affected group, compared to 0.68 mg/dL in the general population. **Conclusion:** Identifying risk factors is essential, as it allows for patient profiling and the development of strategies to prevent acute kidney injury, improve surgical outcomes, shorten hospital stays, reduce the need for dialysis and mortality rates, and consequently lower hospital costs.

Key-words: Cardiac surgery-associated acute kidney injury. Acute kidney injury. Cardiac surgery.

1. INTRODUCTION

Acute Kidney Injury (AKI) is characterized by a sudden decline in kidney function, resulting in your diagnosis made from the identification of increased creatinine and urea serum levels or decreased urine volume, potentially reversible after identification of its triggering factor1, and being classified according to the criteria Kidney Disease Improving Global Outcomes (KDIGO):

Internship	Increased Serum Creatinine	Decline in Urinary Output
1	ÿ0.3 mg/dL or 1.5 to 1.9 times baseline	<0.5 mL/kg/h for 6 to 12 hours
2	2 to 2.9 times baseline	<0.5 mL/kg/h for ÿ12 hours
3	ÿ4.0 mg/dL or ÿ3 times baseline	<0.5 mL/kg/h for ÿ24 hours or anuria for ÿ12 hours

Patients with heart disease and those undergoing cardiac surgery are at increased risk of developing acute kidney injury due to hemodynamic compromise, extracorporeal circulation, intravenous contrast media, and angiotensin-converting enzyme inhibitors. Acute kidney injury is associated with increased morbidity and mortality, longer hospital stays, and higher hospital costs in these patients.1

Among patients undergoing cardiac surgical procedures, approximately 7% to 30% develop acute kidney injury, according to Kochi 2

2 THEORETICAL FRAMEWORK

Cardiac surgeries are often associated with renal hypoperfusion, which results from low cardiac output, low blood pressure and low temperatures caused by the use of extracorporeal circulation.3,4 In addition, there is also aortic clamping, which increases the chances of renal atheroembolism, which can exacerbate ischemia and induce inflammation, requiring transfusion of large volumes of blood components, administration of high doses of vasopressor drugs, which increases the risk of injury renal, when compared to non-cardiac surgeries. 3, 4, 5

The pathophysiology of acute kidney injury after cardiac surgery is not yet completely known, and involves factors such as hypoperfusion, ischemia-reperfusion-related injury, neurohumoral activation, inflammation, oxidative stress, nephrotoxins and mechanical factors.3,4 These factors may be interrelated and present synergism between them, some of them perpetuating from pre to post-operative. [3]

The use of extracorporeal circulation is a major risk factor, and this is due to the inflammatory responses materials and oxidative stress generated by the contact of blood with the artificial surface of the machine, as well as well as changes in regional blood flow with imbalance in the perfusion of the cortex and medulla of the kidney, to renal vasomotor tone, and the reduction in oxygen pressure in the renal parenchyma caused by this device.4,6 Extracorporeal circulation can also induce hemolysis, which leads to the release of he-intravascular free haptoglobin that causes depletion of circulating haptoglobin and consequently direct injury to the endothelium and tubular epithelium through iron-facilitated free radical oxidation.6,7

Long exposure times of cardiopulmonary bypass and aortic clamping also are associated with a higher risk of acute kidney injury, but there is still insufficient evidence to what would be a safe exposure time.5,7

Exposure to drugs that may have nephrotoxic effects, such as antibiotics and anti-inflammatories nonsteroidal antidepressants, is also common in patients undergoing cardiac surgery.,3,8

Correlation between risk factors and scores in the Cleveland Score

Variable	Score
Female	1
Congestive Heart Failure	1

RCMOS – Multidisciplinary Scientific Journal of Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Left Ventricular Ejection Fraction <35%	1
COPD	1
Insulin-dependent diabetes	1
Previous Cardiac Surgery	1
Preoperative Use of Aortic Balloon	2
Emergency Surgery	1
Revascularization Surgery	0
Valve Surgery	1
Coronary Artery Bypass + Valve Surgery	2
Other Surgeries	2
Preoperative Creatinine 1.2 to 2.1mg/dL	2
Preoperative Creatinine >2.1mg/dL	5

Activation of the renin-angiotensin-aldosterone system occurs due to hemodynamic changes, and pro-
moves the production of vasopressin and endothelin[1], leading to systemic vasoconstriction and consequent hy-
renal perfusion.3,9 In addition, patients undergoing cardiac surgery were usually victims of
but myocardial infarction or valvular disease with reduced cardiac output, which contributes to
renal hypoperfusion, and increases the risk of post-surgical injury 5
A number of preoperative factors can increase the risk of developing kidney injury, including
that a scoring system, called the Cleveland Score, was created to predict the chance of
the patient may require renal replacement therapy after surgery; the variables used to calculate
cular this score are as follows:

Correlation between Cleveland Score and Dialysis Risk

Score	Dialysis Risk
0-2	0.4%
3-5	1.8%
6-8	7.8-9.5%
9-13	21.5%

The use of predictive scores such as the Cleveland score allows for the monitoring of patients with greater risk of severe kidney injury, in order to develop effective prevention strategies to try to reduce its incidence., 3,8,10

Obesity has also been independently associated with a higher risk of acute kidney injury after cardiac surgery, particularly in patients with a BMI greater than 40 kg/m² (grade 1 obesity).
3).11 Obesity is a chronic state of inflammation, with the release of pro-inflammatory cytokines, such as interleukins 6 and 10 and tumor necrosis factor ÿ, and changes in hormonal axes, with more activation frequent of the renin-angiotensin-aldosterone system, which in non-obese patients, which is related-kidney injury.11 In addition, microvascular changes due to hyperglycemia are also more common in obese individuals, which leads to changes in the endothelium and renal mesangial cells, making them more susceptible to injury.¹1

Intraoperative transfusion of packed red blood cells also appears to be a risk factor for development of kidney damage, despite the intention of improving oxygen supply and conse-the functioning of the organs.3,7,8,12 Red blood cells from concentrates stored for periods longer than flowers at 14 days become less deformable, suffer depletion of ATP and 2,3-diphosphoglycerate, lose their ability to generate nitric oxide, are more adherent to the vascular endothelium, accumulate pro-molecules inflammatory and release iron and hemoglobin.7,12 Because of this, the transfusion of previously concentrated stored mind can hinder oxygen transport, induce pro-inflammatory states, increase the oxidative stress and activate the coagulation cascade. 7, 12

For the diagnosis of acute kidney injury associated with cardiac surgery, the most commonly used markers are, urinary output, which has the disadvantage of being relatively nonspecific, and the increase in cre-serum tinin, the accuracy of which may be compromised by physiological processes such as urinary clearance of creatinine and muscle mass of each individual, by drugs that block the tubular secretion of creatinine creatinine, and diseases such as diabetes and liver disease.3,9 In addition, serum creatinine often rises approximately 24 to 72 hours after the onset of kidney damage, thus delaying diagnosis and initiation of treatment.3,9,13,14 Thus, new biomarkers of kidney injury are beginning to be used, such as IGFBP7 *(insulin-like growth factor-binding protein* 7) and TIMP-2 *(tissue inhibitor of metalloproteinases-2),* mar-tubular injury and stress indicators detectable through urine tests, and that, in tests with models animals and in preliminary studies with humans, it has shown to be a promising marker of injury renal, having demonstrated a strong association between its elevation upon admission of patients to the UTI and the occurrence of kidney injury in the following 48 hours, according to a prospective cohort study by Oezkur. 3,13,14,15,

There is currently no pharmacological intervention that has been consistently associated with renal protection, which is probably due to the complex pathophysiology of the disease, mostly of the strategies should be guided by the increase in serum creatinine levels, which only occurs after kidney damage has already occurred. have been installed, most of the patient populations studied have a low risk of developing kidney injury after the use of cardiopulmonary bypass, which may mask the small benefits of therapies, most clinical trials involve a small number of patients, making them ineffective. suitable for finding small benefits of the therapies tested. 14

Some perioperative strategies, however, can be considered to try to reduce the incidence of pathology, such as postponing elective surgeries for patients who already have kidney damage acute reversible in the preoperative period.14 The suspension of potentially nephrotoxic drugs also is also recommended, such as NSAIDs (non-steroidal anti-inflammatory drugs), aminoglycoside antibiotics, radiological contrasts, angiotensin-converting enzyme inhibitors, receptor blockers of angiotensin. 5.14

To reduce the risk of acute kidney injury from packed red blood cell transfusion, the *Society of Cardiovascular Diseases (SCCD) diothoracic Surgeons* and Society *of Cardiovascular Anesthesiologists* recommends the use of pre-surgical interventions that increase blood volume, such as erythropoietin, or strategies that decrease intra- and post-operative bleeding, such as autologous blood retransfusion techniques, called *Cell-saving techniques.* 7, 12

One way to reduce the risk of kidney injury is to reduce the use of extracorporeal circulation, which can be done in some surgeries, such as coronary bypass, in which there is the possibility of performing performing surgery with the heart beating, which would guarantee greater physiological renal perfusion, reducing would reduce the systemic inflammatory response and cause less embolization.5,7,15 Another way to reduce these risks in surgeries in which cardiopulmonary bypass is essential is the use of machines extracorporeal circulation that are capable of producing a pulsatile flow, increasing the mechanical energy transmitted, which results in increased release of vasodilator substances, lower resistance systemic vascular disease, decreased edema and improved tissue metabolism.16

Acute kidney injury after cardiac surgery increases morbidity and mortality not only in the postoperative period immediately, but also in the subsequent 10 years, even in patients with complete recovery, the which may be due to the profile of these patients, since AKI after cardiac surgery usually affects mostly elderly people, people with associated comorbidities and patients who have faced some surgical complication.16 In some patients the surgical procedure may have exposed an injury

latent renal disease due to hypertension, focal obstruction of the renal artery, or generalized atherosclerotic disease.
zada.16

2. MATERIAL AND METHOD

1. Study Design

This is an observational, descriptive, cross-sectional study with a control group.

2. Place and Period of Study

The study site is the Ana Nery Hospital, in Salvador, linked to the Unified Health System (SUS),
state reference for highly complex procedures in the areas of cardiology, nephrology and surgery.
vascular surgery.
The study period was between 01/01/2020 and 31/12/2021

3. Study Population

The target population was patients undergoing cardiac surgery at the Ana Nery Hospital, in Salvador, Bahia.

Inclusion Criteria: All patients over 18 years of age undergoing cardiac surgery.

Exclusion Criteria: Patients with chronic kidney disease requiring dialysis.

4. Sample

A convenience sample was made of patients undergoing cardiac surgery at the Hospital
Ana Nery, between January 2020 and December 2021, and who fit the inclusion criteria, and do not meet the exclusion criteria.

5. Data Sources

The relevant information was obtained through a secondary database, built through
of the electronic medical record system of Hospital Ana Nery.

6. Data Collection Instruments

A database in Excel spreadsheet format was used, created from the
electronic medical records from Ana Nery Hospital, which were later exported for analysis
in the Statistical Package for Social Science (SPSS) version 25.

7. Study Variables

Demographic Variables: Age and Sex.

Preoperative Variables: Systemic Arterial Hypertension, Type 2 Diabetes Mellitus, Heart Failure
Heart Failure with Reduced Ejection Fraction, Stroke, Acute Myocardial Infarction
Myocardial Infarction, Chronic Kidney Disease, Endocarditis, Use of Transcatheter-Converting Enzyme Inhibitors
Angiotensin II Receptor Blockers, Intra-Aortic Balloon, Value
Preoperative Creatinine Level.

Intraoperative Variables: Extracorporeal Circulation Time, Aortic Clamping Time
tico, Blood Component Transfusion, Type of Surgery.

Postoperative Variables: Postoperative Creatinine Value, ICU Time, Vasoactive Drug Time (VAD),
Renal Replacement Therapy, Death.

8. Data Analysis Plan

The database is stored in a table in the Excel program, with subsequent export to
analysis in the Statistical Package for Social Science (SPSS) version 25. The
distribution of ordinal and qualitative categorical variables, using parametric tests
metrics for those with normal distribution.

9. Ethical Aspects

The research project was submitted to the Ethics Committee of the Ana Nery Hospital, meeting the
requirements of Resolution No. 466/12 of the National Health Council. The researchers com-
promise to preserve the anonymity of all research participants. The data obtained from
study in question were collected anonymously and confidentially, and the information obtained
were used exclusively for academic and scientific purposes. After analyzing the data,
they will remain stored in a safe place, with the main researcher, and deleted
within a maximum period of 5 years. The research project was approved through opinion 5,576,630
of the Ethics Committee of Hospital Ana Nery, on 08/11/2022

2. RESULTS AND DISCUSSION

In the sample analyzed there was a predominance of males, corresponding to 54% of the population (611
patients), with a median age of 57 years.

RCMOS – Multidisciplinary Scientific Journal of Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Table 1 - Analysis of demographic variables of the population undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=1,132)

Variable	Analysis
Sex	Male - 611, 54.00% Female - 521, 46.00%
Age (in years)	57.00 (45-66)

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

In the analyzed sample, the percentage of hypertensive patients corresponded to 64.9% (731 patients), that of type 2 diabetics 25.2% (286 patients), the percentage of patients with heart failure with reduced ejection fraction corresponded to 16.3% of patients (182 patients); 23.4% of patients suffered a previous acute myocardial infarction (264 patients), and 4% of patients had a history of endocarditis (45 patients).

Table 2 - Analysis of preoperative variables of the population undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=1,132)

Variable	Analysis
Systemic Arterial Hypertension	731, 64.9%
Type 2 Diabetes Mellitus	286, 25.2%
Heart Failure with Reduced Ejection Fraction	182, 16.3%
Stroke	81, 7.2%
Chronic Kidney Disease	69, 6.1%
Acute Myocardial Infarction	264, 23.4%
Endocarditis	45.4%
Intra-Aortic Balloon	20, 1.8%
Angiotensin-Converting Enzyme Inhibitor/Angiotensin Receptor Blocker	339, 30.3%
Preoperative Creatinine (in mg/dL)	1.02 (1.95)

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used, and for those with normal distribution, the mean and standard deviation were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

In the sample analyzed, the median extracorporeal circulation time was 70 minutes, and the median aortic clamping time was 60 minutes.

Table 3 - Analysis of intraoperative variables of the population undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=1,124)

Variable	Analysis
Extracorporeal circulation time (in minutes)	70 (55-95)
Aortic Clamping Time (in minutes)	60 (43-80)
Blood Component Transfusion	30.1% (337)

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

The most frequent type of surgery performed was valve replacement/plasty, corresponding to 45.4% of the total (515 patients), followed by myocardial revascularization, which corresponded to 38.4% (435 patients).

Table 4 - Analysis of the frequency of the type of surgery to which the population underwent, at Hospital Ana Nery, between January/2020 and December/2021 (N=1,124)

Type of Surgery	Analysis
Myocardial Revascularization	435, 38.4%
Valve Replacement/Plasty	515, 45.4%
Valve Replacement + Myocardial Revascularization	51, 4.5%
Bono's Bentall Surgery	40, 3.5%
Ascending Aorta Replacement	15, 1.3%
Correction of Congenital Heart Disease	36, 3.2%
Other Surgeries	42, 3.7%

For the analysis of categorical variables, the absolute N and the valid percentage were used.

In the analyzed sample, 1.4% of patients required renal replacement therapy (16 patients) and 4.9% of patients (55 patients) died.

Table 5 - Analysis of postoperative variables of the population undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=1,124)

Variable	Analysis
Vasoactive Drug Time (in hours)	24 (4-48)
ICU time (in days)	3 (2-4)
Renal Replacement Therapy	16, 1.4%

Postoperative Creatinine Value (mg/dL)	0.68 (0.53-0.86)
Death	55, 4.9%

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

In the sample of patients who developed acute kidney injury, there was a predominance of males, corresponding to 54.5% of the sample (16 patients), with a median age of 53.5 years.

Table 6 - Analysis of demographic variables of the population that suffered acute kidney injury after undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=22)

Variable	Analysis
Sex	Male - 12, 54.50% Female - 10, 45.50%
Age (in years)	53.50 (41-68)

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

In the sample of patients who developed acute kidney injury, the percentage of hypertensive patients corresponded to 77.7% (16 patients), the percentage of type 2 diabetics corresponded to 31.8% (7 patients), the percentage of patients with heart failure with reduced ejection fraction corresponded to 9.1% of patients (2 patients); 27.3% of patients suffered a previous acute myocardial infarction (6 patients), and 22.7% of patients had a history of endocarditis (5 patients).

Table 7 - Analysis of preoperative variables of the population that suffered acute kidney injury after undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=22)

Variable	Analysis
Systemic Arterial Hypertension	16, 77.7%
Type 2 Diabetes Mellitus	7, 31.8%
Heart Failure with Reduced Ejection Fraction	2, 9.1%
Stroke	2, 9.1%
Chronic Kidney Disease	3, 13.6%
Acute Myocardial Infarction	6, 27.3%
Endocarditis	5, 22.7%
Intra-Aortic Balloon	0

Angiotensin-Converting Enzyme Inhibitor/Angiotensin Receptor Blocker	8, 36.4%
Preoperative Creatinine (in mg/dL)	0.98 (0.70-1.29)

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

In the sample analyzed, the median extracorporeal circulation time was 62.5 minutes, and the median aortic clamping time was 47.5 minutes.

Table 8 - Analysis of intraoperative variables of the population who suffered acute kidney injury after undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=22)

Variable	Analysis
Extracorporeal circulation time (in minutes) 62.5 (51.5-97.5)	
Aortic Clamping Time (in minutes)	47.5 (43.75-81.25)
Blood Component Transfusion	13, 59.1%

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

The most frequent type of surgery performed was valve replacement/plasty, corresponding to 50% of the total (11 patients), followed by myocardial revascularization, which corresponded to 36.4% (8 patients).

Table 9 - Analysis of the frequency of the type of surgery to which the population who suffered acute kidney injury after undergoing cardiac surgery at Hospital Ana Nery underwent, between January 2020 and December 2021 (N=22)

Type of Surgery	Analysis
Myocardial Revascularization	8, 36.4%
Valve Replacement/Plasty	11, 50%
Valve Replacement + Myocardial Revascularization	0
Bono's Bentall Surgery	0
Ascending Aorta Replacement	1, 4.5%
Correction of Congenital Heart Disease	0
Other Surgeries	2, 9.1%

For the analysis of categorical variables, the absolute N and the valid percentage were used.

In the analyzed sample, 1.4% of patients required renal replacement therapy (16 patients) and 4.9% of patients (55 patients) died.

Table 10 - Analysis of postoperative variables of the population that suffered acute kidney injury after undergoing cardiac surgery at Hospital Ana Nery, between January 2020 and December 2021 (N=22)

Variable	Analysis
Vasoactive Drug Time (in hours)	24 (9.5-142)
ICU time (in days)	3 (2.5-17)
Renal Replacement Therapy	6, 28.6%
Postoperative Creatinine Value (mg/dL)	2.85 (1.55-3.83)
Death	2, 9.1%

For descriptive analysis of numerical variables with non-normal distribution, the median and IQR (interquartile range) were used. For analysis of categorical variables, the absolute N and the valid percentage were used.

Acute kidney injury is the second most common major complication in the postoperative period of cardiac surgery, associated with increased morbidity and mortality and higher costs to the healthcare system. Several studies in the literature have attempted to profile the most affected patients, and risk factors can be divided into modifiable and non-modifiable, and pre-, intra-, and postoperative.
[17]

Among the main non-modifiable preoperative risk factors are diabetes mellitus and systemic arterial hypertension, which was confirmed by this study, as 77.7% of patients with acute kidney injury as a complication were hypertensive and 31.8% were diabetic, compared to a prevalence of 64.9% of hypertensive and 25.2% of diabetic individuals in the general population. In the case of hypertension, this is likely due to chronic damage to the vessels, glomeruli, and interstitial tubules, leading to progressive renal damage that can rapidly progress to acute renal failure in situations of "circulatory stress."

17,18 And in the case of diabetes mellitus, the likely explanation is the chronic lesions generated in the mesangial cells and glomeruli due to the prolonged hyperglycemic state, which also leads to progressive renal damage, which can rapidly evolve into acute renal failure in situations of “circulatory stress”.
[17,19]

The literature also lists heart failure as a risk factor, which is in contradiction with this study, in which only 9.1% of affected patients had this disease, compared to a prevalence of 16.3% in the general population. This discrepancy may be explained by the fact that this study only considered heart failure patients with a reduced ejection fraction, which may have underestimated the numbers.17

Previous strokes are also found in the literature as predisposing factors for the development of acute kidney injury after cardiac surgery, which can be confirmed by this study, since 9.1% of affected patients had a previous history of stroke, compared to 7.2% of the general population. 5 Previous acute myocardial infarction is also a risk factor, which is consistent with this study, since 27.3% of affected patients had already had an infarction, compared to 23.4% of the general population. This can be explained both by the lower renal perfusion in patients with a history of infarction and by the fact that a large proportion of patients who underwent coronary artery bypass grafting (CABG), which comprised 36.4% of the affected population, underwent this procedure as a form of treatment for acute myocardial infarction. 5

The use of antibiotics is also an important risk factor for the development of acute kidney injury, due to the fact that many are nephrotoxic and can lead to acute interstitial nephritis or

direct injuries, which was confirmed by this study, since 22.7% of affected patients presented endocarditis, compared to 4% of the general population, having to be treated with antibiotics. The high number of patients with endocarditis who presented acute kidney injury can also be explained by the fact that valve diseases are a predisposing factor for bacterial endocarditis, and 50% of the surgeries performed on patients affected by kidney injury were aimed at correcting valve diseases.20 Furthermore, the state of Bahia has high rates of rheumatic fever, a disease that also constitutes an important risk factor for the development of endocarditis and valve diseases.21

Chronic kidney disease is also a risk factor, as it can be exacerbated by circulatory stress caused by cardiac surgery, which was confirmed by this study, since 13.6% of affected patients had chronic kidney disease, compared to 6.1% of patients in the general population.5

Furthermore, preoperative and non-modifiable demographic factors are identified, and according to the literature, there is a higher incidence of acute kidney injury among female patients and older patients.10 This study found a prevalence of 45.5% of affected female patients, which could be explained by the lower number of surgeries performed on women, 46%, or by the lower number of comorbidities, or greater clinical instability of male patients. Regarding age, the median age of the affected population was 53.5 years, compared to 57 years of the general population.

The preoperative use of an intra-aortic balloon constitutes a preoperative risk factor for the development of renal injury in the postoperative period. The balloon consists of a mechanical circulatory support device and is indicated in cases of persistent myocardial ischemia, cardiogenic shock, heart failure refractory to treatment, refractory ventricular arrhythmias, and in the preoperative period of high-risk myocardial revascularization surgeries.22 Its use constitutes a risk for renal injury due to the profile of patients who use it being individuals with significant clinical deterioration and circulatory problems that predispose to renal hypoperfusion.23 None of the patients with renal injury in this study used the intra-aortic balloon, compared to 1.8% of the general population. One hypothesis for this occurrence is the low availability of this device, which is usually used in very few cases and in very serious patients.

The use of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers constitute a risk factor for the development of acute kidney injury, due to their vasodilatory effect on the efferent arteriole, which can result in a reduction in intraglomerular filtration pressure, and consequently in renal hypoperfusion, although they are considered protective medications for patients with chronic kidney disease, in addition there is still not much information about which patient profile would be more predisposed to developing acute kidney injury with the use of this class of drugs.24,25 Regarding the patients in this study, 30.3% of the general population used medications from these classes of drugs, against 36.4% of the affected population.

Elevated preoperative creatinine values are also an important risk factor, as they indicate a possible deficit in renal function, and therefore less resistant to the circulatory stress to which the patient is subjected during cardiac surgery. However, this study found that the median preoperative creatinine of the population affected by renal injury was 0.98 g/dL, while the average creatinine of the unaffected population was 1.02 g/dL.

Regarding intraoperative factors, the type of surgery constitutes a risk factor for this clinical outcome, with valve replacements and valvuloplasties representing a greater risk than myocardial revascularization, and myocardial revascularizations performed together with valve repairs representing an even greater risk.5,10 The greater risk of valve repairs and valvuloplasties was confirmed by this study, since this

This type of surgery was performed by 50% of affected patients, compared to 36.4% of myocardial revascularization surgeries, which may be due to the longer surgical time and circulatory bypass and aortic clamping of valve surgeries, as well as their greater association with comorbidities, such as heart failure.5,10 In contrast, none of the affected patients in this study underwent combined myocardial revascularization surgery associated with valve replacement or repair, which can be explained by the small number of these surgeries performed during the period covered by the research, of only 51 surgeries.

Emergency surgeries are also an important risk factor for the development of acute kidney injury, however, the Ana Nery hospital, where the study was carried out, does not have an emergency room unit, receiving patients through the Regulation Center, because of this, patients undergo surgeries when they have already been hemodynamically stabilized, therefore we did not find any emergency surgeries in this work.26

Intraoperative transfusion of blood components also constitutes a risk factor, especially red blood cell concentrates, as red blood cells in concentrates stored for a period longer than 14 days become less deformable, suffer ATP depletion, accumulate pro-inflammatory molecules and release iron and hemoglobin, which can hinder oxygen transport, increase oxidative stress and activate the coagulation cascade.7,12 This risk factor is confirmed by this study, since 30.1% of the general population underwent transfusion, compared to 59.1% of the affected population.
Other possible explanations for blood transfusion as a risk factor are its association with surgical complications and more unstable clinical conditions, which also favor the occurrence of acute kidney injury.

Among the intraoperative and modifiable risk factors are the time of aortic clamping and the time of use of extracorporeal circulation, which are associated with low cardiac output, hypothermia, and consequent renal hypoperfusion.5,7 This study found a median extracorporeal circulation time of 62.5 minutes in the population affected by acute kidney injury, against a median of 70 minutes in the general population. One hypothesis for this disagreement is the knowledge of the risk factor constituted by a long time of extracorporeal circulation, which may have led the surgical team to rush procedures in patients with a greater number of comorbidities, or more severe and poorly controlled comorbidities, in order to try to avoid the development of renal complications, which may not have been possible in this entire class of patients due to the preponderance of other pre- and postoperative and non-modifiable risk factors. This may also explain the disagreement in the literature regarding the time of anoxia, the median of which was 60 minutes in the general population and 47.5 minutes in the population affected by acute kidney injury.

Postoperative hemodynamic instability is also a risk factor, as it can lead to renal hypoperfusion, especially in cases of cardiogenic shock. The duration of vasoactive drug use is an indicator of the severity and duration of this instability. This class of drugs is used not only to maintain adequate blood pressure and reverse shock, but also to ensure renal perfusion, preventing dysfunction. 27,28 This study found a median duration of vasoactive drug use of 24 hours in the general population, as well as in the population with renal injury, but with a difference between the interquartile ranges of 4 to 48 hours in the general population and 9.5 to 142 hours in the affected population. The medians remain the same because not all affected patients presented major instabilities or serious complications, which are usually associated with milder kidney injuries and reversed in less time, therefore not requiring a long period of use of vasoactive medication. However, there is a difference in the interquartile intervals, because in patients with more severe and lasting hemodynamic instabilities, usually associated with

kidney injuries with a worse prognosis and longer recovery time, there is a need for longer use of this medication.27,28

The postoperative creatinine level is one of the defining criteria for acute kidney injury. Diagnosis requires an increase of 0.3 mg/dL or more in serum creatinine, or 1.5 to 1.9 times the patient's baseline.[1] This study found a median serum creatinine level of 0.68 g/dL in the general population, compared with a median of 2.85 g/dL in the affected population, which is consistent with findings in the literature.

Regarding outcomes, the mortality rate in the population affected by kidney injury was 9.1%, compared to 4.9% in the general population, which confirms the findings in the literature that acute kidney injury is a post-surgical complication closely associated with higher mortality, mainly due to complications associated with kidney failure, such as hydroelectrolytic disorders, such as hyperkalemia, metabolic acidosis, and consequently cardiac arrhythmias, in addition to acute pulmonary edema and failures in the functioning of other organs. 28

The rate of renal replacement therapy in the affected population was 28.6%, compared to 1.4% in the general population, which indicates that acute kidney injury in the first 7 days, that is, in the postoperative period of cardiac surgery, is more common and more severe than other possible late causes of kidney injury, such as hospital infection, and consequently treatment with possible nephrotoxic antibiotics, sepsis or septic shock, the use of nephrotoxic contrast agents for imaging tests, or even COVID-19 infection, a major concern in the years covered by this study.3,5,10

In addition to increased mortality, acute kidney injury also causes increased morbidity, with longer ICU stays. This study found a median ICU stay of 3 days for both groups. However, there was a difference when analyzing the interquartile ranges, which for the general population was 2 to 4 days, and for the affected population it was 2.5 to 17 days. The medians remain the same because not all patients suffer major complications, which will be more prevalent in individuals with higher injury scores according to the KDIGO scale, with more severe or numerous comorbidities, or with worse post-surgical outcomes. Thus, in patients with milder injuries, normal creatinine levels can be reestablished within a period of 2 to 3 days.3 This difference in intervals is related to the possible complications of kidney injury, such as metabolic acidosis, the need for renal replacement therapy, either through hemodialysis or peritoneal dialysis, hydroelectrolytic disturbances and, consequently, possible cardiac arrhythmias.3,28

The study's limitations included a small sample size, a contributing factor being the COVID-19 pandemic, which reduced the number of elective surgeries performed. The study period coincided with the most critical period of the pandemic (2020 and 2021). The study was also conducted at a hospital that only receives referral patients and therefore does not perform emergency surgeries. Furthermore, this was a single-center study, which may not reflect the reality of the general population.

Another limitation was the use of a secondary database and electronic medical records to construct this database, which resulted in missing data due to errors in recording information in the medical records. It also prevented the inclusion of variables in the study that had not been previously collected by the researchers responsible for creating this database. Because this was a retrospective study, we did not have data measuring patients' urine output, which could help diagnose earlier cases of AKI. Furthermore, because this was a final project, the time to complete the study was limited, with a relatively short period between its conception and submission date.

FINAL CONSIDERATIONS

Acute kidney injury in the postoperative period of cardiac surgery is the second leading cause of AKI in the ICU, potentially leading to the need for renal replacement therapy, longer hospital stays, and death. Its development is related to several factors, such as pre-existing comorbidities, infection, blood component transfusions, and the type of surgery.
Identifying risk factors is important because it allows us to profile patients and develop strategies to prevent the development of kidney injury, thus improving surgical outcomes, reducing hospital stays, renal replacement therapy rates, and death, which also contributes to reducing hospital costs generated by these patients.

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