ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF MEDICINE

DEPARTMENT OF CARDIOLOGY

Assessment Of Prevalence And Associated Factors Of Post-Operative Acute Kidney Injury In Patients Who Underwent Open Heart Surgery In Addis Ababa, Ethiopia(2021-2024): A multicenter retrospective cross-sectional study

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MASTER OF SCIENCE IN CARDIOVASCULAR PERFUSION

This is to certify that the thesis prepared by Mahlet Getahun, entitled:

"**Assessment Of Prevalence And Associated Factors Of Post-Operative Acute Kidney Injury In Patients Who Underwent Open Heart Surgery In Addis Ababa, Ethiopia(2021-2024): A multicenter retrospective cross-sectional study**" and submitted in partial fulfillment of the requirements for Master of Cardiovascular Perfusion complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Acronyms/Abbreviations

AKI	Acute kidney injury
ASD	Atrial septal defect
AVR/r	Aortic valve replacement/repair
BMI	Body mass index
CABG	Coronary artery bypass graft
CHD	Congenital heart disease
CKD	Chronic kidney disease
CPB	Cardiopulmonary bypass
CSA-AKI	Cardiac surgery associated acute kidney injury
DM	Diabetes mellitus
DVR	Double valve replacement
GC	Gregorean calendar
HTN	Hypertension
ICU	Intensive Care Unit
IQR	Interquartile range
KDIGO	Kidney Disease: Improving Global Outcomes
LVEF	Left ventricle ejection fraction
MVR/r	Mitral valve replacement/repair
OPD	Outpatient department
RHD	Rheumatic heart disease
SAM	Subaortic membrane
Scr	Serum creatinine
TASH	Tikur anbessa specialized hospital
TOF	Tetrallogy of fallot
TVR/r	Tricuspid valve replacement/repair
VSD	Ventricular septal defect

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ABSTRACT

Background Acute kidney injury (AKI) represents a significant complication following cardiac surgery, associated with increased morbidity and mortality rates adversely affecting patient outcomes. It is crucial to monitor the incidence of cardiac surgery-associated acute kidney injury (CSA-AKI). However, no prior study has been made in the context of the present study setting.

Objectives: This study aimed to investigate the prevalence of cardiac surgery-associated acute kidney injury among adult cardiac surgery patients and its associated factors in cardiac surgery centers in Addis Ababa, Ethiopia.

Methods: Institutional based cross-sectional retrospective study was conducted among 282 patients on systematic random sampling technique, focusing on both pediatric and adult patients who underwent open-heart surgery. Examining factors such as preoperative renal function, duration of cardiopulmonary bypass, intraoperative management, and postoperative renal function. The data was input into Epi data 4.7 and then transferred to STATA 17 for analysis. Associations between the outcome variable and independent variables were evaluated using a chi-square test. Variables showing significance in univariate analysis were analyzed in a multivariable model to assess the strength of associations and identify statistically significant factors. P value ≤ 0.05 of the statistical significance was used. The study took 5 months from January up to May was the study period.

Result: Four of the variables were significant patients with DM have 3.44 times higher risk of developing AKI (AOR = 3.44, 95% CI; 1.43-9.09), age has a significant association with AKI, patients in over 60 years age group had 2.55 times higher risk odds of developing AKI (AOR = 2.55, 95% CI: 1.37-4.77), patients with ischemia periods greater than 90 minutes had 2.15 times the chance of having AKI (OR = 2.15, 95% CI: 1.10-4.22), Patients undergoing repeat operations had 4.20 times higher adjusted odds of developing AKI (AOR = 4.20, 95% CI: 1.25-14.10) compared to those having their first cardiac surgical procedure.

Conclusion: The study revealed that a considerable number of DM, older age, longer aortic cross clamp time, redo surgery has significant association with AKI.

Keywords – Acute kidney injury, cardiopulmonary bypass, open heart surgery, CABG surgery

CHAPTER ONE: INTRODUCTION

1.1 Background

Acute kidney injury is a sudden decrease in kidney function that occurs over hours and sometimes days and is characterized by a rapid increase in serum creatinine, a decrease in urine output, or both, in pediatric and adults(1). Acute Kidney Injury (AKI) is defined by the KDIGO criteria as a ≥0.3 mg/dL (≥26.5 μmol/L) rise in serum creatinine within 48 hours or ≥1.5 times the baseline creatinine level within the prior 7 days, and/or a sustained reduction in urine output to <0.5 mL/kg/h for ≥6 hours, with no requirement for both criteria to be met simultaneously(2). Acute renal damage is a common side effect among hospitalized patients worldwide. AKI has a detrimental effect on patient outcomes and increases the risk of mortality and extended hospital stays(3). Every year, over two million cardiac operations are performed worldwide, with the incidence of cardiac surgery-associated AKI (CSA-AKI) ranging from 5% to 42%(4). A statistical analysis revealed that CSA-AKI is the most common post-surgical complication in patients and is associated with increased rates of morbidity and mortality(5). In pediatrics AKI can occur 15–64 percent of patients after heart surgery(6). A significant increase in 30-day mortality is independently associated with a rise in serum creatinine (sCr) from 0.3 to 0.5 mg/dL following heart surgery(7).

Severe postoperative cardiac surgery associated acute kidney injury is an independent predictor of mortality in cardiac patients. While, the mortality rates following open heart surgery without CSA-AKI is only 1% and 8%, and the odds of death increase more than fourfold following CSA-AKI(8). The development of AKI after heart surgery may be caused by a combination of preoperative, intraoperative, and postoperative risk factors. Patient demographic traits positively correlated with the likelihood of CSA AKI(8). One of the most significant adverse effects of heart surgery and cardiopulmonary bypass (CPB) is acute kidney injury (AKI) (7). In total 20–30% of cardiopulmonary bypass procedures (CPBs) result in AKIs (9).

Prolonged CPB times, particularly those exceeding 120 minutes, have been associated with heightened systemic inflammation, hemodynamic instability and ischemia reperfusion injury, contributing to renal insult. Similarly, prolonged cross-clamp duration, a marker of myocardial ischemia, may exacerbate renal hypoperfusion and increase AKI risk(6).

The majority of cardiac surgery procedures that use CPB are carried out while mild to moderate systemic hypothermia is present (usually a nasopharyngeal temperature between 25 and 32 °C). It is possible to do certain heart procedures in a normothermic setting(10).

Increases in serum creatinine or decreased urine output are frequently used to diagnose AKI, and standard criteria, such as the Kidney Disease Improving Global Outcomes classification, are used to stage the condition(1). The current clinical and epidemiological standard for identifying acute kidney damage, including CS-AKI, is the Kidney Disease Improving Global Outcomes (KDIGO) criteria(11). The "Kidney Disease: Improve Global Outcomes" (KDIGO) AKI study group recently proposed a revised definition of AKI that would level differences between previous definitions and improve comparability and repeatability across various prediction models (12).

1.2 Statement of the problem

Acute kidney injury is a common and major global post-operative complication(7). Patients who undergo cardiac surgery with cardiopulmonary bypass are vulnerable to CSA AKI. AKI is the second most common complication in intensive care unit next to sepsis(10). The prevalence of AKI in Slovenia study people who have undergone heart surgery varies from 5% to 42%, contingent on the type of heart surgery(4).

Cardiac surgery-associated AKI is related with severe complications, prolonged ICU stays, and a reduced quality of life. Additionally, it contributes to increased early and late mortality rates as well as higher healthcare expenditures(3). Furthermore, AKI is linked to an increased need for inotropic support and extended mechanical ventilation(7). Despite its clinical significance, strategies for AKI prevention have not been thoroughly investigated, and their effectiveness in mitigating AKI-related adverse outcomes remains systematically unassessed.

Nonetheless, studies in Africa specifically in Ethiopia are limited, Therefore, our study aimed to evaluate the increase in serum creatinine and the decrease in urine output after adult open cardiac surgery in this study to identify the prevalence and risk factors for AKIs following cardiac interventions from 2021-2024 at multiple centers in Addis Ababa, Ethiopia. However, there is a lack of information in the Ethiopian setting regarding postoperative AKI although cardiac surgeries have been performed since the 2017 G.C.

1.3 Significance of this study

This study contributed to the recognition and intervention of patients who are at high risk for CSA AKI in multiple cardiac centers in Ethiopia. Furthermore this study paves a way for the professionals to get updated evidence concerning the incidence of postoperative AKI. By extension, this may contribute to the overall quality of care partly by emphasizing to prevent postoperative AKI, which will reduce the burden of the problem and its potential consequences.

This study contributes valuable insights into the impact of intraoperative factors on renal outcomes, highlighting the importance of balancing surgical complexity with the goal of reducing the ischemic burden and improving postoperative recovery in cardiac surgery patients and underscoring the considerable variation in the risk of AKI contingent upon the specific type of cardiac surgical intervention performed. Additionally, it contributes to the significant burden of AKI following cardiac surgery and highlights the potential role of pre-existing comorbidities in increasing the risk of postoperative renal complications. The stratification of AKI by severity provides further insight into its clinical impact, emphasizing the need for targeted strategies to mitigate risk factors and improve outcomes in this vulnerable patient population.

So, identifying the prevalence and associated factors of AKI would allow the development of strategies aimed at reducing morbidity and mortality, long hospital stays and unnecessary costs, higher inotropic requirements, more days of mechanical ventilation. AKI in post-cardiac surgery patients has not been studied in our country.

Furthermore, this study provides insight into AKI prevalence and associated factors and how to avoid AKI among all cardiac teams. Finally, data are limited and this study will also serve as a baseline literature for further research related to postoperative CSA AKI.

CHAPTER TWO: LITERATURE REVIEW

Cardiac surgery frequently causes tissue edema and ischemia-reperfusion damage by increasing peripheral vascular resistance and altering microcirculation. Moreover, systemic inflammation is brought on by the related ischemia-reperfusion injury and cardiopulmonary bypass exposure, which encourages the overexpression of pro inflammatory factors and immune cell infiltration into the renal parenchyma, finally leading to fibrosis. Increased mortality rates and the incidence of AKI are correlated with elevated postoperative levels of inflammatory cytokines(13).

After heart surgery, postoperative acute kidney damage (AKI) is now widely acknowledged as a common and dangerous postoperative consequence. In patients having heart surgery, it is among the leading causes of morbidity and death(14). The most popular method for creating a suitable operating area for heart surgeries is cardiopulmonary bypass (CPB). Cardiopulmonary bypass (CPB) combined with heart surgery is known to increase the risk of acute kidney damage (AKI) as well as perioperative morbidity and death. Its prevalence is also influenced by a number of surgical, anesthetic, and patient factors. To reduce the modifiable risks, it is essential to understand the characteristics of a patient who is likely to experience this condition(15).

Hemodilution may be linked to deteriorating kidney function after CPB procedures, according to certain theories. Aortic cross clamping, hemorrhage, vasoplegia development, and inflammatory responses brought on by exposure to an exogenous membrane are other CPB-related variables that have been linked to an increased risk of AKI(16).

2.1 Prevalence of postoperative AKI

A study done in Spain analyzes the influence of various independent risk factors on postoperative acute kidney injury (AKI) in a cohort of 939 consecutive patients who underwent isolated heart valve surgery under cardiopulmonary bypass (CPB) between 2013 and 2018. No patients were excluded or lost during the recruitment process. The relevant variables were prospectively collected from the clinical database for analysis. The overall study reported that the prevalence of postoperative AKI in this cohort was 19.5%(17).

A retrospective study conducted at Changhai Hospital, evaluating adult patients who underwent cardiac surgery between January 7, 2021, and December 31, 2021. Perioperative data were obtained from electronic health records. Acute kidney injury (AKI) was defined according to the

Kidney Disease: Improving Global Outcomes (KDIGO) criteria. Logistic regression analyses were used to identify independent risk factors for AKI. The study reported that postoperative AKI occurred in 257 patients (29.6%)(11).

A prospective observational cohort study conducted at a tertiary care center in Indonesia evaluated 44 pediatric patients, who underwent cardiac surgery between October 2022 and June 2024. The study focused on the prevalence of Acute Kidney Injury (AKI), which was defined and classified using the Acute Kidney Injury Network (AKIN) criteria based on increases in serum creatinine or reductions in urine output within the first three days post-surgery. Kidney function was assessed using traditional markers such as serum creatinine, urine output, and blood urea. The study reported that postoperative AKI occurred in 14 patients (31.8%)(13).

A contextual, descriptive, and retrospective single-center study with data from 476 adult patients admitted post-cardiac surgery between January 2016 and December 2017 at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) in South Africa. All adult patients who underwent elective cardiac surgery, including coronary artery bypass grafting (CABG), valvular, aortic, and other cardiac surgeries on cardiopulmonary bypass (CPB), were included. Peri-operative factors such as patient demographics, baseline renal function, co-morbid conditions, length of CPB, aortic cross-clamp time, degree of hypothermia, and post-operative serum creatinine (SCr) levels were collected. Incomplete essential peri-operative data were excluded. Acute kidney injury (AKI) was defined by the Kidney Disease Improving Global Outcomes (KDIGO) criteria. The study result reported that the prevalence of AKI is 135 (28%)(15).

2.2 Factors affecting post-cardiac surgery

2.2.1 Socio-demographic factors

A study utilized a retrospective quantitative design, involving a convenience sample of 151 adult patients in Egypt who underwent any type of on-pump open heart surgery across three major hospitals. Data were extracted from electronic medical records and analyzed using binary logistic regression to explore socio-demographic and clinical factors associated with postoperative acute kidney injury (AKI). These socio-demographic characteristics were examined for their potential association with the development of postoperative AKI. The sample consisted predominantly of male patients, with approximately two-thirds (66.9%) being male with the majority age range

were between 50 and 59 years old, comprising 32.5% of the sample. In terms of height, more than a third of patients (35.8%) were between 170 and 179 cm tall. The distribution of weight among the patients was more varied, with about one-fourth (25.9%) of patients weighing between 70 and 79 kg. The study reported that cardiac surgery associated acute kidney injury occurred in 49 patients (32.5%)(8).

A retrospective chart review was conducted at the India Institute, all adult patients (≥18 years) who underwent elective open cardiac surgery from January 2012 to December 2015 were evaluated. The study included 276 patients with a mean age of 51.5 ± 13.06 years, consisting of 177 males (64.1%) and 99 females (35.8%). The overall incidence of acute kidney injury (AKI) in the present study was 6.88%(18).

A retrospective chart review study conducted at a tertiary care center in Lebanon evaluated the incidence of Acute Kidney Injury (AKI) in 150 infants and children undergoing cardiac surgeries between 2015 and 2017. The study utilized the Kidney Disease: Improving Global Outcomes (KDIGO) criteria to define AKI, with data collected on socio-demographic and clinical variables, including age, gender, type of heart disease, prior cardiac surgeries, RACHS-1 category, and pre- and post-operative creatinine levels. The cohort consisted of 56.6% males and 43.4% females, with an overall mean age of 4.49 ± 4.03 years. Among the patients, 6% were below 1 year of age, 84% were between 1–10 years, and 10% were between 10–18 years. Postoperatively the result showed that, 14 patients (9.3%) developed AKI, with a higher proportion of males (64.3%) affected compared to females (35.7%)(6).

A retrospective study was conducted on 158 patients undergoing open-heart surgery between January and December 2018, with AKI diagnosed according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria. The study excluded patients with a history of AKI and analyzed socio-demographic and clinical variables to identify predictors of AKI. The mean age of the cohort was 51.2 ± 9.7 years, with AKI patients slightly younger at 48.9 ± 8.1 years. Males comprised 74.7% of the overall sample, while 68.5% of AKI cases occurred in males. The overall incidence of AKI was 34.2%(19).

2.2.2 Surgery-related factors

A comprehensive meta-analysis in America encompassing 91 observational studies investigating patients who underwent cardiac surgery was conducted by the Department of Anesthesiology and Pain Management at the University of Texas Southwestern Medical Center, Dallas, Texas. The findings revealed that acute kidney injury (AKI) occurred in 22.3% of the overall cohort. Notably, the incidence of AKI among patients who underwent coronary artery bypass graft (CABG) surgery was reported at 19.0%. In contrast, those undergoing valve surgeries exhibited a higher AKI incidence of 27.5%, while patients who underwent aortic surgery faced an even greater risk, with an AKI incidence of 29.0% (1).

A retrospective study including adult patients who underwent open heart surgery in China between January 7, 2021, and December 31, 2021, using The Kidney Disease: Improving Global Outcomes (KDIGO) criteria to diagnose acute kidney injury (AKI), showed that 257 individuals, or 29.6% of the total, out of 868 participants experienced postoperative AKI. Different rates of AKI were linked to particular surgical techniques. AKI was found to occur in 12.8% of patients having coronary artery bypass grafting (CABG). For single valve replacement, the rate was 8.9%, while multiple valve replacement procedures showed a higher incidence of 16.3%. Aortic procedures had an AKI occurrence of 22.2%, and surgeries for aortic dissection recorded a rate of 13.6%. Additionally, combined CABG and valve procedures had an AKI rate of 5.1%, and heart transplantation was associated with a 5.4% incidence. Other surgical interventions accounted for 29.2% of AKI cases(11).

A contextual, descriptive, and retrospective single-center study conducted at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) in South Africa, data were meticulously analyzed from a cohort of 476 adult patients. Acute kidney injury (AKI) was defined in accordance with the Kidney Disease: Improving Global Outcomes (KDIGO) criteria. The results indicated that 135 patients, representing 28% of the study population, developed Cardiac surgery-associated acute kidney injury (CSA-AKI). Among these cases, Lowest temperature on pump 30 (30–32) was used, 56 patients (41%) underwent coronary artery bypass grafting (CABG), while another 56 patients (41%) were treated for valve surgeries. Additionally, 5 patients (4%) underwent aortic procedures, and 11 patients (8%) experienced AKI(15).

2.2.3 Coexisting Factors/comorbidities

A retrospective cohort study analyzed the baseline demographic, clinical, biological, and operative characteristics of 564 adult patients who underwent cardiac interventions at King Abdulaziz University Hospital (KAUH) in Jeddah, Saudi Arabia, between 2010 and 2020. The primary focus was on the incidence of acute kidney injury (AKI) following these procedures. A significant prevalence of AKI with comorbidities was observed among the patients, with diabetes mellitus (DM) affecting 94 individuals (85.5%) and hypertension (HTN) affecting 98 patients (89.1%)(9).

A single-center retrospective cohort study investigated the incidence and risk factors of acute kidney injury (AKI) in 495 adult patients undergoing cardiac surgery in Germany. AKI was diagnosed and staged using the full Kidney Disease: Improving Global Outcomes (KDIGO) criteria, incorporating baseline serum creatinine (SC) levels and postoperative SC levels corrected for fluid balance. The study highlighted the significant burden of AKI in this population, with 87 patients (84.5%) diagnosed with cardiac surgery-associated AKI (CSA-AKI). The study reported that, AKI was present in 85.4% (n=88) of cases in hypertensive patients, while AKI was observed in 23.3% (n=24) in diabetes mellitus(20).

A retrospective single-center study analyzed data from 476 adult patients who underwent cardiac surgery at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) in South Africa between January 2016 and December 2017. In this study AKI was observed in 28% of patients, categorized by KDIGO criteria, with older age, female gender, higher serum creatinine levels. The study revealed that AKI was reported in diabetes mellitus (18%), hypertension (25%), smoking (19%), and hypercholesterolemia (15%)(15).

A retrospective study conducted at Changhai Hospital in China investigated the incidence of acute kidney injury (AKI) in adult patients undergoing cardiac surgery. The Kidney Disease: Improving Global Outcomes (KDIGO) criteria were utilized to diagnose AKI in this cohort. The findings revealed that 257 patients (29.6%) developed postoperative AKI, highlighting the high prevalence of this complication in the cardiac surgical population. The study also analyzed that AKI occurred in comorbid conditions within the cohort, present in 25 patients (9.8%) in diabetes mellitus, 5 (20.4%) in hypertension, and 2 (0.8%) chronic liver disease were reported(11).

2.2.4 Cardiopulmonary bypass-related factors

A retrospective study was conducted on 158 patients undergoing open-heart surgery between January and December 2018, with AKI diagnosed according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria. The mean CPB and cross-clamp aorta duration in the AKI group were 101.19 ± 23.91 min and 84.67 ± 25.57 min, respectively. The overall incidence of AKI was 34.2%(19).

A descriptive cross-sectional study was conducted at Dr. Wahidin Sudirohusodo Central General Hospital, Makassar, Indonesia, the study included 33 adult patients undergoing cardiac surgeries Among these patients, 21 (63.6%) developed AKI. The study reported that AKI occurred in patients with Ejection fraction <35% 4.8% and with the mean cardiopulmonary bypass (CPB) duration and aortic cross-clamp time 101.19 ± 23.91 minutes and 84.67 ± 25.57 minutes, respectively(21).

A retrospective study analyzed the occurrence of acute kidney injury (AKI) in children aged 0–17 years who underwent cardiac surgery (CS) with cardiopulmonary bypass (CPB) at an Indian hospital between July 2011 and June 2012. Among 323 children, CS-AKI occurred in 39 (12.1%), with AKI observed more frequently in patients with prolonged CPB times (median: 138 minutes, range: 53–396) compared to those without AKI (median: 107 minutes, range: 31–378). Similarly, longer cross-clamp times were associated with AKI, with a median of 66 minutes (range: 15–172) in the AKI group versus 48 minutes (range: 5–226) in the non-AKI group(22).

A retrospective, single-center study conducted in South Africa at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) analyzed data from 476 adult patients admitted after cardiac surgery between January 2016 and December 2017. This contextual and descriptive study aimed to evaluate the incidence and associated factors of cardiac surgery-associated acute kidney injury (CSA-AKI), using the Kidney Disease: Improving Global Outcomes (KDIGO) criteria for AKI diagnosis. The study reported that 135 patients (28%) developed CSA-AKI, emphasizing the significant burden of this complication in postoperative cardiac surgery patients. Among the intraoperative factors analyzed, AKI developed in patients the median cardiopulmonary bypass (CPB) duration was 157 minutes (interquartile range [IQR]: 121–203), and the median aortic cross-clamp time was 100 minutes (IQR: 81–133)(15).

2.3 Conceptual framework

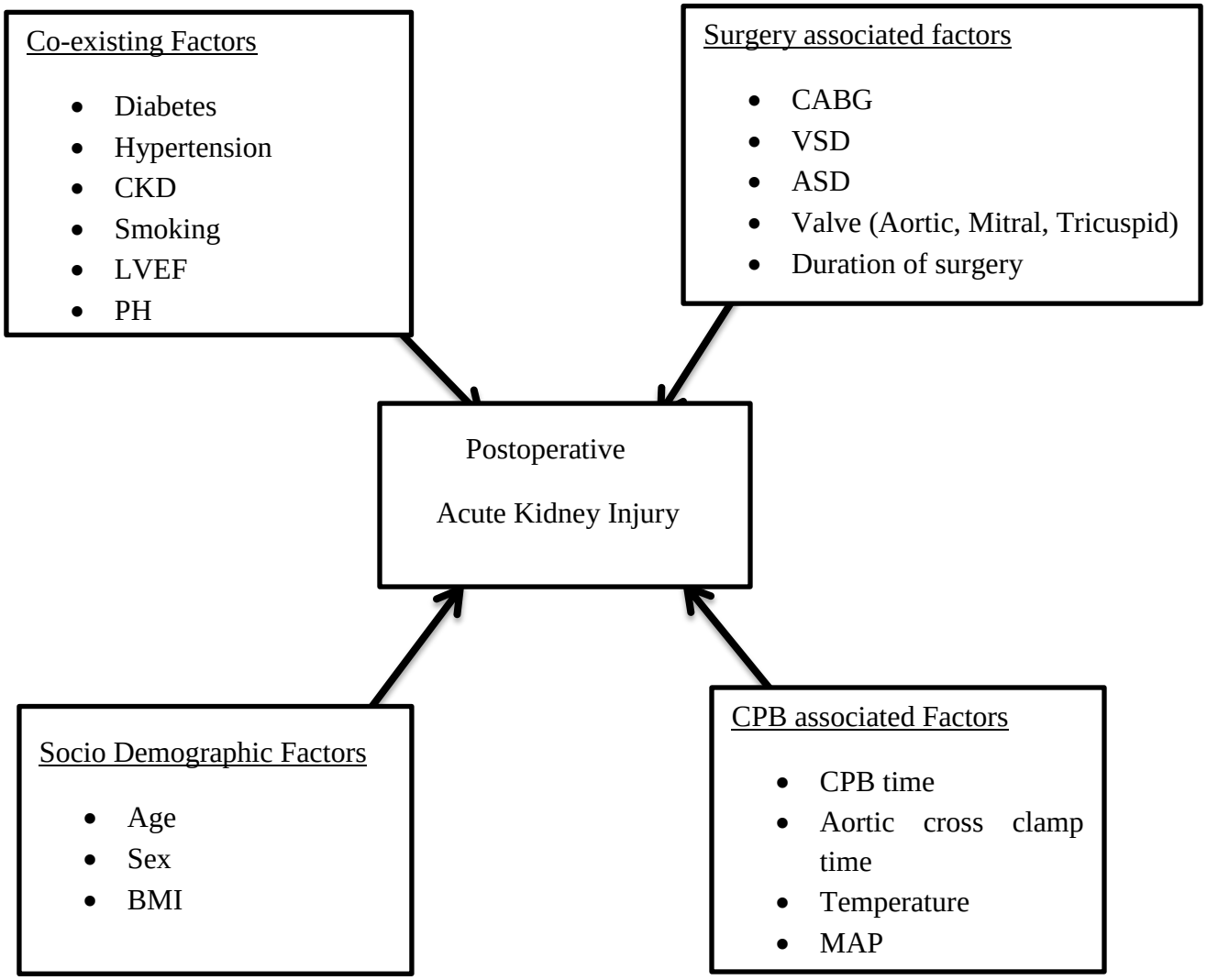

figure 1. conceptual framework: prevalence and associated factors with post-operative acute kidney injury(10)

CHAPTER THREE: OBJECTIVE

3.1 General objective

- To identify the prevalence and associated factors of postoperative AKI in patients who went open cardiac surgery at multi cardiac surgery centers, Addis Ababa, Ethiopia

3.2 Specific objectives

- To determine the prevalence of postoperative AKI in cardiac surgery
- To assess associated factors of post-operative AKI in cardiac surgery

CHAPTER FOUR: Methods and Materials

4.1 Study area

The study took place, in Addis Ababa, Ethiopia from January 1 to May 30, 2025. Ethiopia's capital city, Addis Ababa, is a home to around 5.7 million people and is expanding quickly. The city provides an excellent introduction to Ethiopian culture and is a significant diplomatic hub. There were more than 52 hospitals in Addis as of 2014, comprising over 40 private and 12 state-run facilities. Residents with middle-to-low incomes are the main patients of the state-run hospitals, some of which were constructed more than 30 years ago. The study was conducted across four cardiac surgery centers in Addis Ababa: (Tikur Anbessa Specialized Hospital, Cardiac Center Ethiopia, Elouzeir Cardiac Center, and Tazma Medical and Surgical Specialized Center). In this study, a team is defined as one where the primary cardiac surgeon, cardiologist, perfusionists, cardiac anesthesiologist, intensive care unit lead physician and operating scrub nurses are all local professionals. By addressing the healthcare issues faced by a varied, middle-to-low-income population, conducting this research in these Addis Ababa institutions both public and private facilities offers important insights into the results of heart surgery in a low-resource setting.

4.2 Study design

This is a retrospective, cross-sectional study of pediatric and adult patients who underwent cardiac surgery between January 2021 and December 2024 at multiple cardiac surgery centers in Addis Ababa, Ethiopia.

4.3 Study period

The study period is from to January 1 to May, 2025.

4.4 Population

4.4.1 Source population

All pediatric and adult patients who had underwent open cardiac surgery from January 2021 to December 2024, at multiple cardiac centers in Addis Ababa

4.4.2 Study population

All pediatric and adult patients who underwent open cardiac surgery from January 2021 to December 2024 at multiple cardiac centers within the study period and fulfilled the inclusion criteria

4.5 Eligibility criteria

4.5.1 Inclusion criteria

- Ejection Fraction ≥ 30%
- Patients with normal preoperative creatinine levels in KDIGO criteria
- All open heart Surgery performed in the hospitals between January 2021 and December 2024.

4.5.2 Exclusion criteria

- Missing Data
- CKD patients

4.6 Study variables

4.6.1 Dependent variables

- Postoperative incidence of AKI: As per the KDIGO criteria.

4.6.2 Independent variables

- Age
- Sex
- Weight
- BMI
- Diabetes mellitus
- Hypertension
- Pulmonary hypertension
- Intraoperative mean arterial pressure
- Duration of surgery
- Aortic cross clamp time
- CPB time

- Temperature
- Pre and post createnine
- Post urine output
- Pre-operative LVEF
- Type of surgery

4.7 Operational definitions

Post-operative Acute Kidney Injury (AKI): is defined as a sudden decline in kidney function or a rise in serum creatinine of ≥ 0.3 mg/dL (≥ 26.5 μmol/L) within 48 hours or to ≥ 1.5 times baseline, as evidenced by either a decrease in urine output to < 0.5 mL/kg/hour for 6 or more hours, excluding obstruction or chronic kidney disease, within prior 7 days following surgery.

Open-heart surgery: is a surgical technique that involves making an incision in the chest to access the heart. It frequently involves valve replacements, coronary artery bypass grafting (CABG), or cardiopulmonary bypass for the treatment of cardiac abnormalities.

Left ventricle ejection fraction (LVEF): is the proportion of blood ejected from the left ventricle during each systolic contraction relative to its total end-diastolic volume.

Cardiopulmonary Bypass time (CPB): Is the duration during cardiac surgery when a heart-lung machine is used to temporarily take over the function of the heart and lungs, maintaining blood circulation and oxygenation while the heart is stopped for surgical procedures.

Aortic cross clamp time (ACC): is the duration during cardiac surgery when blood flow through the aorta is halted to allow for surgical procedures.

Intraoperative patient Temperature: is a temperature in open-heart surgery using a CPB machine heater-cooler refers to the precise regulation of cooling and rewarming processes during cardiopulmonary bypass to induce controlled hypothermia, protect organs, and facilitate surgical procedures.

4.8 Sampling method

A systematic random sampling method was used in this study because of its simplicity and effectiveness in delivering a representative sample with little bias in a large population.

4.9 Sample size determination

The sample size for the study was determined by using a single population formula by using a 95% confidence interval 39.8% population proportion and a 5% margin of error.

• $n = \frac{Z^2 P(1-P)}{e^2}$

=Z1−α/2=1.96Z1−α/2=1.96 (95% confidence level),

•P=28% (adjusted prevalence from a 2021 south Africa study on post-operative AKI)(15),

• E=5% (margin of error).

Calculation:

n=Zα/22 x p (q) /d2 = (1.96)2 x (0.28)(1-0.28) / (0.05)2

=309.7≈310 participants.

After adjusting for 10% missing data: n adjusted=310+(310*0.10) = **341** participants

Since the study population is less than 10,000, sample size reduction is used.

Nf = ni/(1+ni/N); Where: -

- nf= final Sample Size
- ni= initial Sample Size
- N= total population

Nf = 310/(1+ 310/1469)

Nf = 310/1.21

Nf = 256.1≈256

Nf = 256

nadjusted=256+(256*0.10) = 281.6 participants

nadjusted ≈ 282 participants.

After adding 10% non-response rate the final sample size is **282**

4.10 Sampling technique

The selection of participants for this retrospective cross-sectional study was conducted using a systematic random sampling technique, focusing on both pediatric and adult patients who underwent open-heart surgery during the study period. Based on the hospital's historical data, it is estimated that there were approximately 1469 pediatric and adult open-heart surgeries performed during the study timeframe. To calculate the sampling interval (k), the formula used will be: $K=N/n=1469/282=5.21 \approx 5$

Where:

- **N** is the total population (all patients),
- **n** is the total sample size (participants).

A random start will be chosen using the lottery method to select the first patient. Afterward, every fifth pediatric and adult patient from the surgery schedule list were included in the study. This approach ensures a systematic and unbiased selection, representing the all population who underwent open-heart surgery during the study period.

4.11 Data collection technique

4.11.1 Data collection technique and instrument

A pretested and adopted structured questionnaire intended to evaluate the prevalence and contributing factors of postoperative acute kidney damage (AKI) in patients having open heart surgery will be used to gather data(15)(1)(7). Patient demographics, preoperative conditions, surgery specifics, and postoperative results was covered in the questionnaire. Health professionals who have worked at cardiac centers for at least two years had collected the data. To make sure they comprehend the goals of the study, the methods for gathering data, and the ethical standards, these selected data collectors got thorough training and orientation from the lead-investigator.

Active tracking and communication with data collectors was regularly supervised to ensure quality. Loss to follow up was declared when death occurs intraoperative. The structured questionnaire was pretested on a small sample to identify any issues, with adjustments made based on feedback to ensure clarity and reliability in the final data collection process.

4.12 Data quality and control

Experienced anesthetists and nurses working in the cardiac surgery unit was the data collectors, and they had received a one-day training session to guarantee high data quality. The goals of the study, hospital permission, respondent rights, informed consent waiver protocols, the value of confidentiality, and the data collection methods was covered in the training. To ensure ethical standards, patient consent was obtained through phone prior to data collection, and all personal identifiers is removed to maintain confidentiality. only anonymized information was used for analysis, adhering to local and international data protection regulations. At the study site, 5% of the entire sample size took a pre-test to evaluate the questionnaire's consistency, clarity, and completeness. In light of the findings, any unclear or troublesome questions was clarified, and any questions that are missing or unnecessary will be changed appropriately. The lead investigator was actively monitored the data gathering procedure to guarantee correctness and consistency. Problems that arose while data collection was promptly addressed and regular feedback was provided to data collectors to maintain high-quality standards throughout the study.

4.13 Data analysis plan

Medical records were reviewed to collect the data of the study variables to be analyzed. The completed questionnaires were manually reviewed post data collection to identify completeness by the investigating perfusionist. The data was then entered into **Epi Data version 4.7** and subsequently transferred to **STATA 17** for analysis. First, missing values was quantified and assessed for randomness using Little's Missing Completely at Random test. Variables with <20% missingness was imputed using multiple imputation by chained equations, while variables with >20% missingness is excluded from multivariable models.

Descriptive statistics is used to summarize baseline characteristics such as age, gender, comorbidities, and surgical variables. Categorical variables were presented as frequency (n) and percentage (%). To assess associations between risk factors and the development of post-operative acute kidney injury (AKI), univariate analysis was performed using the **Chi-square test** for categorical variables. A **p-value of < 0.05** was considered statistically significant. Multivariate logistic regression was conducted to determine the independent predictors of AKI, adjusting for significant confounders identified in the univariate analysis.

4.14 Ethical Consideration

After receiving ethical clearance from the Ethical Review Board and a letter of authorization from Addis Ababa University College of Health Sciences, the study was carried out. To access the recorded data, informed consent was sought from the appropriate hospital authorities onsite medical directors with support letter and Institutional Review Boards (IRBs) letter from the department of anesthesiology. By making sure that all data is anonymized, confidentiality was preserved throughout the investigation. All information gathered was also be safely maintained to preserve privacy and confidentiality. Due to the study's retrospective nature, I had requested the waiver of informed consent.

4.15 Result Dissemination Plan

Following study completion, the findings was sent to the department of anesthesiology and TASH for evaluation and distribution. Efforts will be made to publish the results in reputable journals.

CHAPTER FIVE: RESULT

5.1 Socio-demographic and Clinical Characteristics

A total of 1469 patients had undergone open heart surgery under cardiopulmonary bypass in TASH, CCE, Elouzeir cardiac center and Tazma medical and surgical specialized center from January 2021GC up to December 2024GC. The study populations were 282 patients selected from the above period of time using systematic random sampling method. Patient was selected from each institution in proportional distribution method from TASH 21(7.45%), CCE 47(16.67%), Elouzeir cardiac center 89(31.56%) and Tazma medical and surgical specialized center 125(44.33%). From 282 samples 272 were complete data 10 was incomplete and replaced by other charts, This gives the response rate (the completeness rate) of 98.14%. Demographic characteristics showed a predominantly adult population (58.5% aged 18-60 years), with notable representation of young cases (27.3% aged 1-18 years), old age(9.57% aged >60 years) and pediatrics(4.61% aged 0-1years). Gender distribution was nearly balanced (53.6% male vs 46.4% female), while patient weight and height revealed 41.8% of patients were underweight (BMI ≤18.5). Comorbid conditions included diabetes mellitus (12.4%), hypertension (8.2%), and pulmonary hypertension (46.1%), each demonstrating different associations with postoperative outcomes.

Variables	Characteristics	Frequency	Percentage
Age	0-1 years	13	4.61
	1-18 years	77	27.30
	18-60 years	165	58.51
	> 60 years	27	9.57
Sex	Male	151	53.55
	Female	131	46.45
Body Mass Index	<18.5 kg/m^2	118	41.84
	18.5-24.9 kg/m^2	110	39.01
	25-29.9 kg/m^2	48	17.02
	≥ 30 kg/m^2	6	2.13
Diabetes Mellitus	Yes	35	12.41
	No	247	87.59
Hypertension	Yes	23	8.16
	No	259	91.84
Pulmonary Hypertension	Yes	130	46.10
	No	152	53.90
Smoker	Yes	6	2.13
	No	276	97.87
Left Ventricle Ejection	<30%	3	1.06
Fraction	30-50%	33	11.70
	>50%	246	87.23
Operation type	New	267	94.68
	Redo	15	5.32

Table 1: Socio-demographic and Clinical characteristics of patients who undergone cardiopulmonary bypass surgery at TASH, CCE, Elouzeir and Tazma , Addis Ababa, Ethiopia, June 2025

The following graph shows the distribution of surgical procedures. The most common surgical procedures were MVR (Mitral Valve Replacement) at 23.40%, followed by AVR (Aortic Valve Replacement) at 15.96%. VSD (Ventricular Septal Defect) accounted for 13.12% of procedures, while ASD (Atrial Septal Defect) made up 12.41%. DVR (Double Valve Replacement) was also significant, representing 10.64% of cases. Together, these five procedures constituted over three-quarters (75.18%) of all surgeries listed. The remaining procedures, including CABG (7.45%), TOF (2.84%), SAM (4.96%), AVSD (4.26%), Aortic aneurysm (1.06%), and Others (3.90%), collectively accounted for the final quarter of the total.

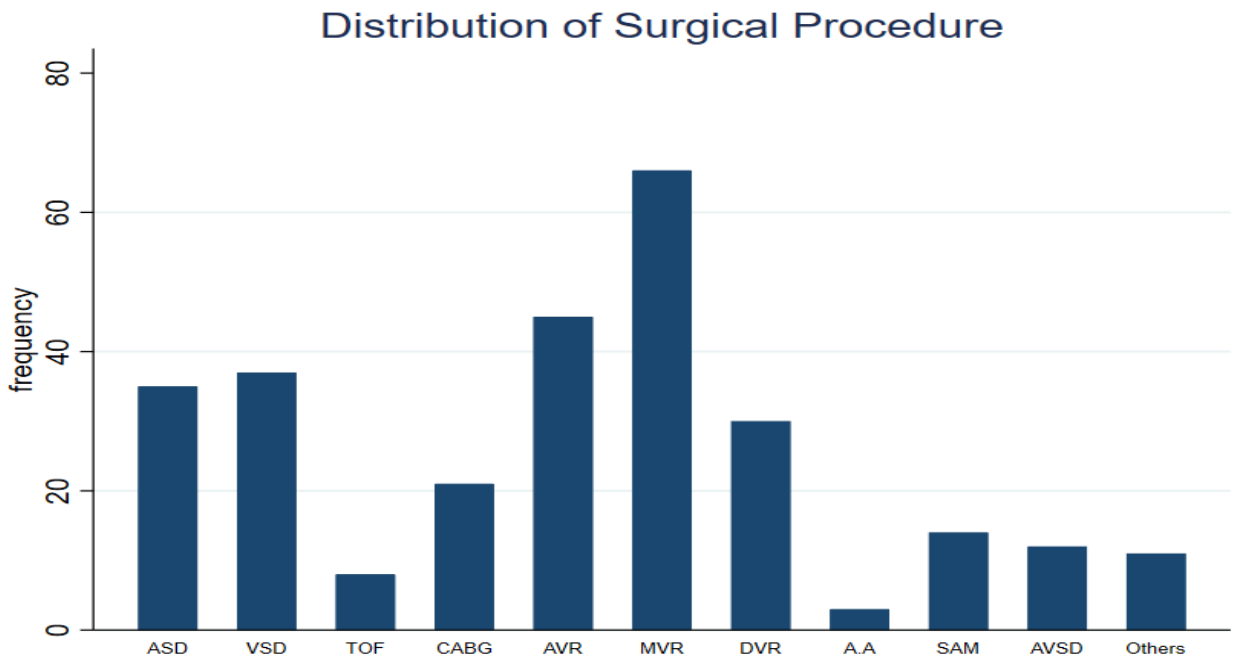

Figure 2 Prevalence of open-heart surgery categories of patients who undergone cardiopulmonary bypass surgery at TASH, Elouzeir, Tazma and CCE, Addis Ababa, Ethiopia, June 2025 (P=0.00)

Perfusion characteristics were equally important; deep hypothermia (28–20°C) quadrupled risk compared to mild hypothermia, while prolonged CPB (>2 hours) and aortic clamping (>90 minutes) doubled the likelihood of AKI. With 84.6% of patients with a creatinine elevation of ≥0.3 mg/dl developing AKI. These results point to three major risk factors: perfusion management (temperature, duration), procedural complexity (valve/redo operations), and patient factors (age, diabetes, and hypertension). The findings imply that older patients with comorbidities undergoing complex procedures should be given priority in targeted renal

protection strategies, especially when long bypass times or substantial hemodynamic shifts are anticipated. Important clinical and demographic trends linked to the development of AKI were found by the analysis. The majority of participants in the study were adults (58.5% between the ages of 18 and 60), with a balanced gender distribution (53.6% male). Univariate analysis revealed notable risk gradients: patients over 60 had 2.55 (OR = 2.55) times higher AKI rates (55.6% VS 44.4%) than younger adults, and diabetics had 3.42 times higher odds (68.6% VS 31.4% AKI rate) than non-diabetics. Univariate analysis revealed an overall AKI incidence of 27.7%. Surgical factors were equally important; valve surgeries like DVR, MVR, AVR have 43.3%, 40.9%, 35.5% proportions, respectively. While congenital cases like ASD and VSD showed ratio of 8.5% and 2.7%, respectively. Reoperations had 4.2 times higher odds (66.7% VS 33.3% AKI) than primary procedures. Strong relationships were observed in perfusion parameters: deep hypothermia (28–20°C) increased risk fivefold (62.5% VS 37.5%), while CPB exceeding 120 minutes quadrupled AKI odds (38.1% VS 61.9% incidence). Postoperative creatinine was the most powerful predictor. Ninety percent of patients with a creatinine elevation of at least 1.5 times developed AKI (OR=1.63), making postoperative renal dysfunction the most powerful predictor. Sex (p=0.08) and pulmonary hypertension (p=0.42) were non-significant factors.

During open cardiac surgical procedures intraoperative parameters are often associated with postoperative adverse outcomes. Identifying and monitoring these parameters are components of the procedure as well as predictors of patient outcomes and prognosis. In this table intraoperative parameters of the patients are stated as follows.

Variables	Characteristics	Frequency	Percentage
Intraoperative-CPB Temperature	<20 ^{0}C	1	0.35
	20-28 ^{0}C	24	8.51
	28-32 ^{0}C	161	57.09
	32 ^{0}C-35^{0}C	96	34.04
Increased serum creatinine Level	≥0.3mg/dl	39	13.83
	≥1.5 times	40	14.18
	None	203	71.99
Duration of surgery	<2 hours	9	3.19
	2-4 hours	153	54.26
	>4 hours	120	42.55
Average mean arterial pressure	Below Average	17	6.03
	Normal	258	91.49
	Above average	7	2.48
Post-operative urine output in 24 hrs	<0.5ml/kg/hr	53	18.79
	0.5-1ml/kg/hr	46	16.31
	>1ml/kg/hr	183	64.89
Post-operative urine output in 48 hrs	<2000ml	167	59.22
	>2000ml	115	40.78

Table 2 Intraoperative characteristics of patients who undergone cardiopulmonary bypass surgery at TASH, Elouzeir, Tazma and CCE, Addis Ababa, Ethiopia, June 2025

5.2 Associated factors with postoperative AKI among patients who underwent cardiopulmonary bypass surgery

An overall AKI incidence of 27.7% was found in this analysis of 282 cardiac surgery patients, with notable differences across clinical and demographic factors. Comorbidities had a significant impact; in comparison between diabetic and non-diabetic patients, diabetic patients have higher proportion of AKI (68.6% vs. 21.9%), while those with hypertension had a twofold of proportion (56.5% vs. 25.1%). Procedure-specific trends showed that reoperations (66.7%) and valve surgeries (MVR 40.9%, DVR 43.3%, AVR 35.6%) were disproportionately higher than congenital repairs (ASD 8.6%, VSD 2.7%).

The pie charts demonstrate a strong relationship between aortic cross-clamp (ACC) time and AKI incidence. Prolonged ischemia (>90 minutes) carries the highest renal risk, with 61.54% of these patients developing AKI – a rate nearly double that of the moderate-duration group (30-90 minutes: 37.18% AKI). Conversely, brief clamping (<30 minutes) rarely caused renal injury (1.28% AKI). And vice versal with the non aki pie chart.

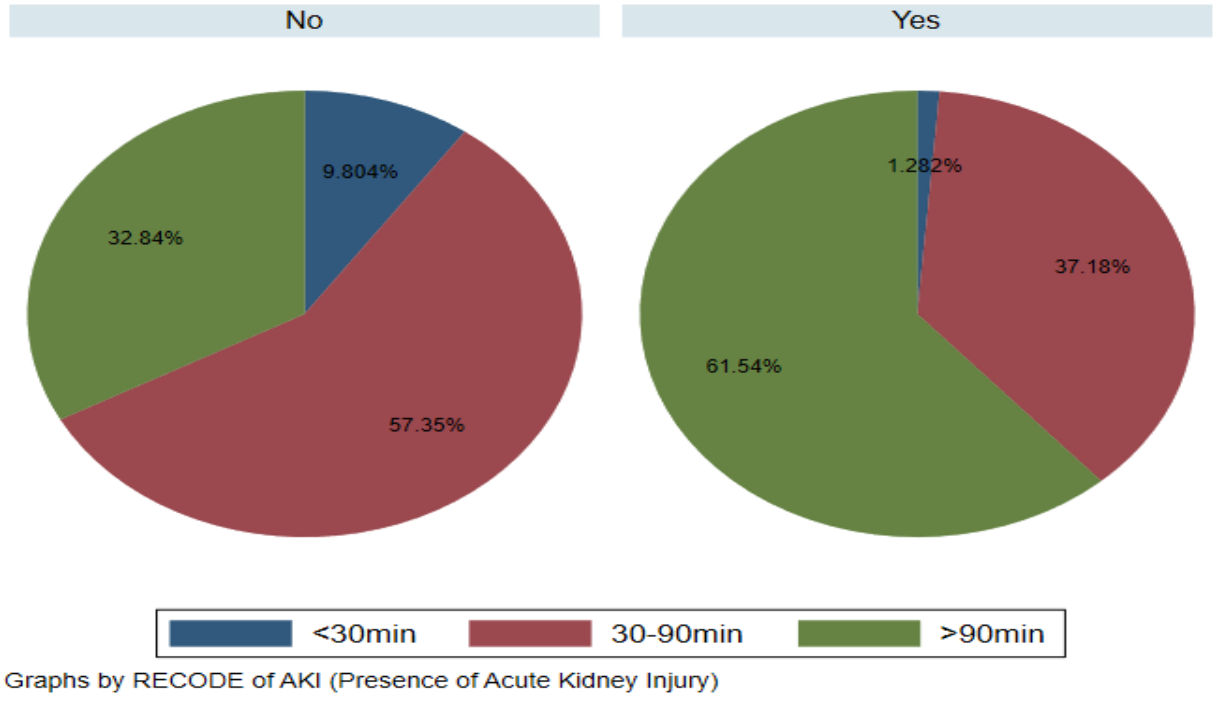

Figure 3 cardiopulmonary bypass surgery distribution by ACC time and AKI at TASH, Elouzeir, Tazma and CCE, Addis Ababa, Ethiopia, June 2025

The pie chart below shows that patients who had diabetes mellitus had developed acute kidney injury which is 30.77% and percentage of patients who had diabetes mellitus but didn't develop acute kidney injury is 5.39%.

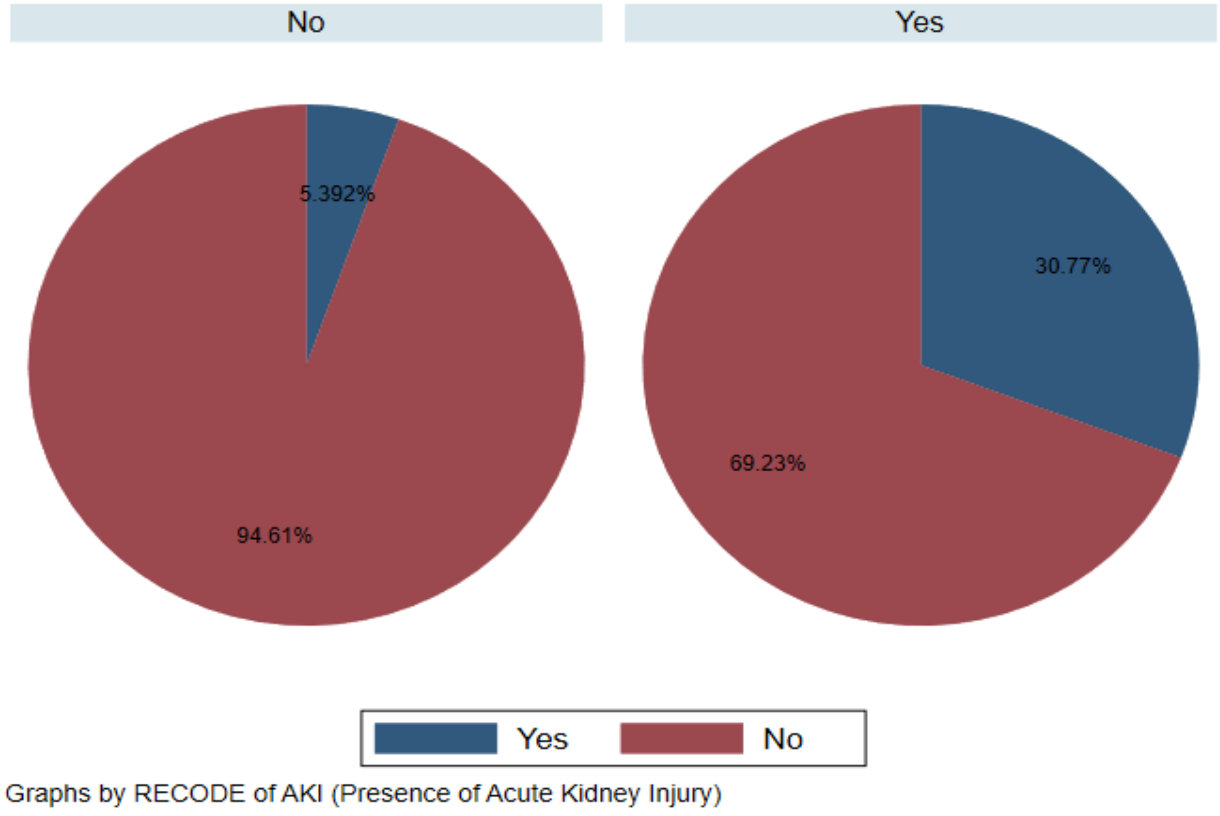

Figure 4 AKI presence in DM patients showed in pie chart in percentage

A total of 269 patients were included in the final logistic regression analysis to identify predictors of acute kidney injury (AKI) following cardiac surgery. The model demonstrated good discriminative ability, with an area under the receiver operating characteristic curve (AUROC) of 0.8227, indicating excellent overall performance and Log-Likelihood is -119.52. The model also showed a pseudo R^2 of 0.2621, suggesting a moderate proportion of variance explained, and had favorable information criteria (AIC = 275.04, BIC = 339.74).

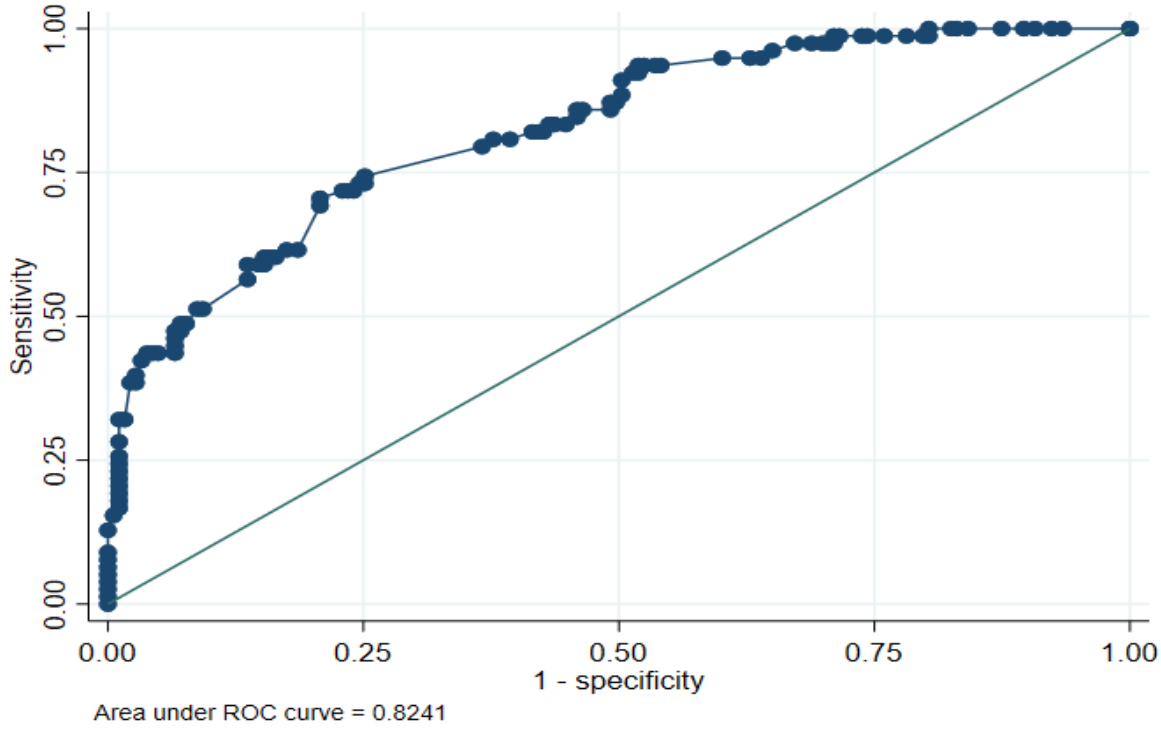

Figure 5 Area under ROC of the multivariate logistic regression result of patients who undergone cardiopulmonary bypass surgery at TASH, Elouzeir, Tazma and CCE, Addis Ababa, Ethiopia, June 2025

5.3 Associated factors with postoperative AKI among patients underwent cardiopulmonary bypass surgery univariate and multivariate logistic regression result

Among the predictors are evaluated diabetes mellitus (DM), type of surgical procedure, CPB time, ACC, patient age group, redo-operation, and hypertension status (HTN) emerged as influential factors in univariate logistic regression analysis. Then these significant variables go to multivariate logistic regression for further analysis then age, DM, ACC, and redo-operation become significant. After adjusting for other variables in the model, patients without diabetic patients are significantly associated with AKI (AOR = 0.28, 95% CI: 0.11, 0.70). This indicates that patients without DM have 72% lower risk of developing AKI. Alternatively, we can also interpret the finding that patients with DM have 3.42 times higher risk of developing AKI (AOR = 3.42, 95% CI; 1.43-9.09). In this study age has a significant association with AKI, patients in over 60 years age group had 2.55 times higher risk odds of developing AKI (AOR = 2.55, 95% CI: 1.37-4.77) compared to patients who are younger (< 18 years). According to this study, ACC and AKI are significantly correlated; patients with ischemia periods greater than 90 minutes had 2.15 times the chance of having AKI (OR = 2.15, 95% CI: 1.10-4.22) than patients with ischemic times shorter than 30 minutes. This study found that redo cardiac surgery was significantly associated with an increased risk of acute kidney injury (AKI). Patients undergoing repeat operations had 4.20 times higher adjusted odds of developing AKI (AOR = 4.20, 95% CI: 1.25-14.10) compared to those having their first cardiac surgical procedure.

Hypertension showed a borderline significant association, with non-hypertensive patients having reduced odds of AKI (OR = 0.34, 95% CI: 0.10–1.12, p = 0.077). Additionally, atrioventricular septal defect (AVSD) procedures showed a strong effect size and marginal significance (OR = 8.04, 95% CI: 0.89–72.27, p = 0.063), warranting further investigation despite wide confidence intervals.

Furthermore other variables, including cardiopulmonary bypass (CPB) duration, sex, and smoking status, were explored in earlier univariate analyses but were not retained in the final model due to lack of statistical significance or issues related to collinearity and model parsimony. Notably, 13 observations were excluded from the model due to perfect prediction or collinearity, particularly in the youngest age group (0–1 years), where AKI did not occur.

Overall, the model identified diabetes mellitus, ACC, redo operation and older age as key independent risk factors for postoperative AKI, with implications for risk stratification and perioperative management.

Variables	Category	AKI (count)		Univariate	Multivariate
		Yes	No		
Age	0-1 years	0	13	1	-
	1-18 years	7	70	0.8 [0.02, 0.23]	0.67[0.24, 1.90]
	18-60years	56	109	0.41[0.18, 0.93]	0.17[0.048, 0.66]
	>60years	15	12	3.78[2.29, 6.26]	2.86[1.60, 5.10]
Sex	Male	34	117	1	-
	Female	44	87	1.74 [1.02, 2.94]	-
BMI	< 18.5 kg/m^2	19	99	1	-
	18.5-24.9 kg/m^2	32	78	2.13 [1.12, 4.05]	-
	25-29.9 kg/m^2	25	23	5.66 [2.67, 11.9]	-
	≥ 30 kg/m^2	2	4	2.60 [0.44, 15.24]	-
DM	No	54	193	0.12 [0.05, 0.27]	0.27[0.11, 0.68]
	Yes	24	11	1	
HTN	No	65	194	0.25 [0.10, 0.61]	-
	Yes	13	10	1	-
Pulmonary HTN	Yes	37	93	1	-
	No	41	11	0.92 [0.55, 1.56]	-
Smoker	Yes	3	3	1	
	No	75	201	0.37 [0.07, 1.88]	
Operation type	New	68	199	1	
	Redo	10	5	5.85[1.93, 17.72]	4.30[1.28, 14.38]
LVEF	<30	1	2	1	
	30-50	20	13	3.07 [0.25, 37.48]	
	>50	57	189	0.6 [0.05, 6.77]	
S_Creatinine	>0.3mg/dl	33	6	1	
	>1.5mg/dl times	36	4	1.63[0.42, 6.31]	
	None	9	194	0.008 [0.002, 0.02]	
T	32-35	15	81	1	
	32-28	47	114	2.22 [1.16, 4.25]	
	28-20	15	9	9[3.33, 24.29]	
	<20	1	0	1	
CPB time	<90minutes	10	68	1	
	90-120minutes	9	40	1.53[0.57, 4.08]	
	>120minutes	59	96	4.17[1.99, 8.74]	
ACC	<30minutes	1	20	1	
	30-90minutes	29	117	4.95 [0.63,38.47]	1.45[0.17, 12.2]

	>90minutes	48	67	14.32[1.85, 11.04]	3.42[0.39, 29.78]
DOS	<2hours	0	9	1	
	2-4 hours	32	121	0.42 [0.24, 0.72]	
	>4hours	46	74	1	
MAP	Below average	3	14	1	
	Normal	74	184	1.87 [0.52, 6.72]	
	Above average	1	6	0.77 [0.06, 9.07]	

Table 3 Multivariate logistic regression analysis of factors associated with acute kidney injury

CHAPTER SIX: DISCUSSION

In this study, we set out to identify the risk factors contributing to acute kidney injury (AKI) after cardiac surgery. We also wanted to see how well established prediction models(KDIGO)(2) performed in our specific population

The occurrence of acute kidney injury (AKI) after open heart surgery in Africa is quite high, and several studies have pinpointed various risk factors. Reports show that AKI develops in roughly 17.7% to 34% of patients undergoing these procedures(23). This condition seriously affects patient outcomes, leading to higher death rates and longer hospital stays.

This study shows following open cardiac surgery with the heart-lung machine (CPB), acute kidney damage (AKI) occurred in more than 25% of patients (27.7%). The AKI rate of 27.7% (with a 95% confidence level that the actual rate is between 29% and 49%) is in perfect agreement with reports from throughout the world, demonstrating that kidney damage is still a common and obstinate problem following heart surgery. Research's throughout Indonesia, and China correlates with this study.

A disturbing fact is revealed by this Changhai Hospital study: Almost one in three adult patients (29.6%) experienced acute kidney damage (AKI) following heart surgery. AKI is still a significant obstacle in contemporary cardiac therapy, as evidenced by the 257 patients whose recoveries were hampered by kidney stress. The researchers made sure all diagnoses complied with international standards by defining AKI using strict KDIGO criteria. They identified characteristics that rendered some patients more susceptible by examining comprehensive electronic health data; the methodology (logistic regression) verifies that these risks were both statistically significant and clinically important, however the specifics were not presented here(11).

This study from Indonesia reveals a concerning truth: After heart surgery, nearly one-third of children (31.8%) suffered acute kidney injury (AKI). That's 14 young patients whose recoveries were complicated by kidney stress—a stark reminder that AKI spares no age group, not even the most vulnerable. Using the AKIN criteria (tracking changes in creatinine and urine output within 72 hours post-surgery), the team detected AKI reliably with accessible, low-cost tools. The fact

that traditional markers like urine output and blood urea identified these cases proves that vigilant kidney monitoring is feasible even in resource-conscious settings(13).

Diabetes mellitus (DM) emerged as a significant independent risk factor for acute kidney injury (AKI) following heart surgery. Patients with DM were found to have 3.42 times higher odds of developing cardiac surgery-associated AKI (CSA-AKI) compared to non-diabetic patients, even after accounting for various factors around the time of surgery such as age, high blood pressure, cardiopulmonary bypass (CPB) time, and pre-operative kidney function (AOR = 3.42; 95% CI: 1.43–9.09). Conversely, individuals without DM were 72% less likely to develop AKI (AOR = 0.28; 95% CI: 0.11–0.70). These results underscore DM as a critical, adjustable risk factor influencing the outcomes of heart surgery. This observation is consistent with findings from observational studies conducted in Saudi Arabia in 2022, another Saudi study, research from China in 2024, and a study in Nigeria.

A meta-analysis from China found that DM was a leading predictor of cardiac surgery-associated AKI (CSA-AKI), with odds ratios ranging from 1.5 to 3.0(11)In line with this a 2022 Saudi study identified diabetes mellitus (DM) as an independent predictor for acute kidney injury (AKI) in their analysis ($P < 0.012$, RR = 2.280, CI = 1.198-4.339)(9). Among 159 cardiac surgery patients in Jeddah, Saudi Arabia, DM was the most common co-existing condition (61%) and a primary risk factor for AKI, with a 34% incidence (OR = 6.68, $P < 0.001$)(5). In another group of 564 patients in Saudi, DM raised the AKI risk by 2.28-fold (RR = 2.28, $P = 0.012$). This suggests that DM acts as a synergistic risk, worsens a patient's susceptibility to other medical challenges(9). Finally, a Nigerian study reported a 28.3% incidence of AKI linked to cardiac surgery. Diabetic patients in that study faced a significantly higher AKI risk ($P = 0.03$), confirming that DM independently increases the chances of AKI(24).

From a health professional's perspective, we attribute this result to the fact that during surgery, shifts in blood flow (like low blood pressure caused by cardiopulmonary bypass, or CPB) worsen damage from reduced blood supply in diabetic kidneys. Renal perfusion is compromised by hemodynamic changes brought on by CPB. The stress CPB puts on the circulatory system makes diabetic kidneys even more vulnerable by reducing blood flow to them. Given the existing diabetic and the overall physiological stress of surgery, any drops in blood pressure during the operation can further compromise kidney function, as noted in this analysis.

The finding that patients aged 60 and above have a 2.55 times higher adjusted risk of developing acute kidney injury (AKI) (AOR = 2.55, 95% CI: 1.37-4.77) compared to younger patients (under 18 years). This result aligns very well with similar studies conducted in Spain, South Africa, and Nigeria.

This large study in Spain confirmed that being 70 years or older is an independent risk factor for AKI after surgery (RR=1.79, 95% CI: 1.17-2.72, P=0.006) (17). A study in South Africa also found that older age was significantly linked to AKI (median age 56 vs. 52 years; p = 0.024). Patients aged 65 years or older in this study had a four times higher risk of developing AKI (P< 0.001) (15). Furthermore a study in Nigeria, retrospective cohort study of 311 patients, clearly showed that being 65 years or older is a significant independent risk factor for cardio renal syndrome-acute kidney injury (CVS-AKI). There was a very strong link between age and CVS-AKI (P<0.001), with elderly patients having a much higher rate of the condition (60.2% compared to 13.0% in younger patients) (24).

This is likely because as people get older, their kidney function naturally declines. This means their kidneys have less reserve and aren't as good at regulating themselves to handle stresses like reduced blood flow (ischemia), the use of a heart-lung machine (CPB), low blood pressure (hypotension), inflammation, or substances toxic to the kidneys (nephrotoxins). Older age is also closely linked to having other conditions, such as diabetes (DM) and high blood pressure (HTN), which are known risk factors for acute kidney injury (AKI) on their own.

Multiple high-quality studies consistently show a strong and clinically important link between a longer aortic cross-clamp (ACC) time and the development of acute kidney injury (AKI) after heart surgery. This analysis confirms that ACC durations exceeding 90 minutes raise the AKI risk by 2.15 fold (OR = 2.15, 95% CI: 1.10–4.22). This finding perfectly matches current research and emphasizes that ACC time is a surgical risk factor that can potentially be managed or changed. This study's results are also well in line with what has been reported globally in countries like the United Kingdom, Italy, Belgium, Argentina, and South Africa.

Research from several countries highlights the impact of surgical times on kidney injury risk. A review of 33 studies from the United Kingdom confirmed that prolonged ACC time is a strong predictor of AKI. This is because extended periods of interrupted blood flow, known as

ischemia, can harm kidney tubules through oxidative stress and inflammation (25). An Italian study found that aortic cross-clamp (ACC) time is a crucial factor. They identified 51 minutes as an optimal cutoff: going beyond this point increases the risk of acute kidney injury (AKI) by 13% (OR 1.13, 95% CI: 1.02–1.26) for every additional 10 minutes. Similarly, every 10-minute increase in cardiopulmonary bypass (CPB) time independently raises AKI risk by 9%. When both ACC time exceeds 51 minutes and CPB time goes over 91 minutes, the risk of kidney damage from endothelial injury and hemolysis significantly increases(19). A Belgian meta-analysis study also found a clear link between longer ACC times and increased AKI risk, (MD 14.384 min, 95% CI: 8.793–19.974, P<0.001). ACC time trended toward significance (P = 0.053), with median times 100 min (AKI) VS 95 min (no AKI).(26). Finally an Argentine study also observed that patients who developed AKI had significantly longer ACC times (51.1 minutes versus 34.7 minutes for those without AKI P = 0.016), (OR 3.26, 95% CI: 1.31–8.21), with the risk growing as surgery became more complex(27). Specifically, ACC activates certain immune responses and releases inflammatory substances like IL-6 and TNF-α, which directly damage kidney cells. Patients with ACC time over 90 minutes show 2.5 times higher levels of a specific kidney injury marker (IL-18) after surgery(25). Finally in South African study, the median time for Aortic Cross-Clamp (ACC) was roughly 95-100 minutes. This means that the user's concern about ACC times exceeding 90 minutes is important from a clinical perspective(15). All of these findings indicate that longer periods of ACC time likely contribute to AKI due to similar issues with blood flow and oxygen supply.

This complements this categorical analysis, confirming if the ischemic time is exceeding AKI incidence also increases it is because it causes metabolic derangements**,** ischemia-reperfusion injury**,** systemic inflammation.

The finding that the risk of acute kidney damage (AKI) is considerably increased by redo heart surgery AOR = 4.20, 95% CI: 1.25–14.10) is one of the most potent independent risk factors for AKI. According to the meta-analysis research conducted in Belgium, the odds ratio for reoperation indicates that redo surgery raises the risk of AKI (OR = 5.19, 95% CI: 2.69–10.04)(26).

This study demonstrated a profound association, it is because of repeated operations frequently entail adhesion dissection, extended operating periods, and hemodynamic instability, all of which

directly contribute to renal hypoperfusion, persistent lesions, Patients who have had a cardiotomy often experience pulmonary hypertension or diastolic dysfunction. Renal perfusion is hampered by elevated central venous pressure (CVP).

CHAPTER SEVEN: CONCLUSION

A study from 2021 and 2024, four different hospitals was investigated how often patients experienced acute kidney injury (AKI) after undergoing open-heart surgery with a heart-lung machine, also known as cardiopulmonary bypass (CPB). They also aimed to identify the factors that increased this risk. A key finding was that AKI developed in 27.7% (with a 95% confidence interval of 0.29–0.49) of patients. This rate aligns with global observations, confirming that AKI continues to be a significant concern after heart surgery. The study highlighted four major independent factors that substantially heightened a patient's risk of AKI. Patients with diabetes mellitus had a 68.6% greater chance of developing AKI (AOR = 3.57, p = 0.009). If the aorta was clamped for over 90 minutes during surgery, the risk of AKI doubled (AOR 2.15, p = 0.025). Individuals over 60 years old has 55.6% increased risk of AKI, (AOR 2.55, p = 0.003). Lastly, patients undergoing a redo heart surgery had a 4.2 times higher risk of developing AKI (AOR 4.2, p = 0.020). These four factors diabetes, the duration of aortic clamping, a patient's age, and whether it's a repeat surgery each contribute to AKI in distinct ways. For instance, diabetes can lead to metabolic imbalances, extended clamping times can cause cell damage due to a lack of oxygen (ischemia-associated lactic acidosis), and prolonged use of the heart-lung machine can contribute to inflammation and stress on the kidneys.

CHAPTER EIGHT: STRENGTH AND LIMITATION OF STUDY

The study has a good strength and quality. There was no research that's been done in this topic in Ethiopia before so, this study gives us a really good starting point for predicting the incidence of post open heart surgery Acute Kidney Injury (AKI**)** in Ethiopia. We've figured out the prevalence and its associated factors. It uses a well calibrated and fitted model to assess the prevalence and associated factors to postoperative AKI. Even if the stastical analysis method accounts for the known confounders, the study attempted to use rigorous statistical regression analysis to control for confounders. Finally, the study also used logistic regression analysis model to identify the association degree to the best possible way. It can be the groundwork for even more research in this area. These are super important because they're the areas we really need to dig into more with future studies, and they should be a major focus for health professionals in their day-to-day work. It is multicenter study it avoid bias by addressing the healthcare issues faced by a varied, middle-to-low-income population, diverse patient groups conducting this research in these Addis Ababa institutions both public and private facilities offers important insights into the results of heart surgery in a low-resource setting it gives us a much clearer picture and stronger evidence.

In some aspects it has its limitation the data did not have some important variables like; hemoglobin level, blood transfusion, inotropic drugs and intraoperative fluid balance. Also This research is only about quantitative method (didn't include like living status).

CHAPTER NINE: RECOMMENDATION

Recommendation for Health Professionals (Perfusionist and Cardiac case team), researchers and local health policy makers

This study indicates during certain heart surgeries, an aortic cross-clamp time as short as possible, ideally under 90 minutes teams should work closely together to keep this. And also heart-lung bypass machine (cardiopulmonary bypass or CPB), we should aim to use it for less than 120 minutes. We should be vigilant about aggressively manage high risk patients, blood sugar have to be tightly controlled and renal function test has to be checked, extra care for old ages, redo surgeries, comorbidities and long ACC time, greater efforts should be made in addressing the associated factors of AKI to optimize quality of life, Implement Pre-operative Risk Scoring and Using techniques like cell savers that collect RBC and return to the patient's blood during surgery, minimizing the need for transfusions and drugs.

The more factors we can identify that put someone at higher risk, the better we can protect them. We should conduct bigger, more comprehensive studies that follow patients over time (prospective studies). This will give us a much clearer picture and stronger evidence.

Reference

1. Cheruku SR, Raphael J, Neyra JA, Fox AA. Acute Kidney Injury after Cardiac Surgery: Prediction, Prevention, and Management. Anesthesiology. 2023;139(6):880–98.

2. Gao P, He W, Jin Y, Zhou C, Zhang P, Wang W, et al. Acute kidney injury after infant cardiac surgery: a comparison of pRIFLE, KDIGO, and pROCK definitions. BMC Nephrol [Internet]. 2023;24(1):1–10. Available from: https://doi.org/10.1186/s12882-023-03306-y

3. Rossouw E, Chetty S. Acute kidney injury after major non-cardiac surgery: Incidence and risk factors. South African Med J. 2023;113(3):135–40.

4. Djordjević A, Šušak S, Velicki L, Antonič M. Acute kidney injury after open-heart surgery procedures. Acta Clin Croat. 2021;60(1):120–6.

5. Al-Githmi IS, Abdulqader AA, Alotaibi A, Aldughather BA, Alsulami OA, Wali SM, et al. Acute Kidney Injury After Open Heart Surgery. Cureus. 2022;14(6):10–5.

6. Aoun B, Daher GA, Daou KN, Sanjad S, Tamim H, El Rassi I, et al. Acute Kidney Injury Post-cardiac Surgery in Infants and Children: A Single-Center Experience in a Developing Country. Front Pediatr. 2021;9(July):1–6.

7. Maruniak S, Loskutov O, Swol J, Todurov B. Factors associated with acute kidney injury after on-pump coronary artery bypass grafting. J Cardiothorac Surg. 2024;19(1):598.

8. Qadan L, Eid Aburuz M, Ahmed FR, Alaloul F. The Open Nursing Journal Higher Body Mass Index and Prolonged Cardiopulmonary Bypass Time increase the Risk of Cardiac Surgery-associated Acute Kidney Injury. 2023;17:18744346256499. Available from: https://opennursingjournal.com

9. Almramhi KG, Alkhateeb MA, Alsulami OA, Alhudaifi SA, Alamoudi H, Nabalawi RA. Prevalence and Risk Factors for Acute Kidney Injury Among Adults Undergoing Cardiac Interventions in King Abdulaziz University Hospital: A Retrospective Review. Cureus. 2022;14(3).

10. Mao H, Katz N, Ariyanon W, Blanca-Martos L, Adýbelli Z, Giuliani A, et al. Cardiac surgery-associated acute kidney injury. CardioRenal Med. 2013;3(3):178–99.

11. Wang XD, Bao R, Lan Y, Zhao ZZ, Yang XY, Wang YY, et al. The incidence, risk factors, and prognosis of acute kidney injury in patients after cardiac surgery. Front Cardiovasc Med [Internet]. 2024;11(July):1–11. Available from: https://doi.org/10.3389/fcvm.2024.1396889

12. Kristovic D, Horvatic I, Husedzinovic I, Sutlic Z, Rudez I, Baric D, et al. Cardiac surgery-associated acute kidney injury: Risk factors analysis and comparison of prediction models. Interact Cardiovasc Thorac Surg. 2015;21(3):366–73.

13. Sharma V, Atluri H. Minimizing Acute Kidney Injury in Pediatric Cardiac Surgery : Incidence , Early Detection , and Preemptive Measures. 2024;16(11).

14. Shin SR, Kim WH, Kim DJ, Shin IW, Sohn JT. Prediction and prevention of acute kidney injury after cardiac surgery. Biomed Res Int. 2016;2016(Table 1).

15. Leballo G, Moutlana HJ, Muteba MK, Chakane PM. Factors associated with acute kidney injury and mortality during cardiac surgery. Cardiovasc J Afr. 2021;32(6):308–13.

16. Singh W, Yalamuri S, Nikravangolsefid N, Suppadungsuk S, Goyal S, Hanson A, et al. Ultrafiltration During Cardiac Surgery Requiring Cardiopulmonary Bypass and Its Effect on Acute Kidney Injury. J Cardiothorac Vasc Anesth. 2024;000.

17. Carrascal Y, Laguna G, Blanco M, Pañeda L, Segura B. Acute kidney injury after heart valve surgery in elderly patients: Any risk factors to modify? Brazilian J Cardiovasc Surg. 2021;36(1):1–9.

18. Rao SN, Shenoy M P, Gopalakrishnan M, Kiran B A. Applicability of the Cleveland clinic scoring system for the risk prediction of acute kidney injury after cardiac surgery in a South Asian cohort. Indian Heart J [Internet]. 2018;70(4):533–7. Available from: https://doi.org/10.1016/j.ihj.2017.11.022

19. Serraino GF, Provenzano M, Jiritano F, Michael A, Ielapi N, Mastroroberto P, et al. Risk factors for acute kidney injury and mortality in high risk patients undergoing cardiac surgery. PLoS One [Internet]. 2021;16(5 May):1–13. Available from: http://dx.doi.org/10.1371/journal.pone.0252209

20. Husain-Syed F, Quattrone MG, Ferrari F, Bezerra P, Lopez-Giacoman S, Danesi TH, et al. Clinical and Operative Determinants of Acute Kidney Injury after Cardiac Surgery. CardioRenal Med. 2020;10(5):340–52.

21. Adil A, Setiawan P, Sembiring Y, Arif S, Amin H. Acute kidney injury incidence following cardiac surgery: A risk factor analysis. Bali J Anesthesiol. 2021;5(1):6–10.

22. Ekure E, Esezobor C, Sridhar A, Vasudevan J, Subramanyan R, Cherian K. Cardiac surgery-associated acute kidney injury in a developing country: Prevalence, risk factors and outcome. Saudi J Kidney Dis Transplant. 2015;26(3):489.

23. Tilahun R, Anesthesiology A, Anesthesiologist C. College of Health Sciences, School of Medicine Specialty Program Research Proposal Prevalence and Associated Factors of Acute Kidney Injury Among Postoperative Patients Admitted To Intensive Care Unit At Tikur Anbessa Specialized Hospital, Addis Ababa, Et. 2021;(Md).

24. Uduagbamen PK, Sanusi M, Udom OB. Cardiac and Vascular Surgery Associated Acute Kidney Injury: Findings from a High Dependency Heart and Vascular Surgical Centre in Nigeria. A Six-Year Retrospective Cohort Study. Int J Heal Sci. 2021;9(4).

25. Harky A, Joshi M, Gupta S, Teoh WY, Gatta F, Snosi M. Acute kidney injury associated with cardiac surgery: A comprehensive literature review. Brazilian J Cardiovasc Surg. 2020;35(2):211–24.

26. Van den Eynde J, Delpire B, Jacquemyn X, Pardi I, Rotbi H, Gewillig M, et al. Risk factors for acute kidney injury after pediatric cardiac surgery: a meta-analysis. Pediatr

Nephrol [Internet]. 2022;37(3):509–19. Available from: https://doi.org/10.1007/s00467-021-05297-0

27. Paula Graziani M, Moser M, Martín Bozzola C, Galvez HM, Garrido JI, Guido Álvarez P, et al. Acute kidney injury in children after cardiac surgery: Risk factors and outcomes. A retrospective cohort study. Arch Argent Pediatr. 2019;117(6):E557–67.

ANNEX I : INFORMATION SHEET

Title of the Research Project: Assessment of prevalence and associated factors with post-operative acute kidney injury in patients who underwent open heart surgery in Addis Ababa, Ethiopia (2021-2024): a multicenter retrospective cross-sectional study.

Name of Principal Investigator: Mahlet Getahun

Name of the Organization: Addis Ababa University, School of Medicine, Department of Cardiology.

Introduction: Greetings! My name is Mahlet Getahun. I am a student at Addis Ababa University College of Medicine Department of Cardiology in MSc in Cardiovascular Perfusion. As part of this degree, I am undertaking a research project "Assessment of prevalence and associated factors with post-operative acute kidney injury in patients who underwent open heart surgery in Addis Ababa, Ethiopia (2021-2024): a multicenter retrospective cross-sectional study."

Purpose of the Research Project: The aim of this study to assess the prevalence and associated factors of post-operative acute kidney injury among patients who undergone open cardiac surgery at TASH, CCE, Tazma and Elouzeir from 2021-2024. The information gained from this research will be used to minimize perioperative complications and improving patient outcomes and to select the best alternative solution.

Procedure: The data collection was conducted in Tikur Anbesa Specialized Hospital (TASH), Cardiac Center of Ethiopia (CCE), Elouzeir cardiac center and Tazma medical and surgical specialized center. Standard questioner is prepared to collect necessary information from patient chart.

Risk and /or Discomfort: The data was taken from patient medical records, so it will not impose any harm on patients.

Confidentiality: During data collection the patients name would not be taken, instead they were identified by their card number in the chart. All questionnaires collected were kept confidential and destroyed after the end of the project. The information collected will be used only for

research purpose. The thesis will be submitted for marking to Addis Ababa University College of Medicine Department of Cardiology and displayed in the University Library and website. This study is also intended to be submitted for publication in scholarly journals.

Right to Refusal or Withdraw: Approval of the manager of the hospital and participant will be required to start data collection.

Person to contact: If you have any further questions or would like to receive further information about the project, please contact:

1. Mahlet Getahun (Principal investigator): +251975437421
2. Ass.Professor Dereje Gulilat (MD, Cardiothoracic Surgeon) (Advisor): +251911215965

ANNEX II: CHECKLIST

Date: ___/____/__

Code. _____

Instruction: For each of the questionnaires, please Encircle the number of alternative(s) that fit the response and fill the blank space provided or provide appropriate response accordingly.

PART I: Questions on socio-demographic and patient status

Sr.no	Questions	Response	Code
101	Age(years)	A.0-1years B.1-18years C.18-60years D.>60years	
102	Sex(M/F)	A. Male B. Female	
103	Weight in kg	_____	
104	Height in meter	_____	
105	BMI	A. ≤18.5 B. 18.5-24.9 C. 25-29.9 D. ≥30	
106	DM	A. YES B. NO	
107	HTN	A. YES B. NO	
108	Smoker	A. YES B. NO	
109	Type of surgery		
	CABG	A. YES B. NO	
	Cardiac valve surgery	A. AVR/ AVr B. MVR/ MVr C. DVR/ r	

	Congenital	A. VSD B. ASD C. AVSD D. SAM E. TGA F. TOF	
	Other		
110	LVEF	A. ≤30% B. 30%-50% C. ≥50%	
111	Pilmonary hypertension	A. Yes B. No	
112	Preoperative renal function	Serum creatinine (mg/dl) _____	
113	Operation type	A. New B. Redo	

PART II. CPB related

Sr.no	**Questions**	**Response**	**Code**
201	Duration of surgery	A. <2hrs B. 2-4hrs C. >4hrs	
202	Average mean arterial pressure for age	A. Below Average B. Normal C. Above Average	
203	Temperature	A. 32 ˚C – 35 ˚C	
		B. < 32 ˚C – 28 ˚C	
		C. < 28 ˚C – 20 ˚C	

		D. < 20 ˚C	
204	CPB time	A. < 90 minutes	
		B. 90 - 120 minutes	
		C. > 120 minutes	
205	Aortic cross-clamp time	A. <30 minutes	
		B. 30 – 90 minutes	
		C. >90 minutes	

PART III. Post-operative patient related

Sr.no	Questions	Response	Code
301	Post-operative Creatinine (mg/dl)	24 hours 48 hours	
302	Increased serum creatinine level (mg/dl)	A. ≥0.3mg/dl B. ≥1.5 times C. None	
303	Post-operative urine output in 24 hrs	A. <0.5ml/kg/hr B. 0.5-1ml/kg/hr C. >1ml/kg/hr	
304	Post-operative urine output in 48 hrs	A. <2000ml B. >2000ml	
305	Presence of AKI	A. Yes B. No	