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ASSESSING ACUTE KIDNEY INJURY IN SURGICAL CARE: PREVALENCE AND CONSEQUENCES IN CARDIAC AND VASCULAR SURGERIES AT A NIGERIAN HIGH DEPENDENCY CENTER

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Abstract: Acute kidney injury (AKI) is a common complication in surgical procedures, particularly heart and vascular surgeries, leading to increased healthcare costs, prolonged hospital stays, and adverse outcomes. Various criteria and definitions have been used to diagnose AKI, with the Kidney Disease: Improving Global Outcome (KDIGO) criteria being the most widely accepted. Cardiac surgery-associated AKI (CSA-AKI) has a reported prevalence of approximately 30%, while the prevalence of AKI requiring dialysis (AKI-D) is around 6%. Accurate and timely diagnosis of CSA-AKI is crucial for early intervention and improved patient outcomes.

Keywords: Acute kidney injury, Cardiac surgery, KDIGO criteria, Surgical complications, Dialysis.

1.0 Introduction

Acute kidney injury (AKI) commonly complicates surgeries particularly heart and vascular surgeries with attendant increases in cost of treatment, hospital stay, morbidity and mortality [1]. Various definitions and criteria for diagnosing AKI have been used but recent, widely validated definitions of AKI are based on declining kidney function evidenced by reduced urine output (OU), elevated serum creatinine (SCr) and declining glomerular filtration rate (GFR). The Acute Dialysis Quality Initiative (ADQI) Group in 2004 introduced the risk-injuryfailure-loss-end-stage kidney disease (RIFLE) criteria defining various stages and severity of AKI [2]. The Acute kidney injury network (AKIN) in 2007 modified the RIFLE criteria based on detected effect of minimal increases in SCr on mortality [3]. Shortcomings from the RIFLE and AKIN definitions, particularly in cardiac surgery patients, led to the widely accepted “Kidney Disease: Improving Global Outcome (KDIGO)” definition in 2012 that gave an improved sensitivity and prediction of in-hospital mortality [4]. The prevalence of cardiac surgery associated AKI (CSA-AKI) is reported to be 30% with a range of 7-40% [5]. The prevalence of AKI requiring dialysis (AKI-D) is reported to be 6% [6].

The pathophysiologic mechanisms of CVSA-AKI include cardiopulmonary bypass-induced hemolysis, neurohormonal activation, toxins, inflammatory changes, oxidative stress and ischemic-reperfusion injury among others. Theselead to excessive vasoconstriction, vascular endothelial and tubular cell death from necrosis and apoptosis [7]. Anemia (irrespective of intraoperative transfusion) is reported to be a risk factor for CVSA-AKI and increased morbidity [8] and hypoalbuminemia has been found to worsen the morbidity and mortality rates in cardiac surgery [9].

Lammy et al [10] reported lower risk of AKI in off-pump CABG compared to on-pump CABG. Shroyer et al [11] in a retrospective study, however found a lower risk for AKI in on-pump compared to off-pump

CABG. It is reported that minimally invasive surgeries are associated with lower incidences of AKI with mini thoracotomy having better renal outcome post-surgery compared to sternotomy. In kidney disease, better treatment outcome are found in minimal catheter based mitral valve repair than in more invasive valvular surgeries [13].

The anesthetic agent used is reported to play some role in determining the severity of CVSA-AKI. Volatile anesthetic agents are less associated with CVSA-AKI compared to total intravenous anesthesia (TIVA). A direct relationship is reported to exist between the duration of surgery and adverse treatment outcome including AKI.[15] just as emergency surgeries are reported to increase the incidence of AKI compared to elective surgeries [16]. AKI could also be from vascular obstruction caused by cholesterol embolization and this tends to be more in vascular and cardiac surgeries than other parts of the body [17]. Genetic predisposition to AKI after cardiac surgery has been linked to the presence of apolipoprotein E (APOE) which has three serotypes Ê2 Ê3 and Ê4 with Ê4 reported to be protective against AKI while individuals with Ê2 and Ê3 were at a higher risk of AKI [18]. The International Society of Nephrology (ISN) is presently coordinating a collaboration program involving governments, donor agencies, health care providers and cooperate bodies aimed at eliminating preventable deaths from AKI by 2025 [19].

Open heart and major vascular surgeries are common procedures in advanced nations and there is vast literature on renal outcome, but in many low income nations (LINs) where the availability of these surgical services is just becoming better, literature is expectedly very scanty.[10, 15]. In view of its preventability, the availability of data on theepidemiology, risk factors and clinical correlates of AKI have become a necessity. We studied AKI complicating cardiac and vascular surgeries and determined the risk factors, prevalence, clinical correlates and short term outcome in a high dependency surgical heart and vascular center in Nigeria.

2.0: Methods

2.1 Study design: This was a 6 year retrospective study conducted at the Tristate Heart and Vascular Center, a high dependency cardiac and vascular surgical center dedicated to providing cardiac and vascular repair, replacement and implantation procedures in South Western Nigeria. The hospital receives patients across all ages from all parts of Nigeria and neighboring West and Central. African nations.

2.2 Data collection:

Case notes, perioperative charts and ICU charts of patients who had cardiac and/vascular surgery in the center from January 2015 to December 2020 were retrieved. Variables retrieved included age, sex, type and cause of cardiac and/or vascular disease, duration of disease, primary presenting complaints, duration of surgery, previous surgical procedure related to disease, elective/emergency surgery, body mass index (BMI), percentage oxygen saturation, pulse rate, mean arterial pressures (MAP), heart rate, duration of hospital stay till discharge or death and comorbidities (heart failure, chronic liver disease, chronic kidney disease, stroke or cancer). Also retrieved on post-operative day 1 (POD1), POD 7 and POD 30, were urine volume, urinalysis, serum electrolyte, urea and creatinine, GFR, full blood count (FBC), erythrocyte sedimentation rate (ESR), blood glucose, fasting lipids (preop, POD 7 and POD 30), arterial blood gases, results of liver function test, infections and daily fluid charts.

2.3 Exclusion criteria:

Excluded from the study were participants less than 16 years, previous surgery within 30 days prior to index surgery, repeat surgeries for same condition, missing data, end stage renal disease (ESRD) brain death, death less than 24 hours after surgery.

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AKI in this study was defined and staged according to the Kidney Disease Improving Global Outcome criteria (KDIGO) [4].

2.4 Definitions of terms:

AKI: Increase in serum creatinine by 0.3 mg/dl (26.5umol/L) within 48 hours, or increase in serum creatinine, x1.5 from baseline, known or known to have occurred within the previous 7 days, or UO <0.5 ml/kg/h for 6 hours.

AKI Stage 1: AKI stage 1: Serum creatinine rise of ≥26 umol/L within 48 hours or 150-199% of baseline within 7 days or UO <0.5ml/kg per hour for more than 6 hours

AKI Stage 2: AKI stage 2: Serum creatinine 200–299% of baseline within 7 days or UO <0.5mls/kg per hour for more than 12 hours

AKI Stage 3: AKI Stage 3: Serum creatinine ≥ 300% of baseline within 7 days or concentration of ≥ 354 umol/L within 48 hr or ≥ 50% rise from baseline within 7 days or any requirement for RRT or OU <0.3ml/kg per hour for 24 hrs or anuria for 12 hrs.

Kidney dysfunction: GFR <60ml/min [20]

Acute kidney disease (AKD): Diagnostic criteria for AKI persistent for up to 1 month [2] Sepsis: Culture confirmedor suspected microbial infection, with at least 2 of these conditions:

temperature > 38°C or < 36°C, pulse rate >90/minute, respiratory rate > 20cycles/minute, white cell count of > 11,000cells/mm^3 or < 4000 cells/mm^3 [21]

Hypovolemia : Fluidloss with features of dehydration and changes in the hemodynamics such as tachycardia and hypotension

Hypotension: Blood pressure <90/60 mmHg [22]

Intraoperative hypotension: MAP fall ≥20mmHg for ≥5 minutes [22]

Hypertension: BP ≥140/90 mmHg or physician diagnosed hypertension or using BP lowering drugs to control BP [22]

Intraoperative hypertension: Mean arterial pressure (MAP) rise ≥10mmHg [22]

Diabetes: Fasting blood glucose >126 mmoL or physician-diagnosed diabetes

Anaemia: Hematocrit <33% [23]

Hypoalbuminemia: Serum albumin <35mg/dL [24]

Metabolic acidosis (MA): Serum bicarbonate <22 mmol/L [25]

Standard base excess (SBE): <-2mEq1^{-1}[25]

Anion gap (AN): Sodium + Potassium – Chloride - Bicarbonate [25]

Elective surgery: Procedure scheduled in advance

Emergency surgery: Procedure not scheduled in advance, with or without attaining stable pre-operative hemodynamic stability

Major surgery: Open heart surgery requiring total intravenous anesthesia

Prolonged surgery: Surgery lasting more than 2 hours (120 minutes)

TIVA: Total intravenous anesthesia (involving the whole body)

2.5 Clinical outcomes

Complete recovery of kidney function: Serum creatinine return to pre-induction value or less [26]

Partial recovery of kidney function: Reduced severity grade of AKI but not less than stage 1[26] Acute kidney disease: Progression of AKI beyond POD 30 [2] Death: from 24 hours into the ICU up to POD 30.

2.6 Statistical analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) version 22.0 (IBM Inc, NY, USA). Continuous variables were presented as means or medians and categorical variables are presented as proportions. Paired t-test was used to determine the association between continuous variables that were normally distributed and continuous variables that were not normally distributed were compared using the Mann–Whitney U-test. Associations between categorical variables were compared using the chi-square test or Fisher's exact test when less than five observations are recorded. Multivariate analyses were conducted to identify independent predictors of AKI in which variables with a p value of <0.25 on univariate analysis were entered, to determine independent associates of "recovering from AKI" with backward elimination to adjust for confounders [27]. It is reported that the use of p<0.05 oftentimes doesn't identify all important variables. Associations between variables were considered to be significant for P-values <0.05.

2.7 Ethical clearance:

The institutional ethical committee of Babcock University approved the study (BUHREC558/19, NHREC/24/01/2018). The research followed the tents of the Declaration of Helsinki.

3.0 Results

Three hundred and eleven (190 males and 121 females) participants who had cardiac and vascular surgery were studied. The mean age of the participants was 56.9 ± 5.3 years (males 55 1 ± 6.2years, females 59.6 ± 9.4 years). The commonest presenting complain was dyspnea (Table 1). Aortic valve disease was the commonest cardiac disorder (26.4%) while valvular surgeries were the commonest surgeries performed (30.9%).

Table 1: History and clinical findings in study population

Variables	Frequency N=311 (%)
Major presenting complaints	
Dyspnea	107 (34.4)
Chest pain	93 (29.9)
Syncope/Dizzy spells	43 (13.8)
Poor exercise intolerance	42 (13.5)
Others	26 (8.4)
Primary cardiac disease	
Aortic valve disease	82 (26.4)
Mitral valve disease	54 (17.4)
3 vessel disease	78 (25.1)
Dilated cardiomyopathy	24 (7.7)
Aneurysmal disease	21 (6.7)

Others	52 (16.7)
Surgeries	
VRR	90 (30.9)
CABG	40 (12.9)
Combined VRR and CABG	38 (12.2)
Catheterization	41 (13.2)
IABP	24 (7.7)
Stenting	18 (5.8)
Others	54 (17.3)

VRR-valve replacement/repair, CABG-coronary artery bypass graft, IABP-intra-aortic balloon pump

Two hundred and fifty six (82.3%) of the surgeries were elective while 55 (17.7%) were emergency (Table 2). Majority of the participants, 229 (73.6%) were young or middle aged while 82 (26.4%) were elderly. The commonest presenting compliant was difficulty with breathing 107 (34.4%). A greater proportion of participants 223 (71.7%) were either underweight or had normal BMI while 88 (28.3%) were overweight.

Diseases of the heart valves 136 (43.7%) were the commonest diagnoses followed by 3 vessel disease (3VD) 78 (25.1%), dilated cardiomyopathy (DCM) 24 (7.7%) and aneurysmal disease 21 (6.8%). Valve repair and replacement (VRR) alone 98 (31.5%) were the commonest surgeries performed followed by coronary artery bypass graft (CABG) 68 (21.9%), VRR and CABG 38 (12.2%), right heart catheterization (RHC) 13 (4.2%), per cutaneous intervention (PCI), and stenting 8 (2.6%) each, and intra-aortic balloon pump (IABP) 5 (1.6%). One hundred and twenty-three (39.5%) participants had at least one comorbidity. One hundred and three (33.1%) had background kidney dysfunction (KD), 94 (30.2%) had hypertension of which 72 (76.6%) were receiving diuretic therapy prior to surgery. Twenty-two (7.1%) had diabetes and 8 (2.6%) had liver disease. The mean pre-induction GFR was 72.2 ± 8.3 ml/min/1.73m².

Preoperative, 208 (66.9%) had no background KD. Of this, 49 (23.6%) had AKI as at POD7 compared to the 39 (37.9%) that had AKI amongst participants with background KD, $P<0.001$. Seventy nine (25.4) participants had proteinuria before surgery. The risk of CVS-AKI was higher in participants with diabetes than with hypertension, P=0.03 and P=0.05 respectively. The duration of anesthesia, intra-op blood transfusion, intraoperative blood loss (≥500ml), pre-op hematocrit and albumin were not associated with increased risk of CVS-AKI, P=0.05, P=0.7, P=0.05, P=0.08 and P=0.05 respectively.

Post-surgery, there were progressive increases in the mean arterial pressure, GFR, standard base excess and hematocrit, P=0.05, P=0.04, P=0.04, P=0.6 and there were significant progressive decline in the SCr, and anion gap, P=0.01 and P=0.03 respectively.

There was no significant differences between the pre-op and POD 30 serum albumin, 36.1 ± 11.3 mg/dl and 37.6 ± 11.9mg/dl, P=0.07. The incidence of AKI on POD 1 and POD 7 were 23.3% and 20.1% respectively, and the cumulative incidence of AKI POD 7 was 28.3%. Of the 88 participants with AKI, 22 (25.0%), 28 (31.8%) and 38 (43.2%) had stage 1, 2 and 3 disease respectively.

Table 2: Sociodemographic, clinical and laboratory characteristics of participants

Variables	No periop AKI	Periop AKI	P-value

	N=223 (%)	N=88 (%)	
	Mean ± SD.	Mean ± SD.	
	Median (range)	Median (range)	
Sex			
Males (n, %)	143 (64.1)	66 (75.0)	0.01
Females (n, %)	80 (35.9)	22 (25.0)	
≥65 years (n, %)	29 (13.0)	53 (60.2)	<0.001
Pre-op kidney dysfunction (n, %)	64 (28.7)	39 (44.3)	<0.001
Pre-op proteinuria (n, %)	47 (21.1)	32 (36.4)	0.01
Pre-op comorbidity (n, %)	74(33.2)	49 (55.7)	0.001
MAP <75 mmHg (n, %)	10 (4.5)	9 (10.2)	0.05
Pre-op SCr, umol/l median (range)	87 (43-138)	111 (45-301)	0.001
GFR, ml/min median (range)	70 (38-97)	47.7 (36.4-59.6)	0.001
SBE, mmol/l median (range)	1.2 (-3.2-2.4)	0.8 (-6.5-2.0)	0.04
Anion gap, mEq (mean ± SD)	17.8 (3.2)	22.6 (3.7)	0.03
Surgical modality, (n, %)			
Elective	206 (80.5)	50 (56.8)	0.001
Emergency	17 (19.5)	38 (43.2)	
Total intravenous anesthesia (n, %)	175 (78.5)	78 (88.6)	0.002
Surgery >3hrs (n, %)	152 (68.2)	74 (84.1)	0.04
DOA <7days (n, %)	74 (33.2)	40 (45.5)	0.02
IOH, (MAP<65mmHg >5min) (n, %)	17 (7.6)	9 (10.2)	0.04
Pre-op sepsis	6 (2.7)	6 (6.8)	0.001
Post-op inotropes (n, %)	19 (8.5)	9 (10.2)	0.1
Post-op mortality	0 (0.0)	9 (10.2)	<0.001*

MAP-mean arterial pressure SCr-serum creatinine, GFR-glomerular filtration rate, SBE-standard base excess, DOA-days on admission, IOH-intra-operative hypotension

3.1 Renal replacement therapy

Thirty five (39.8%) of the 88 participants with AKI {7 (20%) in stage 2 and 28 (80.0%) in stage 3} underwent dialysis treatment (Table 3). Seventy four (84.1%) participants recovered from AKI, of this, 30 (40.5%) had dialysis while 44 (49.5%) were not dialyzed. Fourteen (15.9%) participants with AKI didn't recover, of this, 9 (64.3%) died while 5 (35.7%) had progression of kidney disease. Of the 5 participants who couldn't recover kidney function completely, 3 (60.0%) progressed to AKD and 2 (40.0%) became dialysis dependent. Of the 9 participants with AKI that died, 3 (33.3%) were dialyzed unlike 6 (66.7%), and all (100%) had stage 3 KDIGOAKI.

Table 3: Outcome of AKI in the study population

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Variables	Recovered	Non-recovery	OR	95% CI	P-value
	N=74 (%)	N=14 (%)			
Sex					
Males	57 (86.4)	9 (13.6)	1.981	1.40-4.99	0.04
Females	17 (77.3)	5 (22.7)			
Age, years					
<65	34 (97.1)	1 (2.9)	6.25	1.32-8.48	<0.001
≥65	40 (75.5)	13 (24.5)			
Pre-op GFR, ml/min					
≥60	46 (91.8)	3 (8.2)	5.02	1.62-7.14	<0.001
<60	28 (71.8)	11 (28.2)			
Pre-op MAP, mmHg					
<65	6 (66.7)	3 (33.4)	2.2	1.94-4.83	0.03
≥65	68 (89.5)	11 (10.5)			
KDIGO-AKI stage					
1	22 (100)	0 (0.0)	1		
2	27 (96.4)	1 (3.6)	4.33	0.25-7.12	0.001
3	25 (65.8)	13 (34.2)			
Surgery modality					
Elective	46 (93.9)	4 (6.1)	3.18	0.91-.0. 5.2	0.02
Emergency	28 (73.4)	10 (26.6)			
Surgery duration, hours					
<2	12 (85.7)	2 (14.3)	1.03	1.37-3.50	0.05
≥2	62 (83.8)	12 (16.2)			
Pre-op sepsis					
No	74 (90.2)	8 (9.8)	8.85	2.42-16.69	<0.001
Yes	0 (0.0)	6 (100)			
Comorbidities					
No	36 (92.3)	3 (7.7)	4.46	0.52-4.72	0.002
Yes	38 (77.6)	11 (22.4)			

OR-odds ratio, CI95% confidence interval, GFR-glomerular filtration rate, MAP-mean arterial pressure, AKIKDIGO-AKI- kidney disease improving global outcome-acute kidney injury

Variables in participants with AKI that were associated with treatment outcome, and with P<0.025, were entered into a multivariate model to determine independent predictors of adverse treatment outcome using backward elimination to adjust for confounders. From multivariate analysis (Table 4) advanced age (OR-5.84, CI1.77-10.04), pre-op kidney dysfunction (OR-4.92, CI-0.94-8.40), KDIGO-AKI stage 3 (OR-4.63, CI-1.47-8.88), pre-op sepsis (OR-6.02, CI-1.61-10.35) and comorbidity (OR-6.68, CI-0.89-10.39) independently predicted nonrecovering from AKI.

Table 4: Multivariate analysis showing independent predictors of non-recovering from AKI.

Variables	aOR	95% CI	P-value
Advancing age	5.84	1.77-10.4	0.001
Background kidney dysfunction	4.92	0.94-8.40	0.002
KDIGO-AKI stage 3	4.63	1.47-4.88	0.002
Pre-op sepsis	5.02	1.61-5.35	0.001
Comorbidity	6.68	0.89-6.39	<0.001

KDIGO-AKI-kidney disease improving global outcome-acute kidney injury

4.0 Discussion

We found CVSA-AKI a common finding with a cumulative incidence of 28.3%, 23.1% and 20.3% on POD1 and POD7 respectively. Risk factors for AKI included male gender, elderly, higher BMI, background kidney dysfunction and, other comorbidities, sepsis, emergency surgeries and prolonged (>2 hours) surgeries. AKI was positively related to the anion gap and negatively related to the base excess. Almost 40% of the cohort with AKI needed RRT and there was a positive relationship between the stage of AKI and adverse treatment outcome like death. The incidence of AKI in this study falls within the 4-30% found by Vives et al [5] in a review and similar to findings by Shin et al who reported an incidence of 29% [28]. The incidence is however less than the 43% reported in a previous study [6]. Luo et al [29] in comparing the various diagnostic criteria: RIFLE, AKIN and KDIGO, found incidences of 46.9%, 38.4%, and 51.0%, respectively. The use of various diagnostic criteria prior to the KDIGO criteria particularly in mild AKI has been responsible for the wide variability in incidences [5]. Replacing the increase in SCr in 48 hours in AKIN with 7 days in KDIGO further allowed slower increases in SCr (more subtle worsening of kidney function) to be picked up [5]. Srisawat et al [30] reported that the incidence of CVS-AKI was gender sensitive as he found AKI incidence higher in males, using KDIGO criteria, but found no gender difference with the RIFLE's. The higher risk for AKI found in males is not in agreement with the KDIGO reports in 2012 [18] but agrees with Cobo et al [31] who concluded in their study that females have renoprotective features.

The elderly had a 4 fold increased risk for AKI, this higher risk agrees with several studies that found higher morbidity and mortality rates in the elderly population with CVS-AKI [6, 32]. The declining oxygen tension, renal and cardiac reserve associated with aging coupled with the presence of more comorbidities makes the elderly less able to mount effective response in the face of up-regulation of surgery-induced stressors with activation of the inflammatory cascade.

The risk of non-recovery from CVS-AKI is increased four-fold in background kidney dysfunction. The increased risk agrees with earlier studies that found higher pre-op SCr and low GFR as independent predictors of CVS-AKI [33]. The hypoperfusion and hypothermia induced during cardiopulmonary bypass (CPB) compromises effective renal blood flow resulting in declining glomerular filtration, and if prolonged, could result in tubular cell apoptotic changes, death, sloughing off and blockage, with epithelial obstruction and back flow leakage into the glomerulus further worsening the renal insults [7] The subsequent activation of the inflammatory pathway stimulates the renin angiotensin aldosterone system (RAAS) leading to vasoconstriction and interstitial oedema. This further compromises glomerular and tubular function leading to fluid retention and metabolic acidosis [34] Moreover, it is also reported that the CPB circuit induces an inflammatory response from a non-physiologic contact with red blood cell causing hemolysis.[35]

The higher prevalence of acidosis in participants with AKI further explains the higher anion gap and lower base excess in this group secondary to renal tubular damage [25]. Anemia, as well as hypoalbuminemia were not associated with increased risk of AKI in this study and this disagrees with findings by Gude et al [7] and Paison et al [8]. However,Frenette et al [36] found that intraoperative albumin infusion was associated with a higher risk of CVS-AKI. A previous study had found that optimizing patients' hemodynamic status reduced the incidence of AKI. [37] We believe the non-optimization of patients' hemodynamics in most emergency surgeries accounted for the higher incidence of AKI in this group, considering the fact that unstable hemodynamics and/or threat to life is a common pre-op finding, and that may hinder effective compensatory responses to the stress of surgery.

We found a positive correlation between the risk of developing AKI and the duration of surgery, as it was with the use of TIVA. This mirrors findings in a previous study that associated longer surgery hours with occurrence of AKI [38]. TIVA are commonly used for major (open heart) surgery which are mostly of longer duration. Prolonged hemodilution decreases tissue oxygen delivery, and in the presence of a decreased cardiac output, renal injury could be worsened [7]. Englberger et al [39] however found no association between deep hypothermic circulatory arrest (DHCA) and post CVS-AKI. Episodes of poor blood pressure control, particularly intra-operative hypotension, are more likely with TIVA from the vasodilatation induced by these drugs. Intra-op hypotension when greater than 5 minutes can induce renal tubular ischemia and injury. Hypothermia during CPB can also contribute to the renal vasoconstriction and hypoperfusion and at the end of surgery, even with inotropic support, the lowered GFR limits effective renal perfusion [22].

Sepsis worsened the renal outcome (post cardiac surgery) in this study, this mirrors findings from a previous study. [40]. The inflammatory responses of vasodilatation, increased permeability and poor tissue perfusion and oxygenation, in addition to the hemolytic effect on the red blood cells cause reduced blood flow, cumulating in glomerular and tubular proteinuria [34]. Elevated Neutrophil/Lymphocyte ratio in AKI further buttresses the role of inflammatory mediators in CVS-AKI [41].

The incidence of AKI requiring dialysis (AKI-D) in this study is higher than that reported in a previous study which found an incidence of 5.8% [28]. The higher incidence could be attributed to factors like nonoptimization of pre-op hemodynamics that is common particularly in emergency surgeries, background kidney dysfunction and late referral to the nephrologist. Recovering from AKI was better in the young, early stages of AKI and in the absence of sepsis or comorbidities as has been previously reported [22, 42] but the higher recovery rate in men (and death in females) in this study is in opposition toprevious findings that associated female sex with reno-protection and a lower risk for AKI. Obialo et al [44] reported that with aging, the health survival advantages associated with females are lost. The reductions in the cardiovascular protective female hormones in postmenopausal years could account for the attenuation. The fact that the female cohorts were older in our study further supports these findings.

Limitations encountered in this study included the non-inclusion of blood PH as it was not assessed in all participants, the serum creatinine could only be assessed thrice in 30 days post-surgery to reduce cost hence some cases of AKI of short duration could have been missed. The effect of different types of intravenous fluid administered was not considered. We couldn't classify pre-existing kidney dysfunction as AKI or chronic kidney disease (CKD) as the baseline kidney function of most participants, three months prior to surgery, were not known.
Diabetes was self-reported or with the use hypoglycemic agents, the blood glucose was not determined. Dyslipidemia as a comorbid factor was not considered due to the high cost of investigations.
Effective enlightenment and training programs should be given to the public and health care workers in order to reduce the incidence and health burden associated with AKI. Cardiac and vascular surgery teams should involve nephrologists in managing all patients for open heart surgery. The use of Cystatin C in place of creatinine in determining kidney function should be considered in view of its less dependence on the body size.

4.1 Conclusion:

There was a male preponderance but females were older in participants undergoing cardiac/vascular surgeries. The incidence of CVS-AKI was 28.3%.The risk of AKI was increased in females, elderly, background kidney disease, pre-op sepsis and comorbidities. Pre-op anemia, hypoalbuminemia and blood loss were not associated with significant risks of developing CVS-AKI. A very high proportion of participants with CVS-AKI, particularly females needed RRT but males, the young and participants without background kidney disease were more likely to recover from CVS-AKI. There was a positive relationship between the stage of AKI and the risk of death. There is the need for the optimization of patients' hemodynamics prior to surgery t minimizes the incidence and health burden of CVS-AKI.

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