



Review Article

Prevalence of Post-Operative Acute Kidney Injury and Associated Risk Factors at A Tertiary Trauma Center in Dar Es Salaam, Tanzania

Edwin Lugazia^{1*}, Issa Ramadhan Kaniki¹, Frederic Mbanga¹, Respicious Boniface¹, Francis Furia²

¹Department of Anaesthesiology, School of Medicine, Muhimbili University of Health and Allied Sciences, Tanzania

²Department of Pediatrics and Child Health, School of Medicine, Muhimbili University of Health and Allied Sciences, Tanzania

*Corresponding author: Edwin Lugazia, Department of Anaesthesiology, School of Medicine, Muhimbili University of Health and Allied Sciences, PO BOX 65001, Tanzania

Citation: Lugazia E, Kaniki IR, Mbanga F, Boniface R, Furia F (2022) Prevalence of Post-Operative Acute Kidney Injury and Associated Risk Factors at A Tertiary Trauma Center in Dar Es Salaam, Tanzania. J Surg 7: 1481 DOI: 10.29011/2575-9760.001481

Received Date: 27 February, 2022; **Accepted Date:** 02 March, 2022; **Published Date:** 07 March, 2022

Abstract

Background: Acute kidney injury is one of the complications that can occur in every anaesthetized/operated patient but the magnitude of individual risk will also depend on other contributory factors for each particular patient. Acute Kidney Injury (AKI) may have a spectrum of outcome which include complete recovery, development of chronic kidney disease or if severe may result into death. AKI also contributes to a long hospital stay, total hospital cost, morbidity and mortality. **Objective:** The aim of this study was to determine the prevalence of post-operative acute kidney injury and associated risk factors at Muhimbili Orthopaedic Institute (MOI). **Materials and Methods :** This was a hospital based quantitative cross-sectional study which was carried out among operated patients at Muhimbili Orthopaedic Institute (MOI). Laboratory blood results for serum creatinine before surgery (baseline serum creatinine), 48 hours, 7th day and 28th day post operatively was used for this purpose. Data was processed using IBM Statistical Package for the Social Sciences (SPSS) v23.0 software. Frequency and percentages was used to summarize the demographic, perioperative risks and serum creatinine levels. Bivariate and Multivariate analysis was done to examine the association between risk factors and outcome of interest (AKI). **Results:** Study involved 156 participants who underwent surgical intervention at MOI from October 2019 to March 2020. Among the participants males were 102 (65.4%) and females were 54 (34.6%). Mean age of participants was 48.26 years with standard deviation of 16.75. Study managed to find a prevalence of 12.8% (20/156) of post-operative acute kidney injury among the participants. Most observed risk factors were old age (above 60 years) with prevalence of 16.7% within age group, emergence procedures with prevalence of 18.9%. Other risk factors includes ASA status and pre-existing medical conditions having a prevalence of 18.8% and 20.7% respectively. Prolonged operations had a prevalence of 23.1% with a p-value of 0.001 and intraoperative use of ephedrine had a post-operative kidney injury prevalence of 50% with a p-value of <0.0001. Recovery was observed in 60% of those found to have post-operative acute kidney injury with 30% complete recovery and 30% partial recovery. **Conclusion:** Good documentation of perioperative events can also help determine those in danger of developing post-operative AKI and thus help to provide preventive measures for those at high risk.

Keywords: Acute kidney injury; Intraoperative; Perioperative; Post-operative; Risk factors; Serum creatinine

Introduction

Acute Kidney Injury (AKI) is as a sudden episode of kidney damage that happens within a few hours or a few days [1]. AKI is still a challenge both in management and prevention in many settings within the developing world. Although it is regarded as reversible condition if patient survive this stage and apart of being one of the most common post-operative complications, AKI also contributes to a long hospital stay, total hospital cost, morbidity and mortality. Less severe forms of AKI can go unnoticed in some cases but where the predisposing risk persist or proper action not taken within a critical period this can results into progressive loss of functional unit within renal mass. KDIGO AKI Guideline of 2011 published on 2012 defines Acute Kidney Injury as: [1,2]. Increase in serum creatinine (SCr) by ≥ 0.3 mg/dl (≥ 26.5 $\mu\text{mol/l}$) within 48 hours; or Increase in SCr to ≥ 1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or Urine volume of <0.5 ml/kg/h for 6 hours. KDIGO also classifies AKI in to stages, having stage 1, 2 and 3. Etiology and risk factors ranges from trivial cases to most fared and well known risks in daily practice. Pre-existing medical conditions in surgical conditions {HIV, malaria, sepsis, diabetes mellitus, pre-existing kidney dysfunction, hypertension, cancer, malnutrition etc}, [3-8] nephrotoxic drugs and contrast dyes [9]. Surgical procedures {cardiac and vascular surgeries, abdominal surgeries, orthopedic surgeries, emergency surgeries}, [10,11] age and obesity may also carry an increased risk that can results into several complications in a period immediate post operatively or late during recovery and rehabilitation from particular surgery [12,13].

The extent and outcome of risk for any surgical and anaesthetic complication arises from the interactions between a patient's perioperative health and physiological capacity to withstand surgical and anaesthesia related stresses, and also the type of surgery to be performed, anaesthetic technique used, drugs in perioperative period, fluid and blood products management, competency of anaesthesia provider as well as the role of preoperative evaluation and optimization of a patient [14,15]. Thus there is risk of acute kidney injury in every anaesthetized/operated patient although the magnitude of individual risk varies depending on other contributory factors for each particular patient.

Materials and Methods

Study design

This was a Quantitative descriptive cross-sectional hospital based study that involved adult patients whom were operated at MOI at the stated time period. The evaluation of patient for post

operative acute kidney injury was determined by laboratory values of pre-operative and post operative (at 48 hours) serum creatinine using KDIGO criteria which is validated and internationally accepted tool [16-18]. Risk factors and outcome of those found to have AKI within 28 days post operatively was documented and analyzed [19].

Study setting

Study was conducted at Muhimbili Orthopedic Institute patients' wards, ICU and HDU. The hospital has more than 500 beds with 8 operating rooms, among which two operating rooms are designated for emergency operations. The hospital is located in Ilala district, Dar es salaam, Tanzania. MOI also serves as a teaching hospital for the Muhimbili University of Health and Allied Sciences (MUHAS) and other nearby universities in the region. The hospital serves a national trauma, orthopedic and neurosurgery center in the country. The study period was 9 months, divided into the first 5 months of data collection from October 2019 to March 2020 then followed by another 4 months of data analysis, interpretation and report writing from April to July 2020.

Study participants

This study included all adult patients who underwent (elective and emergency) surgical procedures on emergence and elective basis at MOI in the stated time period.

Exclusion criteria

- Patients on renal replacement therapy
- Same Day Surgery (SDS) patients
- Death before 48 hours post operatively
- American Society of Anesthesiologists patients physical classification category five and six (ASA V, VI patients)

Data source

Data was collected by the researcher and one trained research assistants (medical officers who are registrar in the department of Anaesthesia at MOI). Patient demographic data, presence of comorbidity and other significant medical/surgical information was obtained from patient's records in the hospital information system. Preoperative Patient evaluation and determination of risk was done by a researcher, research assistants and hospital anaesthesia team. Intra-operative events/risks was obtained from anaesthetic record form used during operation for monitoring and anaesthetic recordings. Structured checklist was used to record the demographic characteristics, preoperative information, risk factors, baseline serum creatinine, postoperative serum creatinine and intraoperative events, medications and type of anaesthesia given.

Data management and analysis

Checklist was checked for completeness, accuracy and consistency then presented for editing, classification, cleaning, transformation, tabulation and coding. The Quantitative data was entered into the computer system for quantitative analysis by using Statistical Package for Social Sciences (SPSS) computer software version 24. The descriptive statistical analysis was used to summarize the results for the objective (i) which was to determine the prevalence of post-operative acute kidney injury in adult patients at MOI. The descriptive analysis was also used to summarize the results from the objectives

Ethical considerations

Ethical clearance was granted by MUHAS Institutional Review Board (IRB) (Ref. No.) and the permission to conduct the study from MOI authority. Patient's names were not used to ensure confidentiality and access to participants' information was restricted to researchers only. Data collection tool had demographic parameters such as age and sex and other variables such as diagnosis, procedures done, part of the body that has been operated on, baseline and post-operative serum creatinine, intra-operative events, medications given intraoperatively, fluids and blood products given intraoperatively.

Results

Social-demographic characteristics of study participants

As shown in Table 1, majority of participants were males 102 (65.4%), most participants were aged between 35-60 years 66 (42.3%) with a median age of 49 years. Mean serum creatinine before surgery an 48 hours postoperatively were 77.68 (std deviation of 24.72) and 81.47 (std deviation of 33.70) respectively. Hypertension was the most comorbidity among the participants involving 38 (24.4%) of cases while. Many participants underwent elective surgeries 119 (76.3%). On physical fitness classification, 71 (45.5%) participants were ASA class 2 at the time of surgery. Majority of surgery were done under general anaesthesia 105 (67.3%) and most surgeries were done less than two hours 91 (58.3%).

Demography	Frequency (%)
Sex	
Male	102 (65.4%)
Female	54 (34.6%)
Age	

18-35	48 (30.8%)
35-60	66 (42.3%)
>60	42 (26.9%)
Pre Existing Medical Condition	
Hypertension	38 (24.4%)
Hypertension & Diabetes mellitus	8 (5.1%)
Other diseases	12 (7.6%)
No comorbidity	98 (62.9%)
Category of operation	
Emergency	37 (23.7%)
Elective	119 (76.3%)
ASA Status	
ASA 1	69 (44.2%)
ASA 2	71 (45.5%)
ASA 3	16 (10.3%)
Duration Of Surgery	
<2hrs	91 (58.3%)
>2hrs	65 (41.7%)
Type Of Anaesthesia	
GA	105 (67.3%)
SAB & Local Infiltration	51 (32.7%)
Mean Serum Creatinine with Std D	
Baseline	77.68 (std D 24.72)
At 48 hours	81.47 (std D 33.70)

Table 1: Social-demographic characteristics of study participants (n=156).

Risk factors associated with post-operative AKI

In this study, among the risk factors we were looking upon, there were those factors that were observed to be significantly associated with post-operative AKI. These were, operation duration more than 2 hours (p-value 0.001), intraoperative use of ephedrine (p-value 0.000), intraoperative hypotension (p-value 0.002) and intraoperative blood transfusion (p-value 0.000) as shown in table below

Citation: Lugazia E, Kaniki IR, Mbanga F, Boniface R, Furia F (2022) Prevalence of Post-Operative Acute Kidney Injury and Associated Risk Factors at A Tertiary Trauma Center in Dar Es Salaam, Tanzania. J Surg 7: 1481 DOI: 10.29011/2575-9760.001481

Variable	Normal (%)	With Post Op Aki (%)	P-Value
Category Of Operation			
Emergence	30 (81.1%)	7 (18.9%)	
Elective	106 (89.1%)	13 (10.9%)	0.204
ASA Status			
ASA 1	64 (92.8%)	5 (7.2%)	
ASA 2	59 (83.1%)	12 (16.9%)	
ASA 3	13 (81.3%)	3 (12.8%)	0.176
Pre Existing Medical Conditions			
Hypertension	33 (86.8%)	5 (13.2%)	
Hypertension and Diabetes Melitus	3 (37.5%)	5 (62.5%)	
Others	11 (91.7%)	1 (8.3%)	0.09
Duration Of Operation			
<2hrs	86 (94.5%)	5 (5.5%)	
>2hrs	50 (76.9%)	15 (23.1%)	0.001
Type of Anaesthesia			
GA	89 (84.8%)	16 (15.2%)	
SAB & L. infiltration	47 (92.2%)	4 (8.3%)	0.396
Intraoperative fluids			
Crystalloids			
≤2liters	40 (93.0%)	3 (7.0%)	
>2 liters	96 (85.0%)	17 (15.0%)	0.337
Colloids given	9 (69.2%)	4 (30.8%)	0.913
Intraoperative ephedrine			
Given	9 (50%)	9 (50%)	
Not given	127 (92.0%)	11 (12.8%)	0.000
Intraoperative hypotension			
Had Hypotension	26 (72.2%)	10 (27.8%)	
No hypotension	110 (91.7%)	10 (8.3%)	0.002
Preoperative Hb			
<11 g/dl	21 (91.3%)	2 (8.7%)	
≥11 g/dl	113 (86.3%)	18 (13.7%)	0.04
Intraoperative blood loss			

<300mls	83 (93.3%)	6 (6.7%)	
≥300mls	53 (79.1%)	14 (20.9%)	0.116
Intraoperative blood transfusion			
Given	34 (73.9%)	12 (26.1%)	
Not given	102 (92.7%)	8 (7.3%)	0.000

Table 2: Risk factors associated with post-operative AKI (n=156).

Multivariate logistic regression

Prolonged operations (aOR 2.881, 95% CI 0.867-9.566, p-value 0.044), intra-operative use of ephedrine (aOR 0.169, 95% CI 0.042-0.684, p-value 0.013) and intra-operative hypotension (aOR 0.831, 95% CI 0.215-3.207) were found to be independent risk factors of developing post-operative acute kidney injury as shown in the table below.

Risk factor	Crude OR(95%CI)	p-value	Adjusted OR(95% CI)	p-value
Operation duration				
>2 hours	5.160 (1.769-15.050)		2.881 (0.867-9.566)	
<2 hours	1	0.002	1	0.044
Intraop ephedrine				
Given	6.273 (3.019-13.033)		0.169 (0.042-0.684)	
Not given	1	0	1	0.013
Intraop hypotension				
Hypotension	3.333 (1.508-7.370)		0.831 (0.215-3.207)	
No hypotension	1	0.008		0.038
Intraop BT				
Blood given	4.5 (1.697-11.932)		1.747 (0.549-5.562)	
Blood not given	1	0.003	1	0.345
Operation category				
Emergency	1.732 (0.746-4.018)	0.259	0.623 (0.19-2.045)	
Elective	1		1	0.435

Table 3: Multivariate logistic regression.

Outcome of AKI at day 7 post op

Complete recovery was observed in 6 participants (30%) and partial recovery in another 6 (30%) participants while there were loss of follow up in 3 participants (Table 4).

Outcome	Count and percentage
Complete recovery	6 (30%)
Partial recovery	6 (30%)
No recovery	3 (15%)
Death	2 (10%)
Lost follow up at day 7	3 (15%)
Total	20 (100%)

Table 4: Outcomes of post-operative acute kidney injury.

Discussion

Prevalence of post-operative acute kidney injury at MOI

We carried out a Quantitative descriptive cross-sectional hospital based study involving 156 adult patients whom were operated at MOI from October 2019 to March 2020 to determine the prevalence of post-operative AKI and associated risk factors. We also looked on outcome in those found to have post-operative acute kidney injury. The overall prevalence of post-operative AKI we found in this study was 12.8% (20/156) that encompasses all cases with different risk factors, surgical interventions (orthopedic and neurosurgery) as well as different demographic characters. These results are close to findings from other similar studies done by Nicker et al in South Africa who reported a prevalence of 11% from surgical causes [8] and one done by Deng et al in China where the postoperative acute kidney injury had a prevalence of 13.5% [20]. However, a study done by Nowicka and team on elective hip and knee arthroplasty cases had a lower AKI incident of only 6.2% [21] and one by Raji et al in Nigeria on all type of surgeries reported a prevalence of 22.5% both studies looked at subjects who were different from the ones in this work i.e. combined orthopedic and neurosurgery cases [22]. The most affected group were participants aged above 60 years (16.7% prevalence), this was also reported in the study done by Biteker, et al. [12]. On the other hand females shows relatively high prevalence of post-operative AKI with 14.8% (8/54) of post-operative AKI compared with males 11.8% (12/102). These results differ from most studies done in other centers [23] as in this study we used KIDGO definition of AKI and only serum creatinine was used while in other studies there were other components like eGFR, and cystatin C.

Risk factors associated with post-operative AKI

In this study we found that length of the operation is an independent risk factor for developing post-operative acute kidney injury, this was also reported in other studies done by Raji et al in Nigeria and Deng et al in China. [18, 20]. Raji et al found that, among those surgeries took more than 2 hours, the incidence of perioperative AKI was 65.3% (32/49). There for a good patient preparation for those surgeries known to take long time or presumed to be prolonged surgeries together with close intraoperative monitoring and surveillance is important in order to minimize the risk. On the other hand, intraoperative hypotension was significantly associated with a post-operative AKI and plays as independent risk. Other studies also reported the same finding on the effect of hypotension and post-operative AKI using either MAP or direct measurement of blood pressure [20,24]. Walsh et al found a prevalence of 7.2% among the patients who had intraoperative MAP <55mmHg indicating the contribution of hypotension on the post-operative AKI. In this study it was also observed that, intraoperative use of ephedrine and blood transfusion was significantly associated with post-operative AKI as ephedrine (vasoconstrictor) and blood transfusion are mostly utilized to restore hemodynamic stability in cases of hypotension and severe bleeding signifying the effect of hypotension intraoperatively. Biteker et al in their study they reported a prevalence of 18% among those received intraoperative vasopressors while Deng et al observed an increased incidence among those received blood intraoperatively [12,20]. Generally all measure to prevent and/or early identification of intraoperative hypotension and its aggressive managements is important for prevention and reduction of complications that are associated with post-operative AKI [12,15,22,24,25]. Compared to other studies there were a slight difference from observation in other studies upon looking at the pre-operative hemoglobin level and the prevalence of post-operative kidney injury as those with acceptable level of hemoglobin had high prevalence of post-operative AKI in our study compared to those whom were operated with low preoperative hemoglobin level. Raji et al in Nigeria found a prevalence of 44.9% among those who had pre-operative anemia [22,24]. Further studies are needed to look upon the relationship between pre-operative low hemoglobin levels and post-operative renal function. On the other hand the amount of blood lost intraoperatively and the prevalence of post-operative AKI found in this study correlates with findings obtained in other studies on the linear increase in the incidence of post-operative AKI with increase in amount of blood lost intraoperatively. Deng et al reported an increased risk of 1.04 fold for each 100mls of blood lost intraoperatively [20,22].

Emergence procedures is an independent risk for patients to develop post-operative AKI and this was also reported in the study

done by Biteker et al in US that found a prevalence 21% among those underwent emergence surgeries, Raji et al also pointed out the same findings on the relationship between urgency of surgery and post-operative AKI [12,22]. This reflects the fact that most of the emergence surgeries are done to restore physiological function or to save lives and thus there is little time to evaluate the patients or even to do the proper optimization of these patients before surgery. Results from our study were not statistically significant hence calling for more studies with big sample size to be done on this area. ASA status of the participants was found to be a risk factor related to post-operative AKI as there was a relation between the ASA status and post-operative AKI, the high the ASA status the higher the risk of developing post-operative acute kidney injury. It has to be noted that ASA status also encompasses pre-existing medical conditions that has been pointed out in study done by Raji et al in Nigeria as an independent risk factor for developing post-operative AKI [22]. Biteker et al reported a prevalence of 49% among patients who had hypertension and 30% in those having diabetes mellitus [12]. Patients with more than one preexisting medical condition had more risk, for example patients with both hypertension and diabetes had a prevalence of 62.5% of post-operative AKI in our study. There is a need to do a thorough pre-operative evaluation in those patients to know their renal function status and optimize before schedule them for surgery. It also imperative to weigh the risk a particular surgery carries and the type of comorbidity a patient has as well having a perioperative plan for renal care. Also further studies are needed to evaluate the exact risk of each particular disease in our settings.

We also observed a high prevalence of post-operative AKI in patients who received general anaesthesia compared to other anaesthesia techniques. But the choice and type of anaesthesia technique given to particular patient depends on the type of surgery, expected length of surgery, patient's particular conditions and urgency of surgery thus all of these could act as a cofounder of results in this particular group. Thus studies are needed to clarify the risk of anaesthesia technique towards post-operative acute kidney injury. It was found that patients who received between 2 and 4 liters of crystalloids had high prevalence of post-operative AKI compared to others, this could be reflecting intraoperatively fluid overload or deficit. On the other hand those who received colloids had a high prevalence representing the ongoing fluid deficit or observed hemodynamic disturbances requiring plasma expanders to restore it back to normal. Monitoring central venous pressure in this group would have provided additional information, however this is not routine practice at the facility for patients undergoing trauma surgery.

Recovery was observed in 60% of those found to have developed post-operative AKI, with complete recovery in 30% of the cases and partial recovery in the other 30%. During the follow

up period 15% of the subjects did not recover while mortality was observed in 10% of those who developed AKI. These findings are similar to those observed in other studies where analysis of recovery patterns after AKI revealed a non-recovery rate of 41.2% of patients with AKI before hospital discharge [26-28]. The studies also demonstrated a mortality rate ranging between 10-20% which is comparable to one observed in our patients who developed AKI [29]. Despite a good proportion of the subjects recovering from AKI, those with severe AKI usually require temporary Renal Replacement Therapy(RRT). None of the subjects who developed post-operative AKI underwent temporary RRT. Those who do not recover may end up with chronic renal failure and require long term RRT or death in the event of complications or lack of access to this life sustaining therapy due to economic hardships [29,30,31]. These observed outcomes and anticipated social economic and health impact of post-operative AKI on quality of life calls for deliberate efforts to prevent and aggressively treat perioperative AKI.

Study limitations

Findings from this study cannot be used to generalize the rest of the population as it is a cross section study and time limited. Due to the nature and reality of patients turn-over at MOI, there was missing information and data from some of the subjects that causes a drop out from the study despite initial enrollment. Data collection activities were also interrupted by CORONA VIRUS diseases pandemic and preventive measures which affected number and type of most surgeries during the period. It also resulted in changes of academic activities and public service requirements. This caused a short in number of participants recruited in this study to fall to 156 with complete information rather than 290 that was expected to be involved. We need more studies looking at the identified risk factors for post operative AKI and mitigation strategies in similar resource constrained environment post the COVID 19 pandemic.

Conclusion

Post operative acute kidney injury is a problem in our settings and MOI could be a representative of other surgical settings in our country. Most of the risk factors that has been observed in this study are preventable/modifiable thus a strong follow up and adherence to Standard operating procedures together with multidisciplinary care of patients can help to reduce the incidence as well provide a good care for the affected individuals. Good documentation of perioperative events can also help determine those in danger of developing post operative AKI and thus help to provide preventive measures for those at high risk. Apart from primary surgical issues that patients present with at our surgical centers, we should also try to find and optimize other underlying medical issues that are known to increase risks of perioperative unwanted and avoidable

complications such as post operative acute kidney injury as observed in this study

References

1. Acute Kidney Injury (AKI) | National Kidney Foundation 2019.
2. KDIGO (2012) Clinical Practice Guideline for Acute Kidney Injury (AKI). *Kidney Int Suppl* 2012.
3. Levey AS, Eckardt K-U, Tsukamoto Y, Levin A, Coresh J, et al. (2019) Definition and classification of chronic kidney disease: A position statement from Kidney Disease: Improving Global Outcomes (KDIGO). *Kidney Int* 67: 2089-2100.
4. WHO | Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. WHO 2018.
5. Matot I, Sprung CL (2001) Definition of sepsis. *Intensive Care Med* 27: S3-9.
6. WHO | WHO/ISH Hypertension guidelines. WHO 2013.
7. The Emerging Risk Factors Collaboration (2019) Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *Lancet* 375: 2215-22.
8. Naicker S, Aboud O, Gharbi MB (2008) Epidemiology of Acute Kidney Injury in Africa. *Semin Nephrol* 2008.
9. Davenport MS, Khalatbari S, Cohan RH, Dillman JR, Myles JD, et al. (2013) Contrast Material-induced Nephrotoxicity and Intravenous Low-Osmolality Iodinated Contrast Material: Risk Stratification by Using Estimated Glomerular Filtration Rate. *Radiology* 2013.
10. Jiang L, Jiang S, Zhang M (2016) Acute kidney injury in the perioperative period and in intensive care units (excluding renal replacement therapies). *Chinese J Emerg Med* 25: 862-863.
11. Sear JW (2005) Kidney dysfunction in the postoperative period. *Br J Anaesth* 95: 20-32.
12. Biteker M, Biteker F, Duman D, Dayan A (2011) Predictors of perioperative renal failure after noncardiac, nonvascular surgery in patients with previously normal renal function. *Eur Heart J* 32: 849.
13. Borthwick E, Ferguson A (2010) Perioperative acute kidney injury: risk factors, recognition, management, and outcomes. *BMJ* 341: c3365.
14. McKinlay J, Tyson E, Forni LG (2018) Renal complications of anaesthesia. *Anaesthesia* 73: 85-94.
15. Romagnoli S, Ronco C (2018) Perioperative Acute Kidney Injury : Prevention , Early Recognition , and Supportive Measures 2018.
16. Bell S, Ross VC, Zealley KA, Millar F, Isles C (2019) Management of post-operative acute kidney injury. *QJM* 110: 175.
17. Jha V, Kumar V (2014) Validating the KDIGO definition and staging - One step at a time. *Nat Rev Nephrol* 10: 550-551.
18. Fujii T, Uchino S, Takinami M, Bellomo R (2014) Validation of the kidney disease improving global outcomes criteria for AKI and comparison of three criteria in hospitalized patients. *Clin J Am Soc Nephrol* 9: 848-854.
19. WHO | Risk factors. WHO 2017.
20. Deng Y, Yuan J, Chi R, Ye H, Zhou D, et al. (2017) The Incidence, Risk Factors and Outcomes of Postoperative Acute Kidney Injury in Neurosurgical Critically Ill Patients. *Sci Rep* 7: 1-9.
21. Nowicka A, Selvaraj T (2016) Incidence of acute kidney injury after elective lower limb arthroplasty. *J Clin Anesth* 34: 520-523.
22. Raji YR, Ajayi SO, Ademola AF, Lawal TA, Ayandipo OO, et al. (2018) Acute kidney injury among adult patients undergoing major surgery in a tertiary hospital in Nigeria. *Clin Kidney J* 11: 443-449.
23. Bell S, Dekker FW, Vadiveloo T, Marwick C, Deshmukh H, et al. (2015) Risk of postoperative acute kidney injury in patients undergoing orthopaedic surgery-development and validation of a risk score and effect of acute kidney injury on survival: Observational cohort study. *BMJ* 2015: 351.
24. Walsh M, Devereaux PJ, Garg AX, Kurz A, Turan A, et al. (2013) Relationship between intraoperative mean arterial pressure and clinical outcomes after noncardiac surgery: Toward an empirical definition of hypotension. *Anesthesiology* 2013.
25. Perregaard H, Damholt MB, Solgaard S, Petersen MB (2016) Renal function after elective total hip replacement. *Acta Orthop* 2016.
26. Chawla LS, Bellomo R, Bihorac A, Goldstein SL, Siew ED, et al. (2019) Acute kidney disease and renal recovery: consensus report of the Acute Disease Quality Initiative (ADQI) 16 Workgroup. *Nat Rev Nephrol* 13: 241-257.
27. Kellum JA, Selby NM (2018) Global epidemiology and outcomes of acute kidney injury. *Nat Rev Nephrol* 2018.
28. Olowu WA, Niang A, Osafo C, Ashuntantang G, Arogundade FA, et al. (2016) Outcomes of acute kidney injury in children and adults in sub-Saharan Africa : a systematic review. *Lancet Glob Heal* 4: 242-250.
29. Injury K, Hobson C, Ozrazgat-baslanti T, Kuxhausen A (2014) Cost and Mortality Associated With Postoperative Acute 2014: 1-8.
30. Kerr M, Bedford M, Matthews B, O'donoghue D (2014) The economic impact of acute kidney injury in England. *Nephrol Dial Transplant* 2014.
31. Bell S, Ross VC, Zealley KA, Millar F, Isles C (2019) Management of post-operative acute kidney injury Diagnosis and definition of post-operative AKI 2019.