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Original Research Article

Epidemiology, Management and Risk Factors Associated with Mortality in Acute Kidney Failure in Head Hospital in a Low-Income Country in Africa

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Abstract: ***Objective*:** To describe the epidemiological, therapeutic, and mortality factors of acute kidney injury (AKI) in the multi-specialty intensive care unit (ICU) of the Brazzaville University Hospital (BHC). ***Patients and Methods*:** The study was cross-sectional, conducted from January 1 to June 30, 2023, in the multi-specialty ICU of the BHC. We included all patients aged 18 years and older with AKI. Epidemiological, clinical, and therapeutic variables were analyzed using Epi-info version 7.2 and IBM-SPSS 20. ***Results*:** Of 220 adult admissions, 91 patients had AKI (40.6%). The mean age was 46.8 ± 19.4 years with sex ratio of 0.9. The presence of comorbidity was observed in 57.1% and dominated by arterial hypertension and diabetes mellitus. Admissions were surgical (50.6%), including 39.6% from the operating room. The reasons for admission were dominated by arterial hypotension (48.4%), respiratory distress (34.0%) and impaired consciousness (30.8%). The main diagnoses were dominated by acute generalized peritonitis (25.3%) and severe preeclampsia (8.8%). AKI was parenchymal (70.3%) and classified as KDIGO stage 3 (49.4%). Anuria (82.1%) and hyperkalemia (37.5%) were the observed consequences. Management consisted of ultrasound-guided fluid replacement (33.0%), catecholamine therapy (58.2%), mechanical intubation-ventilation (61.5%), and dialysis (17.6%). The mortality rate was 50.5% by multi-organ failure. The mortality associated factors were: Glasgow Coma Scale score ≤ 8, oligoanuria, liver failure, KDIGO stages 2 and 3, and mechanical ventilation. ***Conclusion*:** AKI is common and carries a high mortality rate in ICU. The most common diagnoses were generalized peritonitis and eclampsia. Management is difficult due to the lack of a dialysis unit at the BHC.

Keywords: Acute Kidney Injury, Epidemiology, Management, Risks Factors, ICU, Brazzaville.

INTRODUCTION

Acute kidney injury (AKI) is a relatively common and serious complication found in patients hospitalized in intensive care. It is life-threatening in the short term and affects the patient's functional prognosis in the longer term [1, 2]. AKI is defined by a sudden drop (from a few hours to a few days) in the glomerular filtration rate (GFR) associated with the inability of the kidneys to eliminate waste products from nitrogen metabolism and maintain homeostasis [2]. Several definitions for AKI have been proposed over the years, the most recent and considered consensual is that proposed by the criteria of the "Kidney Disease Improving Global Outcomes" (KDIGO) classification in 2012 [3]. This three-stage classification makes it possible to correlate the intensity of AKI with mortality and requires close monitoring of plasma creatinine and diuresis [2]. AKI is the basis of significant medical and surgical morbidity and mortality that appear in several clinical settings, and is associated with a significant increase in healthcare costs and is also linked to both higher hospital costs and longer lengths of stay [2]. The causes of AKI are numerous and varied. They are classically grouped into three categories: pre-renal or functional secondary to the decrease in renal, renal or

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parenchymal perfusion pressure linked to lesions of the renal tissue components (glomeruli, tubules, interstitium or vessels) and post-renal or obstructive linked to an obstacle in the excretory pathways. In intensive care, AKI is most often multifactorial, secondary to hypovolemia and sepsis inducing renal hypoperfusion and acute tubular necrosis (ATN). Thus, the prevention of the occurrence of AKI is, first and foremost, the fight against renal hypoperfusion by restoring effective blood volume [4, 5]. The nephrologist must be involved in all stages, from the prevention of the first episode of AKI (upon arrival in intensive care) to long-term follow-up and the management of possible chronic kidney disease. It is a real public health problem because it affects more than 13 million people worldwide according to reports from the World Health Organization (WHO). Its incidence has been increasing in recent years, its hospital frequency is estimated at 24% [6]. In intensive care, AKI occurs in more than 50% of patients and is responsible for an increase in morbidity (length of hospitalization, dependence on dialysis) and mortality. In Africa, this frequency is very variable, ranging from 12.4 to 50.2% in intensive care units with a mortality rate reaching 68.5% [1-9]. In the Republic of Congo, ARI represented 37.9% of intensive care admissions in 2023 and 71% of patients admitted for the management of sepsis/septic shock in intensive care [10]. The main objective of our study was to describe the epidemiological and therapeutic aspects as well as the factors associated with the mortality of ARI in the multipurpose intensive care unit of the Brazzaville University Hospital.

PATIENTS ET METHODS

The study was designed and planned by the research team of the multipurpose intensive care unit and approval from the ethics committee was obtained according to note n°034-40/MESRSIT/DGRST/CERSSA/-23. It was a prospective cohort study, over a six-month period from January 1 to June 30, 2023. It took place in the polyvalent intensive care unit of the BHC, located in the city center of Brazzaville. With a bed capacity of approximately 650 beds, it is a level 3 hospital with a triple vocation of care, research and teaching. It is divided into several departments including the multipurpose intensive care unit. The polyvalent intensive care unit included five anesthesiologist-resuscitation doctors and five general practitioners. The paramedical staff consisted of a nursing supervisor, 38 nurses and 10 nursing assistants divided into a permanent team in the morning and then six teams alternating every 12 hours, coordinated by a state-registered nurse team leader. The department is composed of eight rooms, five of which are individual and three shared with two beds, for a total of 11 mobile and modifiable beds; only nine were functional during the study period. It is equipped with seven functional fixed respirators, five mucus suction devices, two transport respirators, two emergency trolleys, a functional gasometry device, a mobile X-ray device and an ultrasound device. Each room has the following elements: wall-mounted oxygen, air and vacuum inlets, multi-parameter monitor (ECG, BP, HR, RR, SpO2, temperature), electric syringe pumps. The hospital on-call service, 12 hours on weekdays and 24 hours on weekends and public holidays, is provided by two general practitioners under the supervision of a anesthesiologist-resuscitation doctor ensuring weekly on-call. Prescriptions are the sole responsibility of the patients or their relatives. The BHC does not have a hemodialysis unit. When indicated, it is done at the expense of the patient and/or their relatives in one of the four (4) private hemodialysis centers available; the patient is transported either in a medicalized or non-medical ambulance or in personal vehicles depending on the patient's clinical condition. Our study population consisted of all patients hospitalized in intensive care during the study period. We included all patients aged at least 18 years, regardless of gender, who had presented with AKI upon admission and/or during their stay in intensive care, from whom we could obtain their informed consent or that of the family. We did not include patients with known chronic kidney disease (CKD) or those on chronic dialysis. Data were collected from ICU admission registers, written ICU medical records, and patient prescription and monitoring sheets. For this purpose, a survey form was pre-established. The following variables were studied: epidemiological (frequency, age, sex, educational and socioeconomic level, comorbidity, history, lifestyle), clinical (origin, type of admission, admission diagnosis, reason for admission to ICU, clinical signs and vital signs at admission), and therapeutic (conditioning, resuscitation measures, namely filling, vasoactive drugs, mechanical ventilation, oxygen therapy, blood transfusion, probabilistic or directed antibiotic therapy, dialysis, heparin therapy, stress ulcer prevention) and evolutionary (observed complications, deaths, causes and time of death, and length of stay in ICU). We used Microsoft Epi-info 7.2 software to create the database and compile the graphs. Quantitative variables were expressed as mean ± standard deviation and qualitative variables were expressed as number and percentage (%). Statistical analysis was performed using Pearson's Chi2 test or the Fisher exact test using IBM-SPSS 20 software. The p value used to confirm the existence of a statistically significant difference between two percentages of two variables was set at 0.05.

RESULTS

During our study period, we recorded 240 admissions to intensive care. Ninety-one of them presented with AKI diagnosed upon admission and/or during the stay in intensive care, representing a frequency of 37.9% (Figure 1).

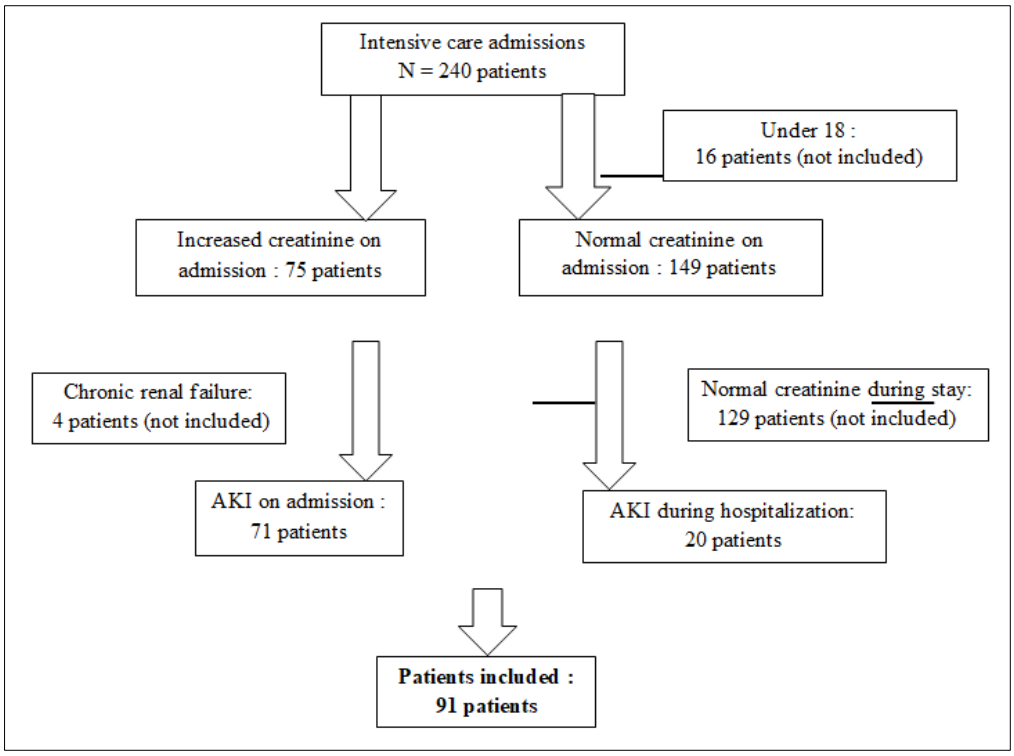

Figure 1: Flow chart of our entire study population

The mean age of our patients was 46.8 ± 19.4 years with extremes of 18 and 90 years. The age range from 25 to 44 years represented 35.2% of cases. Female gender was observed in 52.7% (sex ratio of 0.9). Average secondary education and socioeconomic levels were noted in 52.8% and 54.9% of cases, respectively. The existence of comorbidity was observed in 52 patients (57.1%); arterial hypertension (67.3%) and diabetes mellitus (30.8%) being the most observed. Regular alcohol consumption, nonsteroidal anti-inflammatory drugs (NSAIDs) and herbal medicine were the most reported lifestyle habits in 58.2%, 23.1% and 22.0% of cases respectively. Previous surgery was noted in 14 patients (21.9%). Table 1 illustrates the distribution of patients according to epidemiological characteristics.

Table I: Distribution of patients by epidemiological characteristics

	Number (n = 91)	**Percentage (%)**
Age Groups (years)		
< 25	13	14.3
25 à 44	32	35.1
45 à 64	26	28.6
≥ 65	20	22.0
Sex		
Female	48	52.7
Male	43	47.3
Educational Level		
No education	4	4.4
Primary	9	9.9
Secondary	48	52.7
Higher education	30	33.0
Socioeconomic level		
Low	28	30.8
Medium	50	54.9
High	13	14.3
Comorbidities		
None	39	42.8
Yes	52	57.2
High Blood Pressure	35	67.3
Diabetes	16	30.8

	Number (n = 91)	Percentage (%)
Heart failure	8	15.4
HIV*	8	15.4
Prostate tumor	4	7.7
Chronic liver disease	4	7.7
Cancer	2	3.8
Sickle cell disease	2	3.8
Hematological malignancy	2	3.8
Habits and Lifestyle		
Taking NSAIDs **	22	24.2
Herbal tea	20	22.0
Alcohol	53	58.2
Tobacco	13	14.3
Exposure to ICM***	6	6.6
Chemotherapy	4	4.4

*: Human immunodeficiency virus
**: Non-steroidal anti-inflammatory drugs
***: Iodinated Contrast Media

Patients came mainly from the operating room (39.6%) and medical emergencies (17.6%). The reasons for admission were dominated by arterial hypotension (48.4%), respiratory distress (34.0%) and impaired consciousness (30.8%). The main diagnoses were dominated by acute generalized peritonitis (25.3%), severe preeclampsia (8.8%) and stroke (7.7%). Table 2 and 3 illustrate the distribution of patients according to origin, reasons and diagnoses of admission.

Table II: Distribution of patients by origin, reasons, and diagnoses upon admission

	Number (n = 91)	Percentage (%)
Origin		
Operating room	36	39.6
Medical and Surgical Emergency Department	25	17.6
Gynecological Emergency Department	9	9.9
Digestive Surgery	4	4.4
Hematology	3	3.3
Infectious Diseases	2	2.2
Cardiology	2	2.2
Polyvalent Surgery	2	2.2
Gastroenterology	2	2.2
Neurovascular Unit	2	2.2
Metabolic Diseases	1	1.1
Nephrology	1	1.1
Reasons for admission		
Hypotension	44	48.4
Respiratory distress	31	34.0
Impaired consciousness	28	30.8
Seizures	11	12.0
Acute Renal Failure	10	11.0
Dyskalemia	2	2.2
Dysnatremia	3	3.3
Others *	3	3.3

*:Acute coronary syndrome, Transient ischemic attack, Complete arrhythmia by atrial fibrillation.

Table III: distribution of patients according to diagnoses on admission

	Number (n = 91)	Percentage (%)
Digestive Diseases	**30**	**33.0**
Acute Generalized Peritonitis	23	76.7
Fulminant Hepatitis	3	10.0
Lower Gastrointestinal Hemorrhage	1	3.3
Acute Intestinal Obstruction	1	3.3

	Number (n = 91)	Percentage (%)
Acute Pancreatitis	1	3.3
Gyneco-obstetric pathologies	**19**	**20.9**
Severe preeclampsia	8	42.1
Immediate PPH	5	26.3
Retroplacental hematoma	2	10.5
Ruptured ectopic pregnancy	1	5.6
Endometritis	1	5.6
Postabortal hemorrhage	1	5.6
Cervical tumor	1	5.6
Neurological pathologies	**16**	**17.6**
Stroke	7	43.7
Severe head trauma	4	25.0
Meningoencephalitis	3	18.8
Severe malaria	1	6.3
Lupus neurological flare-up	1	6.2

PPH: postpartum hemorrhage; EP: ectopic pregnancy

The clinical examination on admission revealed desaturation (SpO2 < 92%) in 37.4%, dehydration with hypotension (15.4%), anuria (28.6%) and lower limb edema (11.0%). Table 4 illustrates the distribution of patients according to clinical characteristics.

Table IV: distribution of patients according to clinical characteristics

	Number (n = 91)	Percentage (%)
Glasgow Coma Scale		
≤ 8	18	19.8
9 – 12	38	41.7
13 – 14	3	3.3
15	32	35.2
Blood pressure (mmHg)		
Hypotension	14	15.4
Normal	47	51.7
Hypertension	30	32.9
Heart rate (bpm)		
< 60	1	1.1
60 – 100	36	39.6
> 100	54	59.3
Respiratory rate (cpm)		
< 12	3	3.3
12 – 20	35	38.5
> 20	53	58.2
Pulsed oxygen saturation (%)		
< 92	34	37.4
92 – 94	10	10.9
≥ 95	47	51.7
Diuresis (mL/kg/h)		
0,5 – 1	55	60.5
0,3 – 0,5	10	10.9
< 0,3	26	28.6
Clinical signs		
Dehydration	10	10.9
Edema of the lower limbs	10	10.9
Acute pulmonary edema	4	4.4
Pleurisy	3	3.3
Ascites	1	3.3

AKI was parenchymal (70.3%), functional (28.6%) and obstructive (1.1%). According to severity, AKI was classified as KDIGO stage 3 (49.4%) followed by stages 1 (35.2%) and 2 (15.4%). Anuria (82.1%) and

hyperkalemia (37.5%) were the complications observed. Crystalloid-based vascular filling was performed in 33.0% of patients. Seven patients (7.7%) received non-invasive ventilation (NIV) and tracheal intubation with mechanical ventilation and/or sedation was required in 56 patients (65.1%). The use of catecholamines was noted in 53 patients (58.2%). In our series, antibiotics were administered in 82.4% of patients as part of probabilistic antibiotic therapy. Hydrocortisone-based corticosteroid therapy was administered in 26.4% of patients with septic shock. The use of loop diuretics was noted in 19 patients (20.9%) and alkalinization of urine with injectable bicarbonate was observed in 9 patients (9.9%). Extra-renal purification (ERP) was indicated in 16 patients (17.6%), of whom nine (56.3%) had benefited from at least one ERP session. Its indications were represented by anuria ≥ 24 hours in 10 patients (62.5%), refractory acute pulmonary edema (APO) in 5 patients (31.5%), severe hyperkalemia and uremic coma in 3 patients (18.7%) respectively. In our series, the outcome was favorable for 45 patients (49.5%) with transfer to other hospitalization services. Complete remission was observed in 57.8% of them with a mean time of 3.5 ± 1.3 days. Mortality affected 46 patients (50.5%); multi-organ failure (47.8%) was the main cause of death (Table 5).

Table V: distribution of patients by cause of death

	Number (n=46)	Percentage (%)
Multiple organ failure	22	47.7%
Septic shock	6	13.0%
Hemorrhagic shock	5	10.9%
Cerebral herniation	5	10.9%
Respiratory distress	4	8.7%
Cardiogenic shock	2	4.3%
Diabetic ketoacidosis	1	2.2%
Hepatic encephalopathy	1	2.2%

The median length of hospitalization of our patients was 4 days [3-8]. After multivariate analysis, the factors associated with mortality from ARI in intensive care were: Glasgow coma scale ≤ 8, oligoanuria, respiratory failure, liver failure, KDIGO stages 2 and 3 and mechanical ventilation (Table 6).

Table VI: multivariate analysis of factors associated with AKI mortality

	Death		*p value*	Odd ratio IC
	Yes n(%)	No n(%)		
Age groups (years)				
18-24	6(13.0)	7 (15.6)	0.482	0.8 [0.3 ; 2.6]
25-44	15(32.6)	17 (37.8)	0.383	0.8 [0.3 ; 1.8]
45-64	14(30.4)	12 (26.7)	0.434	1.2 [0.5 ; 2.9]
≥ 65	11(23.9)	9 (20.0)	0.422	1.3 [0.4 ; 3.4]
Comorbidities				
HIV	6(13.0)	2 (4.4)	0.083	-
Diabetes	9(19.6)	7 (15.6)	0.820	0.9 [0.4 ; 2.1]
Reasons for admission				
Seizures	5(10.9)	6(13.3)	0.484	0.8 [0.2 ; 2.8]
Hypotension	22(47.9)	22(48.9)	0.543	0.9 [0.4 ; 2.1]
Respiratory distress	18(40.0)	13(28.9)	0.209	1.5 [0.6 ; 3.7]
Impaired consciousness	***24(53.2)***	***4(8.9)***	***0.000***	***11.1[3.4 ; 36.3]***
Evaluation initiale				
SpO2 ≤ 92%	***23(50.0)***	***11(24.4)***	***0.010***	***3.1 [1.2 ; 7.5]***
Oligo-anurie	***25(54.4)***	***8(17.8)***	***0.000***	***5.5 [2.1 ; 14.4]***
Complication				
Anuria	***34(73.9)***	***12(26.7)***	***0.000***	***7.8 [3.0 ; 19.8]***
Coma	***39(86.7)***	***6(13.3)***	***0.000***	***36.2 [11.1 ; 117.5]***
Heart failure	5(10.9)	3(6.7)	0.369	-
Liver failure	***22(47.8)***	***13(28.9)***	***0.050***	***2.2 [0.9 ; 5.3]***
Hyperkalemia	9(19.6)	6(13.3)	0.302	-
Sévérité de l'IRA				
Stade 2 ou 3 KDIGO	***37(80,4)***	***22(48.9)***	***0.001***	***4.3 [1.6 ; 10.9]***
Données thérapeutiques				
Hemodialysis	6(13.0)	3(6.7)	0.253	-

	Death		***p value***	**Odd ratio IC**
	Yes n(%)	**No n(%)**		
Aminoglycosides	13(28.3)	11(24.4)	0.430	-
Mechanical ventilation	***39(86.7)***	***17(37.8)***	***0.000***	***9.2 [3.3 ; 25.1]***
Non invasive ventilation	3(6.5)	4(8.9)	0.487	-

DISCUSSION

Some limitations in our study must be taken into consideration for a better interpretation of our results: the single-center nature and the short duration did not allow us to have a large sample size to extrapolate the results on a national scale and the low socioeconomic level of certain patients, which prevented the monitoring of serum creatinine every 48 hours, thus underestimating the frequency of AKI and the performance of additional tests to confirm or rule out associated complications (arterial blood gas analysis not available). However, this study constitutes a basis on which future research studies, preferably multicenter with a larger sample size, can be based. In our study, the frequency of AKI in intensive care was 39.5%. Our result corroborates those of several African studies. Indeed, Ngoma *et al*., (36.5%) in Gabon [11], Metogo *et al*., (35.6%) in Cameroon [12], Benouaz (32.5%) in Algeria [1], and Diallo *et al*., (29.5%) in Senegal [13], had reported similar results. Other authors had reported lower frequencies [14-16]. This difference could be explained by our different study settings and populations as well as the diversity of ARI definitions. In our study, surgical admissions represented 50.5%. This frequency can be justified by the fact that 40.6% of our patients came from the operating room. Effa *et al*., in 2014 in Nigeria [17], and Ephraim in Ghana [18], as well as Samaké *et al*., [19], had reported admissions were more medical in type [17-19]. Arterial hypotension (48.3%) was the most common reason for admission in our study. This result corroborates that of Okoue *et al*., in Gabon who reported that arterial hypotension was found in 32.5% [20]. Dicko *et al.,* for their part, found 42.9% of arterial hypotension as a reason for admission of patients to intensive care [21]. Metogo *et al*., in Cameroon reported sepsis and hypovolemia as the main cause of ARI in their series [12]. We found age ≥ 65 years (p-value=0.0129; OR= 2.5 [1.1; 5.4]), arterial hypertension (p-value=0.001; OR= 3.0 [1.6; 5.7]), diabetes (p-value=0.006; OR= 3.7 [1.4; 9.5]), herbal tea intake (p-value=0.005; OR= 3.4 [1.4; 7.6]), NSAIDs intake (p-value=0.013; OR= 2.7 [1.2; 5.7]), hemodynamic instability (p-value=0.000; OR= 4.1 [2.2; 7.5]) and sepsis (p-value=0.000; OR= 2.9 [1.6; 5.1]) at admission as factors associated with the occurrence of AKI in intensive care. Our results are comparable to most studies that found high blood pressure, diabetes and age ≥ 65 years as factors in the occurrence of AKI [22-24]. Indeed, patients from 65 years of age have twice the risk of AKI due to the physiological aging of the kidneys which is proportional to age, weakening the kidney and making it susceptible to any acute renal attack. High Blood Pressure (HBP), for its part, increases the risk of AKI by three times due to the probable existence of underlying nephropathy, particularly diabetic and/or hypertensive. The kidneys of hypertensive and diabetic patients would then be vulnerable to the slightest acute renal attack. The use of herbal tea and NSAIDs increases the risk of AKI by three and two times respectively. The mechanism incriminated is that of direct toxicity secondary to the intake of herbal tea causing lesions of the acute tubular necrosis (ATN) type. This toxicity depends on the nature of the herbal tea, the quantity ingested and the underlying state of the kidneys. Being a frequent habit in our country, the intake of herbal tea is a risk factor to be taken into account. Indeed, Ahoui *et al*., as well as Fouda *et al*., had reported that the intake of herbal tea was statistically associated with the occurrence of AKI [15-25]. NSAIDs, by their vasoconstrictor properties by inhibition of prostaglandin synthesis, attack the kidneys by modifying the hemodynamics of the glomerular capillaries. Thus, during situations of hypovolemia where there are hemodynamic changes, the latter constitute factors precipitating renal damage. In our context where NSAIDs are used unreasonably by the population through the daily practice of self-medication would then explain our results. Sepsis and septic shock are recognized as risk factors for AKI and two mechanisms explain this. An ischemic mechanism related to peripheral hypoperfusion favored by the state of shock, which when prolonged gives rise to ischemic ANT-type lesions; in intensive care units, shock being a frequent situation, sepsis and septic shock are the main factors for the occurrence of AKI in intensive care as reported by most studies [7-26].

In our study, we found a high frequency of arterial hypotension; it increased the risk of AKI by 5.6 times. This could be explained by the fact that induction anesthetic drugs cause arterial hypotension, which is aggravated in patients with hypovolemia, given that we recorded a significant proportion of operated patients. In our series, the mortality rate was 50.5%. This result is comparable to those of Metogo *et al*., (59.5%) in Cameroon [12], Masewu (58%) in DRC [27], and Dicko *et al*., (55.6%) in Mali [21]. Lower rates had been noted by some African authors, notably Diallo *et al*., (38.9%) and Leye *et al*., (32.5%) in Senegal as well as Beye *et al*., (24.6%) in Mali [9-16]. We found as factors associated with mortality: Glasgow score ≤ 8, oligoanuria, liver failure, KDIGO stages 2 and 3 and mechanical ventilation. The mortality factors of ARI found in our series are similar to those described in the African literature [12-28]. The presence of these factors could be explained by the profile of our patients who are mostly septic; the natural evolution of sepsis is towards multi-organ failure worsening the clinical condition and vital

prognosis of the patients. Also, the polyvalent intensive care unit of Brazzaville University Hospital is the only service taking care of patients whose condition is critical. The mortality associated with renal failure is all the higher when it is severe.

CONCLUSION

AKI is a serious and common condition in intensive care. It mainly affects young adults with a female predominance; the average socioeconomic level was the most observed. Hypertension and diabetes were the most common comorbidities. Hypotension was the most common reason for admission in our study. Parenchymal AKI was the most common and the etiologies were dominated by the duo sepsis/septic shock. Hypertensive, diabetic and elderly patients constituted populations at risk of AKI occurrence. Herbal tea intake, NSAID intake, hypotension and sepsis represented risky situations. Management is difficult due to limited access to the EER thus generating additional costs. Mortality related to AKI is high in intensive care and factors associated with mortality are oligo-anuria, coma, liver failure, and severity of AKI. The high incidence and mortality of ARI, as well as the difficulty in management, require particular emphasis on preventive measures.

Ethics Approval and Consent to Participate: conditional favorable approval from the Ethics Committee was obtained according to note no. 034-40/MESRSIT/DGRST/CERSSA/-23.

Consent for Publication: all authors have given consent for publication.

Availability of Data and Materials: the data has been retained and will be made available if necessary.

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Author Contributions:

M. Elombila: writing – review and editing, visualization
G.M. Koumous Mafongo: conceptualization, methodology, investigation, writing – original draft preparation
M. C. Mpoy Emy Monkessa, G. Niengo Outsouta: investigation, formal analysis
M.A. Bokoba Nde Ngala, S. Iwoba Rebet, I. Kibamba Nieme, R. Koumou, G. Bayoundoula: ressources
G.F. Otiobanda: supervision, project administration

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