Original article

Incidence and Risk Factors of Acute Kidney Injury in Critically Ill Patients in Intensive Care Units of Tertiary Care Hospitals

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ABSTRACT

Background: Over the last decade, the occurrence of acute kidney injury (AKI) in intensive care units (ICUs) has risen due to heightened severity and improved identification of such cases. The study objectives are to identify the incidence and evaluate the risk factors of acute kidney injury in critically ill patients in tertiary care hospitals.

Patients and methods: This cross-sectional study was carried out between July and August 2022 at Pakistan Institute of Medical Sciences and Federal Government Services Hospital, Islamabad Pakistan. The study involved the collection of data from 300 critically ill patients admitted to medical, cardiac, and surgical ICUs. The severity of AKI was evaluated according to Kidney Disease Improving Global Outcomes (KDIGO) staging. Patients' information regarding history of renal disease in family, comorbidities, kidney functions, measurements of urea and creatinine levels was collected. Subsequently, the analysis was conducted at SPSS v 23.

Results: Patients mean age was 60.65 ± 4.87 years. Those who developed AKI post-ICU admission had a mean urea level of 61.64 ± 7.5 mg/dl and creatinine 1.63 ± 0.1mg/dl, which increased to 2.2 ± 0.1mg/dl at the time of diagnosis. Majority cases of AKI were categorized as stage 1 (40%) and stage 2 (60%). Among the patients, 60% (n=180) maintained normal kidney functions, while 40% (n=120) developed AKI during their ICU stay. Notably, 35.7% (n=70) of those who developed AKI were males. A notable association was observed between AKI development and factors such as sepsis, hypovolemia, ischemic heart diseases, age, diabetes mellitus, and hypertension (p-value ≤0.05).

Conclusion: The key point of the study highlighted a notable incidence of AKI among ICU-admitted patients. Sepsis and hypovolemia emerged as the primary causative factors leading to the onset of AKI.

Keywords:

Acute kidney injury, Critical illness, Hospitals, Intensive care units Risk factors

INTRODUCTION

Despite dedicated endeavors in prevention and early detection, the worldwide occurrence of kidney diseases is on the upswing.[1] Particularly concerning is the escalating prevalence of acute kidney injury (AKI), estimated range in intensive care unit (ICU) from 1% to 70% depending on criteria used.[2] Pakistan confront a comparable predicament, witnessing a growing prevalence of renal conditions that pose a significant strain on the healthcare expenditures.[3] AKI or acute renal failure, manifests as the abrupt deterioration of kidney function, marked by a swift decrease in glomerular filtration rate (GFR) that typically ranges between 115 to 125 ml/min.[4] This decline occurs rapidly within hours or days.[4]

The consequence of this condition includes the retention of nitrogenous waste products like urea and creatinine, along with non-nitrogenous waste products arising from metabolic processes. Additionally, acute kidney injury disrupts electrolyte balance, fluid regulation, and acid-base equilibrium.[5] The categorization of AKI has undergone a transformation from the Risk, Injury, Failure, Loss, and End-stage (RIFLE) criteria and Acute Kidney Injury Network (AKIN) stages to the Kidney Disease Improving Global Outcomes (KDIGO) stages. According to KDIGO's clinical guidelines, AKI is considered a subset of acute kidney diseases (AKD) and disorders.[6,7] Numerous studies have delved into the incidence of AKI in intensive care units (ICUs), revealing a wide-ranging spectrum from 5% to a staggering 67%.[8] Furthermore, a compelling study provides additional support for these observations, indicating a close association between episodes of arterial hypotension (defined by a mean arterial pressure ≤73 mmHg) and the development of AKI in an ICU population with sepsis.[9] This raises an

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intriguing question that do similar findings persist within a more representative, unselected ICU populations? While there is a consensus on the definition of AKI, the rationale behind this study lies in the substantial variations observed in its incidence. Delving into these variations in AKI risk aims to unravel the shared contributing factors and confounding variables, providing a deeper understanding of the condition. The objective of the study was to estimate the incidence and evaluate the risk factors of AKI in critically ill patients in tertiary care hospitals.

PATIENTS AND METHODS

A cross-sectional study was done between July and August 2022 in two tertiary care hospitals, namely Pakistan Institute of Medical Sciences and Federal Government Services Hospital, Islamabad Pakistan. Total 300 patients were recruited through non-probability consecutive sampling, utilizing the WHO sample size calculator with a 95% confidence interval, 5% alpha error, and an assumed AKI incidence of 27%.[10] The inclusion criteria encompassed individuals of both genders (male/female), aged 30 to 70 years, presenting with AKI or AKI after admission in ICU, sepsis, and comorbidities (hypertension, diabetes mellitus, ischemic heart disease, respiratory disease, and liver cirrhosis). Additionally, admitted patients who developed AKI during ICU stay not exceeding 48 hours were also included. Exclusion criteria involved individuals with preexisting chronic kidney disease, drug-induced kidney injury, recent surgical procedures (laparotomy), and malignancy. Upon receiving approval from ethical committee of the institutes (Ref. No. 28/PIMS/IRB/July-22, Dated: 22 July, 2022) and obtaining informed verbal consent from each patient, data collection was initiated. Total 300 patients from ICUs including Medical ICU (n=100), Cardiac ICU (n=100), and Surgical ICU (n=100) were evaluated. The comprehensive data collection covered various aspects of patient outcomes, including demographic characteristics, family history of renal disease, comorbidities, kidney functions, and urea and creatinine levels. The data was collected on excel sheet by a senior nephrologist, using the abovementioned patients' outcome variables as well as KIDGO staging system.

The severity of AKI was determined using the KDIGO staging system. AKI severity was categorized as; Stage 1 (increase in creatinine 1.5-1.9 times at baseline or ≥0.3mg/dl, urine output ≤0.5ml/kg/hour in 6-12 hours), Stage 2 (creatinine 2-2.9 times at baseline, urine output remaining ≤0.5 ml/kg/hour in ≥12 hours), and Stage 3 (creatinine three times at baseline or ≥4 mg/dl, or at baseline in patients of renal replacement therapy aged ≥18 years or eGFR to ≤35ml/min/1.73 m^2, urine output ≤0.3 ml/kg/hour in ≥24 hours or anuria in ≥ 12 hours).[11]

The data was analyzed using SPSS v 23. Mean and standard deviations were calculated for quantitative data, while frequencies and percentages determined for qualitative data. To evaluate the risk factors for AKI development, multivariate logistic regression was employed, odd ratio with 95% confidence intervals was calculated. Effect modifiers were examined through stratification, and post stratification analysis of association was conducted using the chi-square test. A p-value of ≤0.05 was taken as significant.

RESULTS

Three hundred patients were enrolled from three ICUs. Mean age of the patients was 60.65 ± 4.87 years. For those who developed AKI post-admission to the ICUs, the mean urea level was 61.64 ± 7.5mg/dl, and creatinine was 1.63 ± 0.1mg/dl, whereas it increased to 2.2 ± 0.1mg/dl at the time of diagnosis. Severity grading of AKI included stage 1 (40%) and stage 2 (60%). The sociodemographic of the patients, encompassing age, gender, family history of renal disease, and comorbidities are summarized in Table 1.

Hypertension (HTN) emerged as the most prevalent comorbidity in 120 (40%) cases, followed by diabetes mellitus (DM) in 90 (30%), ischemic heart diseases (IHD) in 45 (15%), respiratory disease and liver cirrhosis in 30 (10%), and 15 (5%), respectively. Of the total patients, 180 (60%) exhibited normal kidney functions, while 120 (40%) developed AKI during their ICUs stay. Among those who experienced AKI, the majority were males (n=70, 35.7%). Patients were primarily admitted to the ICUs for various reasons, with sepsis being the leading cause in 180 (60%) cases,

Table 1: Sociodemographic characteristics of ICU patients

Characteristics	Frequency (%)
Age (years)	
30-50	139 (46.3)
51-70	161(53.7)
Gender	
Male	210 (70)
Female	90 (30)
Family history of renal disease	201 (67)
Comorbidities	
Hypertension (HTN)	120 (40)
Diabetes mellitus (DM)	90 (30)
Ischemic heart disease (IHD)	45 (15)
Respiratory disease	30 (10)
Liver cirrhosis	15 (5.0)

Table 2: Etiological analysis of AKI patient's admission in ICU

Characteristics	Frequency (%)
Etiology of admission in ICU	
Sepsis	180 (60)
Respiratory disease	30 (10)
Neurological disorders	90 (30)
Etiology of AKI	
Sepsis	180 (60)
Respiratory disease	30 (10)
Hypovolemic shock	90 (30)

Abbreviations: AKI: acute kidney injury

Table 3: Statistics of risk factors and predictors for AKI

Characteristics	Odds ratio	95% CI (LL – UL)	p-value
Gender	1.5	1 - 20	0.524
Age (≥50 years)	1.9	1 - 4.4	0.001
Sepsis	6.8	2 - 15.8	0.001
Hypovolemia	4.9	1.8 - 12.2	0.001
Ischemic heart disease	2.7	0.8 - 7.1	0.001
Diabetes mellitus	2.3	1 - 4	0.001
Hypertension	2.5	1 - 6	0.001
Respiratory diseases	0.8	0.2 - 1	0.064

Abbreviations: CI: confidence interval, **LL**: lower limits, **UL**: upper limits

followed by respiratory diseases at 30 (10%) and neurological disorders in 90 (30%) cases. The main etiological factors contributing to the development of AKI mirrored these admission reasons, with sepsis accounting for 180 (60%), respiratory diseases for 30 (10%), and hypovolemic shock for 90 (30%) patients (Table 2).

There was an AKI incidence of 40%, affecting 120 patients during their ICUs stay. In patients, significance predictors were identified through multivariate logistic regression. These included sepsis (OR: 6.8, 95% CI; 2-15.8, p-value = 0.001), hypovolemia (OR: 4.9, 95% CI; 1.8-12.2, p-value = 0.001), ischemic heart disease (OR: 2.7, 95% CI; 0.8-7.1, p-value = 0.001), age ≥50 years (OR: 1.9, 95% CI; 1-4.4, p-value = 0.001), diabetes mellitus (OR: 2.3, 95% CI; 1-4, p-value = 0.001), and hypertension (OR: 2.5, 95% CI; 1-6, p-value = 0.001). The predictors are presented in Table 3. The analysis of factors associated with AKI considered gender, age, sepsis, hypovolemia, HTN, DM, IHD, and respiratory disorders (Table 4). Significantly, there was an association between the development of AKI and various factors, including sepsis, hypovolemia, IHD, age, DM, and HTN (p-value ≤0.05).

DISCUSSION

The study aimed to document the incidence and risk factors of AKI in the ICU setting, specifically investigating its incidence among patients during their ICUs admission. The primary observation was a noteworthy AKI incidence of 40% within the study population. The secondary focus was on identifying predictors for AKI development in ICU-admitted patients. The key predictors found to be significantly associated with AKI in ICUs included sepsis, hypovolemia, IHD, age ≥50 years, DM, and HTN. It is worth noting that certain predictors, like ischemic heart diseases, may potentially serve as confounders, contributing to conditions like cardio-renal syndrome. Additionally, the observational nature of the study design makes it challenging to completely rule out the other confounding factors such as hepato-renal disease and cardio-renal disease. The age factor (≥50 years) emerged as a predictor for AKI development, possibly due to the associated comorbidities in this age group.

In present study, observed incidence of AKI (40%) was lower than the reported incidence in a Chinese study, where AKI was documented at 51%. This variance can be ascribed to inherent dissimilarities between two samples and discrepancies in criteria employed for AKI stages. The breakdown of AKI incidence encompassed stage 1 (23.1%), stage 2 (11.8%), and stage 3 (15.7%).[12] In contrast, the current study primarily witnessed severity grading concentrated in stage 1 (40%) and stage 2 (60%) for AKI. Osman and coworkers conducted an extensive retrospective study, where the incidence of AKI was 5.7%, markedly lower than the 40% observed in this study.[13] The substantial disparities between these studies may be the differences in study design, quality of care, and variations in data sources (ICUs *vs.* hospital wards). In an Egyptian study spanning four hospitals, 39.6% of patients developed AKI during their ICU admission, closely aligning with our study's findings (40%).[14] Notably, the Sudanese and Malaysian studies highlighted a predominance of males in the AKI, with sepsis and hypovolemia identified as common factors for AKI in both investigations.[15,16] In this study, a noteworthy association was found between age, hypertension, and diabetes mellitus in the development of AKI in the ICUs, aligning with similar findings in a Sudanese study.[15] Severity of AKI predominantly comprised stage 1 (40%) and stage 2 (60%), resembling the Egyptian study, but differing from the Sudanese study where the majority were in stage 3 (47.9%).[13,14] A meta-analysis on trauma patients in the ICU reported a 24% incidence of AKI.[17] Some factors identified in this study, such as age, HTN, DM, shock, and sepsis, were also documented in this review. In a multicenter observational study in Thailand, AKI was reported in 52.9% of patients, stage 1 (7.5%), stage 2 (16.5%), and stage 3 (28.9%).[18] A multinational, multicenter observational study across four countries (North America, Europe, and Australia) found that 32% of patients developed AKI in the ICUs.[19]

Table 4: Stratification of AKI development in ICU patients, n=300

Characteristics	AKI development		Total	Chi-square	p-value
	No	Yes			
Age (years)					
30-50	99	40	139	12.35	0.001
51-70	81	80	161		
Gender					
Male	140	70	210	2.58	0.524
Female	40	50	90		
Sepsis					
No	120	0	120	16.44	0.001
Yes	60	120	180		
Hypovolemia					
No	210	0	210	24.27	0.001
Yes	0	90	90		
Ischemic heart diseases					
No	255	0	255	22.19	0.001
Yes	0	45	45		
Diabetes mellitus					
No	210	0	210	24.16	0.001
Yes	0	90	90		
Hypertension					
No	120	0	120	16.40	0.001
Yes	60	120	180		
Respiratory disease					
No	270	0	270	8.31	0.064
Yes	0	30	30		

The present study has some limitations, the primary constraint is the relatively small sample, which may impact the generalizability of our findings. The reliance on clinical records for data reporting introduces a potential for bias. Additionally, the nature of the hospital itself poses limitations, as selection bias could influence case intake, potentially deviating from a representative sample of AKI patients in Islamabad. Furthermore, our study lacks exploration mortality rates, and the recovery of renal function, presenting further limitations in comprehensive insights.

CONCLUSION

The study primarily highlighted a notable incidence of AKI among ICUs-admitted patients, with sepsis and hypovolemia identified as the main contributing factors. There was a significant association observed between the development of AKI in the ICUs and factors such as sepsis, hypovolemia, IHD, age ≥50 years, DM, and HTN. The study underscores the importance of stratifying patients admitted to the ICUs based on their individual vulnerabilities and exposures to assess the risk of AKI.

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