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ASSOCIATION OF URINARY ELECTROLYTES AND URINARY CREATININE IN PREDICTING ACUTE KIDNEY INJURY IN POSTOPERATIVE CRITICALLY ILL SURGICAL PATIENTS: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Acute kidney injury (AKI) is a frequent and serious complication among postoperative critically ill surgical patients, leading to increased morbidity, mortality, and prolonged intensive care stay. Early identification of AKI using simple urinary biomarkers may improve timely intervention and clinical outcomes. **Aim:** To evaluate the association of urinary electrolytes and urinary creatinine with the development of AKI in postoperative critically ill surgical patients. **Methods:** This prospective observational study included 90 postoperative critically ill surgical patients admitted to the ICU. Baseline demographic, surgical, biochemical, and urinary parameters were recorded. Serial measurements of urinary sodium, urinary potassium, urinary creatinine, fractional excretion of sodium (FENa), fractional excretion of potassium (FEK), and serum creatinine were performed from baseline through postoperative day 7. AKI was diagnosed and staged according to KDIGO criteria. Logistic regression and ROC analyses were used to assess predictive performance of urinary biomarkers. **Results:** AKI developed in 30 patients (33.33%), with Stage 1 AKI being the most common presentation (53.33%). Patients with AKI showed significantly lower urinary sodium and urinary creatinine levels and higher urinary potassium and FEK values compared to non-AKI patients ($p<0.001$). Serum creatinine increased significantly only after postoperative day 1. Baseline urinary chloride (AUC=0.95) and urinary sodium (AUC=0.94) demonstrated excellent predictive performance for AKI. Higher SOFA scores and vasopressor requirement were significantly associated with AKI. Patients with AKI had longer ICU stay, greater requirement for renal replacement therapy, and higher mortality. **Conclusion:** Urinary electrolyte parameters and urinary creatinine are useful early, non-invasive predictors of postoperative AKI in critically ill surgical patients and may aid in early risk stratification and timely intervention.

KEYWORDS

Creatinine, Kidney injury, urinary electrolytes, AKI, Biomarkers.

INTRODUCTION

Acute kidney injury (AKI) is a common and serious complication among critically ill patients, particularly in the postoperative period following major surgical interventions. [1]. Early detection of AKI remains a cornerstone in improving outcomes; however, this continues to be a major limitation in clinical practice. Traditionally, AKI has been diagnosed using serum creatinine levels and urine output, as defined by standardized criteria such as the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines. Postoperative critically ill surgical patients are at high risk of AKI due to hypotension, blood loss, fluid shifts, ischemia–reperfusion injury, and exposure to anesthetic agents, all of which can impair renal perfusion and function [2].

Serum creatinine, although widely used, is an imperfect marker of renal function rises only after a substantial decline in glomerular filtration rate (GFR), often lagging behind actual kidney injury by 24–48 hours. Additionally, serum creatinine levels are influenced by factors such as age, muscle mass, hydration status, and nutritional state, which are often altered in critically ill patients [3].

Recent studies have highlighted the potential role of urinary electrolytes and urinary creatinine in predicting AKI development, severity, and outcomes in ICU patients. Changes in urinary electrolyte patterns have been shown to correlate with renal tubular injury and hemodynamic compromise. Moreover, serial monitoring of these parameters may offer dynamic information about renal recovery or progression of injury, which static serum markers often fail to capture [4]. Despite these promising findings, the clinical utility of urinary electrolytes and urinary creatinine in routine AKI prediction remains underexplored, particularly in postoperative critically ill surgical patients.

Furthermore, there is limited prospective data evaluating the association between urinary electrolytes, urinary creatinine, and AKI development specifically in postoperative critically ill surgical patients. Most available studies have focused on heterogeneous ICU populations or specific subgroups such as septic or medical ICU patients. Given the distinct pathophysiological mechanisms involved in postoperative AKI, it is essential to assess these markers within this targeted population to generate clinically relevant evidence [5].

The present prospective observational study was designed to evaluate the association of urinary electrolytes and urinary creatinine with the development of acute kidney injury in postoperative critically ill surgical patients admitted to the ICU.

MATERIALS AND METHODS

The prospective observational study was conducted in the Department of Anaesthesiology, in collaboration with the Surgical Intensive Care Unit (ICU), at BRD Medical College, Gorakhpur, over a period of one year, after receiving ethical clearance from the Institutional Ethics Committee. A non-probability consecutive sampling technique was used and 90 patients fulfilling the inclusion criteria were selected for the study.3

Inclusion Criteria

Adult patients aged 18 years and above admitted to the surgical ICU following major surgery within 24 hours of admission, at risk of developing acute kidney injury (AKI), with an expected ICU stay of 48 hours or more.

Exclusion Criteria

Patients with pre-existing AKI, detected based on serum creatinine levels at admission, chronic kidney disease (CKD), end-stage renal disease on dialysis, uncontrolled systemic hypertension, uncontrolled diabetes mellitus, cardiovascular disease, cerebrovascular insufficiency, hepatic insufficiency, or any other uncontrolled systemic illness, urinary tract obstruction or bladder dysfunction affecting urine collection, receiving nephrotoxic drugs prior to ICU admission, pregnant ladies, refusing to provide informed consent.

Baseline clinical and laboratory parameters were recorded within 24 hours of ICU admission. Patients were followed prospectively during their ICU stay for the development of AKI as per KDIGO criteria. Serum creatinine and serum electrolytes were measured at baseline and subsequently on postoperative days 1, 3, 5, and 7. Urinary electrolytes and urinary creatinine were measured at the same time intervals. Urine output was recorded hourly for the first 48 hours, followed by six-hourly recordings thereafter.

Acute kidney injury was defined according to KDIGO criteria, which included an increase in serum creatinine by ≥0.3 mg/dL within 48 hours or a reduction in urine output as specified in the guidelines.

AKI Staging – KDIGO

AKI stage	Serum Creatinine criteria	Urine output criteria
1	SCr increase ≥26 μmol/L within 48 hrs or SCr increase ≥1.5–2 fold from baseline	<0.5 mL/kg/hr for 6 consecutive hrs
2	SCr increase ≥2–3 fold from baseline	<0.5 mL/kg/hr for 12 hrs
3	SCr increase ≥3 fold from baseline or SCr increase ≥354 μmol/L or initiated on RRT (irrespective of stage at time of initiation)	<0.3 mL/kg/hr for 24 hr or anuria for 12 hr

Data were entered and analysedq using Statistical Package for Social Sciences (SPSS) version 24. Continuous variables were expressed as mean ± standard deviation or median, while categorical variables were expressed as frequencies and percentages.

RESULTS

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (n=90)

Variable	Frequency (n=90)	Percentage (%)
Age Group (years)		
18–30	34	37.78
31–40	12	13.33
41–50	6	6.67
51–60	15	16.67
>60	23	25.56
Mean Age ± SD	-	43.88 ± 18.95
Gender		
Male	65	72.22
Female	25	27.78
Male: Female Ratio	-	2.6:1
BMI Category		
Normal (18.5–24.9)	30	33.33
Overweight (25.0–29.9)	39	43.33
Obese (>30)	21	23.33
Mean BMI ± SD	-	26.76 ± 4.69
Comorbidities		
Hypertension	22	24.44
Diabetes Mellitus	20	22.22
None	48	53.33

The study population had a mean age of 43.88 ± 18.95 years, with the majority belonging to the 18–30 year's age group (37.78%), followed by patients aged >60 years (25.56%). Males predominated, constituting 72.22% of the cohort, with a male-to-female ratio of 2.6:1. Most patients were overweight (43.33%), while 33.33% had normal BMI and 23.33% were obese, with a mean BMI of 26.76 ± 4.69 kg/m². More than half of the participants (53.33%) had no known comorbidity, whereas hypertension and diabetes mellitus were present in 24.44% and 22.22% of patients, respectively.

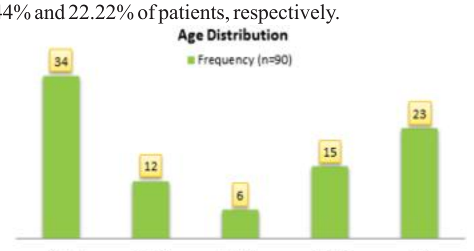

Figure 1. Bar Chart Illustrating Age Distribution of the Study Population

Table 2. Surgical and Intraoperative Characteristics of the Study Population (n=90)

Variable	Frequency (n=90)	Percentage (%)
Diagnosis Category		
Perforation Peritonitis	43	47.78
Abdominal Trauma	14	15.56
Obstruction (Acute Intestinal Obstruction & Obstructed Hernia)	19	21.11
Infection/Abscess (Ruptured Liver/Pyoperitoneum)	4	4.44
Others (Penetrating Injury & Gunshot)	10	11.11
Type of Surgical Procedure		
EL + Stoma (Ileostomy/Colostomy)	40	44.44
Resection Anastomosis / Primary Repair	14	15.56
Modified Graham Patch Repair	18	20.00
Organ-specific Surgery	9	10.00
Others (Exploratory/Drainage Procedures)	9	10.00
Duration of Surgery		
<2 hours	20	22.22
2–4 hours	69	76.67
>4 hours	1	1.11
Mean Duration ± SD (minutes)	-	139.39 ±

The present study demonstrated that perforation peritonitis was the most common diagnosis, accounting for 52.22% of cases, followed by intestinal obstruction (21.11%) and abdominal trauma (15.56%), reflecting the predominance of severe emergency abdominal condi-tions associated with sepsis and hemodynamic instability. Exploratory laparotomy with stoma formation was the most frequently performed procedure (44.44%), followed by modified Graham patch repair (20%) and resection with primary repair (15.56%), indicating the high burden of contaminated abdominal surgeries requiring diversion procedures. Most surgeries lasted 2–4 hours (46.67%), while 36.67% extended beyond 4 hours, with a mean operative duration of 204.78 ± 70.81 minutes, suggesting substantial perioperative physiological stress and increased susceptibility to postoperative complications such as acute kidney injury.

Table 3. Intraoperative Hemodynamic and Fluid Parameters among AKI and Non-AKI Groups

Parameter	AKI	Non-AKI	p-Value
Estimated Blood Loss (ml)	493.70 ± 150.21	450.40 ± 96.03	0.10 (NS)
Intraoperative Vasopressor Use, n (%)	20 (66.67%)	14 (23.33%)	p<0.001 *
Intraoperative Fluid Administered (ml)	2842.10 ± 907.73	2746.58 ± 682.39	0.58 (NS)

*Significant ($p < 0.05$); NS = Not Significant.

p-values calculated using Independent Samples t-test and Chi-square test as appropriate.

Among patients who received vasopressors, 20 out of 34 (58.82%) developed AKI, whereas among those who did not receive vasopressors, only 10 out of 56 (17.86%) developed AKI. This difference was found to be statistically highly significant ($p < 0.001$), indicating a strong associ-ation between vasopressor use and the occurrence of AKI. This may reflect the underlying hemodynamic instability and severity of illness in patients requiring vasopressor support, which could contribute to impaired renal perfusion and subsequent kidney injury.

The mean intraoperative fluid administered did not differ significantly between patients who developed AKI and those who did not, suggesting that absolute fluid volume alone may not be an independent predictor of postoperative AKI. This finding is consistent with current evidence indicating that perioperative renal outcomes are more strongly influenced by fluid balance, hemodynamic stability, and individualized fluid responsiveness rather than total volume administered.

Table 4. ICU Clinical Parameters and Organ Support among AKI and Non-AKI Groups

Parameter	AKI	Non-AKI	p-Value
SOFA Score at ICU Admission	8.43 ± 2.10	5.93 ± 1.69	p<0.001*
Mechanical Ventilation Required, n (%)	7 (23%)	23 (38%)	0.15 (NS)
Postoperative Vasopressor Support, n (%)	19 (63%)	0 (0%)	p<0.001*
Diuretics Used, n (%)	13 (43%)	15 (25%)	0.08 (NS)

*Significant (p<0.05); NS=Not Significant.
p-values calculated using Independent Samples t-test and Chi-square test as appropriate.

The overall mean SOFA score at ICU admission was 6.77 ± 2.17. Patients who developed AKI had significantly higher SOFA scores (8.43 ± 2.10) compared to non-AKI patients (5.93 ± 1.69), and this difference was statistically highly significant ($p < 0.001$), suggesting that greater severity of illness at admission is associated with an increased risk of AKI.

Mechanical ventilation was more frequently required in the non-AKI group; however, the difference between groups was not statistically significant (p=0.15). Similarly, diuretic use was more common among AKI patients (43% vs. 25%), although this association did not reach statistical significance (p=0.08). These observations may reflect differences in postoperative clinical management and fluid balance strategies rather than direct predictors of AKI.

Table 5. Baseline Serum and Urinary Biochemical Parameters among Study Participants (n=90)

Parameter	Mean ± SD	Range	Normal Range
Serum Parameters			
Creatinine (mg/dL)	0.91 ± 0.18	0.6 – 1.3	0.6 – 1.2
Sodium (mEq/L)	137.63 ± 3.82	130 – 145	135 – 145
Potassium (mEq/L)	4.12 ± 0.54	3.2 – 5.2	3.5 – 5.0
Chloride (mEq/L)	101.84 ± 3.15	96 – 108	98 – 106
Urinary Parameters			
Urinary Sodium (mEq/L)	59.64 ± 20.12	20.92 – 97.67	40 – 220
Urinary Potassium (mEq/L)	35.70 ± 12.27	12.73 – 80.36	25 – 145
Urinary Chloride (mEq/L)	57.18 ± 17.71	13.46 – 88.92	40 – 120
Urinary Creatinine (mg/dL)	80.32 ± 23.89	36.79 – 149.07	20 – 300

The mean serum creatinine was 0.91 ± 0.18 mg/dL, indicating that the majority of patients had normal baseline renal function at admission. The mean serum sodium level was 137.63 ± 3.82 mEq/L, while the mean potassium and chloride levels were 4.12 ± 0.54 mEq/L and 101.84 ± 3.15 mEq/L, respectively.

All measured parameters were within physiological reference ranges, suggesting that the study population had stable baseline biochemical status, thereby supporting the assessment of new-onset postoperative acute kidney injury during the study period.

The mean urinary sodium level was 59.64 ± 20.12 mEq/L, with values ranging from 20.92 to 97.67 mEq/L. The mean urinary potassium was 35.70 ± 12.27 mEq/L, with a range of 12.73 to 80.36 mEq/L. Similarly, the mean urinary chloride level was 57.18 ± 17.71 mEq/L, ranging from 13.46 to 88.92 mEq/L. The mean urinary creatinine was 80.32 ± 23.89 mg/dL, with observed values between 36.79 and 149.07 mg/dL.

These findings demonstrate a wide distribution of urinary electrolyte values within the study population, reflecting variability in renal tubular handling of electrolytes among critically ill postoperative patients.

Table 6. Incidence and Severity of Acute Kidney Injury According to KDIGO Classification (n=90)

Parameter	Number	Percentage (%)
AKI Incidence		
AKI Present	30	33.37
AKI Absent	60	66.63
KDIGO Staging of AKI (n=30)		
Stage 1	16	53.33
Stage 2	9	30.00
Stage 3	5	16.67

- Out of 90 patients, 30 patients (33.33%) developed AKI, while 60 patients (66.67%) did not develop AKI during the study period.
- This indicates that approximately one-third of the postoperative critically ill surgical patients developed AKI, highlighting the significant burden of renal complications in this population.
- Among the 30 patients with AKI, the majority were classified as Stage 1 (53.33%), followed by Stage 2 (30.00%), while Stage 3 AKI was observed in 16.67% of patients.
- These findings indicate that most cases of AKI were detected at an early stage, with a smaller proportion progressing to more severe stages. This suggests the potential for early identification and intervention in postoperative critically ill patients, which may help prevent progression to severe renal dysfunction.

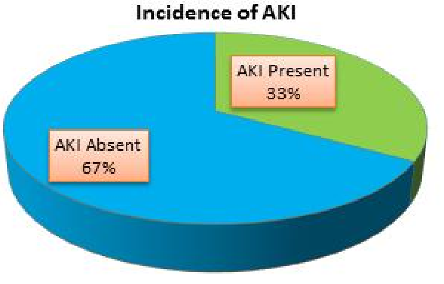

Fig. 2 Pie Chart Representing the Incidence of Acute Kidney Injury

Figure 3. Bar Chart Illustrating the Distribution of AKI Stages

Table 7. Trend of Serum Creatinine Levels from Postoperative Day 1 to Day 7:

Day	AKI	Non-AKI	p-Value
Baseline	0.90 ± 0.18	0.92 ± 0.17	0.64 (NS)
Day 1	1.20 ± 0.31	0.98 ± 0.17	p<0.001*
Day 3	1.41 ± 0.29	0.97 ± 0.19	p<0.001*
Day 5	1.98 ± 0.43	0.98 ± 0.20	p<0.001*
Day 7	2.16 ± 0.64	1.01 ± 0.20	p<0.001*

(*)=Significant, (p < 0.05); (NS)= Not Significant
p-value calculated using Independent Samples t-test.

At baseline, there was no statistically significant difference in serum creatinine levels between the two groups (p = 0.64), indicating comparable baseline renal function.

However, from postoperative day 1 onwards, serum creatinine levels were significantly higher in the AKI group compared to the non-AKI group, and this difference remained statistically highly significant throughout the study period ($p < 0.001$). The mean serum creatinine in the AKI group showed a progressive rise from day 1 to day 7, whereas it remained relatively stable in the non-AKI group. These findings demonstrate that serum creatinine levels increase significantly over time in patients who develop AKI, highlighting its role as a marker of renal dysfunction, although changes become evident only after the onset of kidney injury.

Table 8. Postoperative Trends in Urinary Biomarkers and Fractional Excretion Indices among AKI and Non-AKI Groups

Parameter	Day	AKI (Mean ± SD)	Non-AKI (Mean ± SD)	p-value
Urinary Sodium (mEq/L)	Baseline	39.25 ± 12.04	69.84 ± 14.92	p<0.001*
	Day 1	41.78 ± 12.38	67.71 ± 14.90	p<0.001*
	Day 3	37.42 ± 9.56	73.47 ± 14.91	p<0.001*
	Day 5	36.47 ± 7.09	70.46 ± 15.18	p<0.001*
	Day 7	38.80 ± 9.52	69.69 ± 11.64	p<0.001*
Urinary Potassium (mEq/L)	Baseline	45.61 ± 13.98	30.75 ± 7.50	p<0.001*
	Day 1	44.82 ± 11.09	28.93 ± 7.70	p<0.001*
	Day 3	49.50 ± 10.90	30.71 ± 8.84	p<0.001*
	Day 5	48.14 ± 11.48	33.60 ± 9.24	p<0.001*
	Day 7	47.29 ± 11.36	33.85 ± 5.99	p<0.001*
Urinary Creatinine (mg/dL)	Baseline	61.70 ± 12.23	89.64 ± 22.87	p<0.001*
	Day 1	61.84 ± 11.38	91.28 ± 16.08	p<0.001*
	Day 3	54.61 ± 12.42	87.50 ± 17.74	p<0.001*
	Day 5	53.30 ± 9.87	81.67 ± 13.23	p<0.001*
	Day 7	58.65 ± 13.07	82.23 ± 16.97	p<0.001*

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FENa (%)	Day 1	0.62 ± 0.28	0.55 ± 0.19	0.18 (NS)
	Day 3	0.72 ± 0.34	0.62 ± 0.22	p=0.03*
	Day 5	1.01 ± 0.38	0.62 ± 0.21	p<0.001*
	Day 7	1.11 ± 0.59	0.64 ± 0.18	p<0.001*
FEK (%)	Day 1	22.72 ± 12.01	7.72 ± 2.68	p<0.001*
	Day 3	31.43 ± 10.98	9.10 ± 3.98	p<0.001*
	Day 5	48.07 ± 22.44	10.39 ± 5.14	p<0.001*
	Day 7	47.48 ± 24.83	10.78 ± 4.12	p<0.001*

*Significant ($p < 0.05$); NS = Not Significant.
p-values calculated using Independent Samples t-test.

Patients who developed postoperative AKI demonstrated significantly lower urinary sodium and urinary creatinine levels, along with significantly higher urinary potassium and FEK% values throughout the postoperative period compared to non-AKI patients (p<0.001). FENa% showed significant elevation from postoperative day 3 onward, indicating progressive renal tubular dysfunction. These findings suggest that alterations in urinary electrolyte excretion and fractional excretion indices occur early in AKI and may serve as useful predictors of postoperative renal injury in critically ill surgical patients.

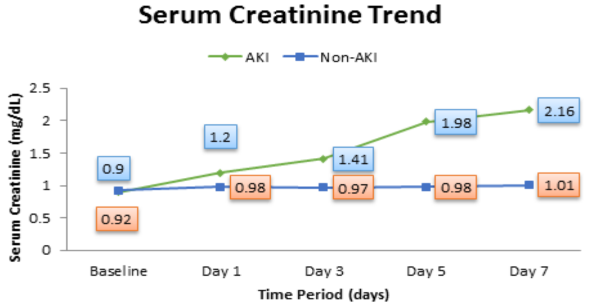

Figure 4. Line Graph Depicting Serial Changes in Serum Creatinine Levels

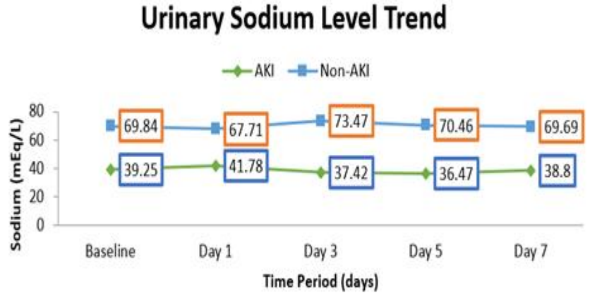

Figure 5. Line Graph Demonstrating Trends in Urinary Sodium Levels

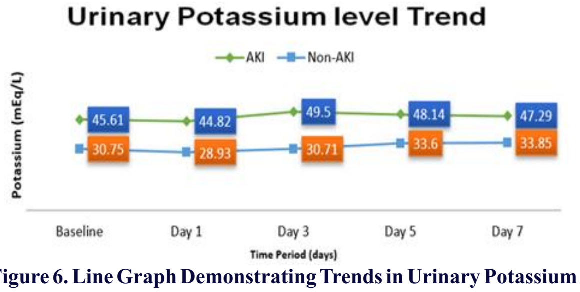

Figure 6. Line Graph Demonstrating Trends in Urinary Potassium Levels

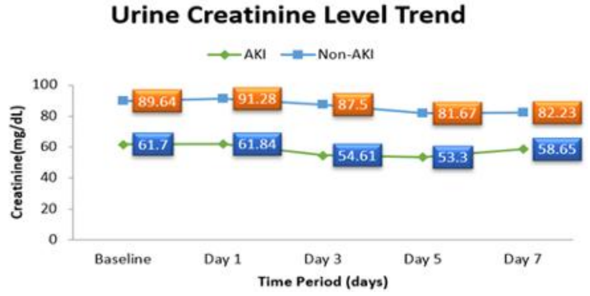

Figure 7. Line Graph Depicting Serial Changes in Urinary Creatinine Levels

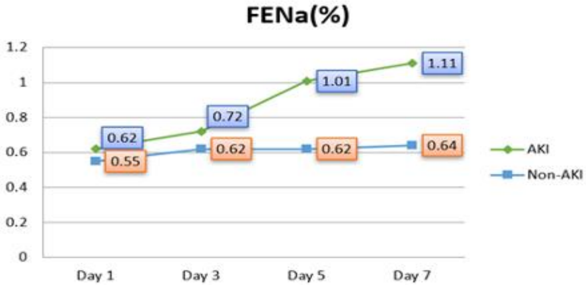

Figure 8. Line Graph Depicting Serial Changes in Fractional Excretion of Sodium (FENa%)

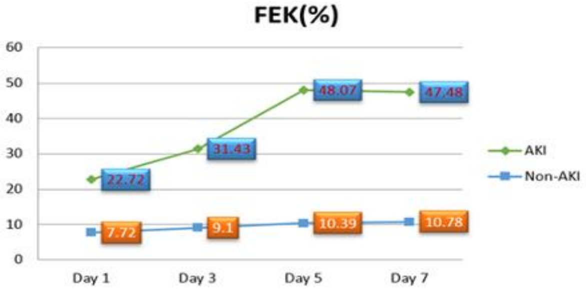

Figure 9. Line Graph Depicting Serial Changes in Fractional Excretion of Potassium (FEK%)

Table 9. Correlation between Urinary Electrolyte Parameters and Creatinine Clearance:

Parameter	Correlation Coefficient (r)	p-Value
Urinary Sodium	0.07	0.52(NS)
Urinary Potassium	0.03	0.81(NS)
Urinary Chloride	0.05	0.65(NS)
Urinary Creatinine	-0.13	0.21(NS)
FENa(%)	0.19	0.08(NS)
FEK(%)	0.16	0.12(NS)

(*)=Significant,($p < 0.05$); (NS)= Not Significant.
r= Pearson's Correlation Coefficient;
Significance evaluated through Pearson's test (two-tailed).

All urinary parameters demonstrated very weak correlations with creatinine clearance. Urinary sodium (r = 0.07), potassium (r = 0.03), and chloride (r = 0.05) showed weak positive correlations, whereas urinary creatinine showed a weak negative correlation (r = -0.13).

However, none of these correlations were statistically significant ($p > 0.05$), indicating that baseline urinary electrolyte levels did not show a significant linear relationship with creatinine clearance in the study population.

Table 10. Predictive Performance of Urinary Biomarkers for Acute Kidney Injury

Predictor	β-coefficient	p-Value	Odds Ratio	95% CI	Accuracy	Specificity	Sensitivity	AUC
Baseline Urine Creatinine	-0.08	<0.001*	0.92	0.89 – 0.96	0.78	0.87	0.60	0.85
Baseline Urine Chloride	-0.18	<0.001*	0.84	0.78 – 0.90	0.86	0.90	0.77	0.95
Baseline Urine Potassium	0.14	<0.001*	1.16	1.08 – 1.23	0.84	0.97	0.60	0.83
Baseline Urine Sodium	-0.15	<0.001*	0.86	0.81 – 0.92	0.84	0.90	0.73	0.94
SOFA Score-ICU	0.75	<0.001*	2.09	1.50 – 2.92	—	—	—	—
BMI	-0.08	0.12 (NS)	0.92	0.84 – 1.02	—	—	—	—

*Significant ($p < 0.05$); NS = Not Significant.
p-values calculated using Multivariate Logistic Regression and ROC analysis.

Multivariate logistic regression analysis demonstrated that baseline urinary sodium, urinary chloride, urinary creatinine, urinary potassium, and SOFA score were significant independent predictors of postoperative AKI. Lower urinary sodium, chloride, and creatinine levels were associated with increased AKI risk, whereas higher urinary potassium levels and elevated SOFA scores significantly increased the likelihood of AKI development.

ROC analysis further showed excellent predictive performance of urinary biomarkers. Baseline urinary chloride (AUC=0.95) and urinary sodium (AUC=0.94) demonstrated the highest diagnostic accuracy for predicting AKI, followed by urinary creatinine (AUC=0.85) and urinary potassium (AUC=0.83). These findings indicate that urinary electrolyte parameters, particularly urinary chloride and sodium, may serve as reliable early biomarkers for identifying critically ill postoperative surgical patients at risk for acute kidney injury.

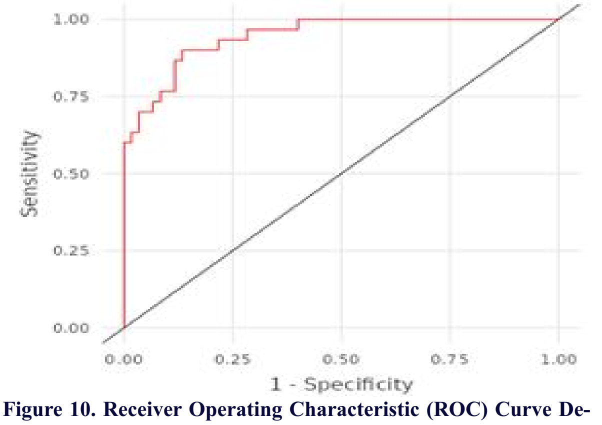

Figure 10. Receiver Operating Characteristic (ROC) Curve Demonstrating Predictive Performance of Urinary Biomarkers

Table 11. Comparison of Clinical Outcomes between AKI and Non-AKI Groups:

Outcome	AKI	Non-AKI	p value
ICU Stay (days)	10.87 ± 2.05	9.20 ± 1.88	p=0.0002*
RRT Required	5 (17%)	0 (0%)	p=0.001*
Mortality	9 (30%)	1 (2%)	p<0.001*

(*) =Significant, (p < 0.05); (NS)= Not Significant
p-value calculated using Independent Samples t-test for continuous variables and Fisher's Exact test for categorical variables.

Patients who developed AKI had a significantly longer ICU stay (10.87 ± 2.05 days vs 9.20 ± 1.88 days) compared to those without AKI, and this difference was statistically highly significant (p < 0.001).

The requirement of renal replacement therapy (RRT) was observed in 5 patients (16.67%) in the AKI group, whereas none of the patients in the non-AKI group required RRT, which was statistically significant (p = 0.001).

DISCUSSION

The aim of our study was to evaluate the association of urinary electrolytes and urinary creatinine in predicting acute kidney injury in post-operative critically ill surgical patients.

The present study demonstrated a predominantly male cohort with a wide age distribution, with younger adults constituting the largest subgroup, although a substantial proportion of patients were elderly. The presence of older patients is clinically relevant because advancing age is associated with reduced renal reserve and increased susceptibility to postoperative AKI. Prasad et al. [6] similarly identified older age as an important determinant of adverse renal outcomes in AKI patients. Most patients were overweight or obese, indicating a considerable burden of metabolic stress; however, BMI was not an independent predictor of AKI in multivariate analysis, suggesting that acute physiological derangements outweighed baseline anthropometric factors. Liu et al. [7] also reported that systemic clinical status had greater prognostic importance than body composition alone. Hypertension and diabetes were common comorbidities, consistent with findings by Prasad et al. [6], although more than half of the cohort had no documented chronic illness, indicating that severe perioperative stress alone may precipitate AKI even in previously healthy individuals.

Perforation peritonitis was the predominant diagnosis, followed by intestinal obstruction and abdominal trauma, reflecting a cohort exposed to severe sepsis, inflammation, and hemodynamic compromise. Similar observations were reported by Prasad et al. [6] and Ravikumar et al. [8], who identified sepsis as a major contributor to AKI development. Exploratory laparotomy with stoma formation was the most common surgical procedure, and most operations lasted between 2–4 hours, indicating substantial operative stress. Hu et al. [9] reported a similarly high incidence of postoperative AKI among critically ill emergency surgical patients, emphasizing the importance of surgical severity and systemic physiological burden.

Intraoperative vasopressor requirement showed a strong association with postoperative AKI, suggesting that hemodynamic instability and renal hypoperfusion play a central role in renal injury. In contrast, estimated blood loss and intraoperative fluid administration did not significantly differ between AKI and non-AKI groups. These findings are consistent with Prasad et al. [6], who highlighted the adverse prognostic impact of circulatory instability in AKI. Shen et al. [10] and Perner et al. [11] also emphasized the complex relationship between fluid balance, perfusion status, and renal dysfunction in critically ill patients.

Patients who developed AKI had significantly higher SOFA scores and greater postoperative vasopressor requirement, indicating more severe organ dysfunction and circulatory compromise. Similar findings were reported by Ravikumar et al. [8] and Hu et al. [9] and, who demonstrated that severity indices and hemodynamic instability are major determinants of postoperative AKI. Mechanical ventilation and diuretic use were not significantly associated with AKI in the present study, suggesting that global illness severity rather than isolated supportive interventions was more closely linked to renal injury.

Baseline serum biochemical parameters were largely within normal limits, indicating preserved renal function at ICU admission. However, urinary electrolyte and urinary creatinine values showed considerable variability, supporting the concept that urinary biochemical alterations may precede overt serum creatinine elevation. De Morais et al. [12] and Maciel et al. [13] similarly demonstrated that urinary sodium and potassium abnormalities may appear before conventional AKI diagnosis. These findings support the role of urinary biomarkers as early indicators of evolving renal dysfunction in critically ill postoperative patients.

AKI occurred in one-third of the study population, with Stage 1 AKI being the most common presentation. This incidence is comparable to reports by Ravikumar et al. [8] and Hu et al. [9], who documented high AKI frequencies among critically ill and septic populations. The predominance of early-stage AKI is clinically important because it indicates a potential window for early detection and intervention before progression to severe renal dysfunction.

Baseline serum creatinine values were similar between AKI and non-AKI groups, but significant elevations became apparent from postoperative day 1 onward in AKI patients. These findings indicate that serum creatinine rises relatively late during AKI evolution. Similar observations were reported by Maciel et al. [13], who showed that urinary biochemical abnormalities may be detectable despite initially normal serum creatinine levels.

Patients with AKI demonstrated persistently lower urinary sodium and urinary creatinine levels and higher urinary potassium and FEK% values throughout the postoperative period. FENa became significantly elevated only from day 3 onward, whereas FEK showed significant elevation from the earliest postoperative measurement, suggesting that FEK may be a more sensitive early indicator of renal dysfunction. Similar findings were reported by Maciel et al. [13] and Ravikumar et al. [8], who emphasized the early predictive role of FEK in AKI. Kumar et al. [14] and Burns et al. [15] also demonstrated the diagnostic utility of urinary potassium excretion in predicting renal injury.

Correlation analysis demonstrated no statistically significant relationship between urinary electrolyte parameters, fractional excretion indices, and creatinine clearance. Although weak positive correlations were observed for FENa and FEK, these did not achieve significance, suggesting that isolated urinary biochemical parameters may not directly reflect dynamic renal filtration capacity. These findings indicate that urinary biomarkers may have greater utility in early AKI prediction rather than in estimating creatinine clearance alone.

Postoperative AKI was associated with significantly prolonged ICU stay, increased requirement for renal replacement therapy, and markedly higher mortality. These findings are consistent with previous studies by Hu et al. [9], Liu et al. [7], and Ravikumar et al. [8], all of whom demonstrated worse outcomes among patients developing AKI. The present results reinforce that AKI is a clinically significant postoperative complication associated with substantial morbidity and mortality, highlighting the importance of early biomarker-based identification and timely intervention.

STRENGTH & LIMITATIONS

The present study has several important strengths, including its focus on a high-risk population of postoperative critically ill surgical patients, prospective serial monitoring of urinary electrolytes, urinary creatinine, FENa, FEK, and serum creatinine from baseline to postoperative day 7, and the use of KDIGO criteria for standardized AKI diagnosis. Additionally, inclusion of clinically meaningful outcomes such as ICU stay, requirement of renal replacement therapy, and mortality enhanced the translational and clinical relevance of the findings. The study provides structured evidence supporting urinary electrolyte profiling as a simple, early, and non-invasive approach for AKI prediction in critically ill surgical patients. However, certain limitations should be acknowledged. The relatively small sample size and single-center design may limit generalizability, while the short follow-up period of seven days may not reflect long-term renal outcomes. Furthermore, potential confounding variables such as nutritional status, severity of infection, and detailed intraoperative hemodynamic variations were not comprehensively evaluated. The study also assessed only conventional urinary biomarkers without comparison to newer renal injury biomarkers. Therefore, although the findings are clinically promising, larger multi-centric studies with longer follow-up and broader biomarker assessment are required before these observations can be widely implemented into routine clinical practice.

CONCLUSION

The study concludes that urinary electrolyte profiling and urinary creatinine estimation are practical, non-invasive, and clinically valuable early indicators of postoperative acute kidney injury in critically ill surgical patients. Their integration with severity assessment such as SOFA score may improve early risk stratification, facilitate timely renal-protective interventions, and potentially reduce morbidity, dialysis requirement, and mortality in this high-risk population.

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