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Acute kidney injury in critically ill older adults: clinical severity and nursing workload

Injúria renal aguda em idosos críticos: gravidade clínica e carga de trabalho da enfermagem

Lesión renal aguda en pacientes ancianos críticamente enfermos: gravedad clínica y carga de trabajo de enfermería

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ABSTRACT

Objective: To determine the incidence and association of acute kidney injury, clinical severity, and nursing workload with prognostic outcomes in older patients admitted to an Intensive Care Unit.

Method: A retrospective cohort study conducted between January and December 2023 in an Intensive Care Unit. Data were collected using a structured questionnaire applied to medical records. Two-sided p-values <0.05 were considered statistically significant.

Results: Among the 81 older patients analyzed, 32% developed acute kidney injury. Of these, 22.2% had moderate to severe impairment of renal function. The use of norepinephrine ($p=0.019$) and the need for mechanical ventilation ($p<0.001$) were significantly associated with the occurrence of acute kidney injury. In addition, nursing workload was significantly higher in the group with renal impairment ($p=0.006$).

Conclusion: A relevant incidence of acute kidney injury of moderate to high severity was observed among older patients admitted to the Intensive Care Unit. Patients with acute kidney injury had a higher nursing workload, as evidenced by higher Nursing Activities Score values. In addition, acute kidney injury was associated with unfavorable prognostic outcomes, including prolonged length of stay and a greater need for advanced support.

Descriptors: Nursing; Acute Kidney Injury; Intensive Care Units; Aged.

RESUMO

Objetivo: Verificar a incidência e a associação de injúria renal aguda, gravidade clínica, carga de trabalho da equipe de enfermagem com desfechos prognósticos em pacientes idosos internados em unidade de terapia intensiva.

Método: Coorte retrospectiva realizada entre janeiro e dezembro de 2023 em uma unidade de terapia intensiva. Para coleta de dados utilizou-se questionário estruturado, aplicado a prontuários. Valores de p bilaterais $<0,05$ foram considerados estatisticamente significativos.

Resultados: Entre os 81 pacientes idosos analisados, 32% desenvolveram injúria renal aguda. Desses, 22,2% apresentaram comprometimento moderado a grave da função renal. A utilização de noradrenalina ($p=0,019$) e a necessidade de ventilação mecânica ($p<0,001$) mostraram-se significativamente associadas à ocorrência de injúria renal aguda. Além disso, a carga de trabalho da equipe de enfermagem foi significativamente maior no grupo com comprometimento renal ($p=0,006$).

Conclusão: Observou-se incidência relevante de injúria renal aguda de moderada a elevada gravidade entre pacientes idosos internados em unidade de terapia intensiva. Os pacientes com injúria renal aguda apresentaram maior carga de trabalho da equipe de enfermagem, evidenciada por valores mais elevados do *Nursing Activities Score*. Além disso, a injúria renal aguda mostrou-se associada a desfechos prognósticos desfavoráveis, incluindo prolongamento do tempo de internação e maior necessidade de suporte avançado.

Descritores: Enfermagem; Injúria Renal Aguda; Unidades de Terapia Intensiva; Idoso.

RESUMEN

Objetivo: Verificar la incidencia y la asociación entre la lesión renal aguda, la gravedad clínica, la carga de trabajo del personal de enfermería y los resultados pronósticos en pacientes ancianos ingresados en una Unidad de Cuidados Intensivos.

Método: Estudio de cohorte retrospectivo realizado entre enero y diciembre de 2023 en una Unidad de Cuidados Intensivos. Para la recopilación de datos se utilizó un cuestionario estructurado aplicado a los historiales médicos. Los valores p bilaterales $< 0,05$ se consideraron estadísticamente significativos.

Resultados: De los 81 pacientes ancianos analizados, el 32% desarrolló lesión renal aguda. De estos, el 22,2% presentó deterioro de la función renal de moderado a grave. El uso de norepinefrina ($p=0,019$) y la necesidad de ventilación mecánica ($p<0,001$) se asociaron significativamente con la aparición de lesión renal aguda. Además, la carga de trabajo del personal de enfermería fue significativamente mayor en el grupo con insuficiencia renal ($p=0,006$).

Conclusión: Se observó una incidencia significativa de lesión renal aguda moderada a grave en pacientes de edad avanzada ingresados en la Unidad de Cuidados Intensivos. Los pacientes con lesión renal aguda presentaron una mayor carga de trabajo para el personal de enfermería, evidenciada por valores más altos en la Nursing Activities Score. Además, la lesión renal aguda se asoció con pronósticos desfavorables, incluyendo una estancia hospitalaria prolongada y una mayor necesidad de apoyo avanzado.

Descriptores: Enfermería; Lesión Renal Aguda; Unidades de Cuidados Intensivos; Anciano.

INTRODUCTION

More than half of patients admitted to Intensive Care Units (ICUs) experience at least one episode of acute kidney injury (AKI) during hospitalization, a condition recognized as an important risk factor for increased morbidity and mortality⁽¹⁾. Recent studies have shown that the population treated in these units is progressively older and has a greater burden of comorbidities, which increases both the risk and complexity of care⁽²⁾.

The combination of aging, multimorbidity, and AKI is associated with unfavorable clinical outcomes, such as the need for Renal Replacement Therapy (RRT) and mortality rates ranging from 31% to 80%, depending on clinical severity⁽³⁻⁴⁾. These outcomes are particularly relevant in critically ill patients, in whom organ dysfunction, hemodynamic instability, and invasive interventions predispose patients to the development and progression of AKI⁽³⁻⁵⁾.

Scientific evidence indicates that greater clinical severity is associated not only with an increased incidence of AKI but also with its persistence and the occurrence of adverse outcomes, including death⁽⁶⁻⁷⁾. AKI, per se, is characterized by a sudden loss of kidney function, evidenced by increased serum creatinine (SCr) and/or reduced urine output. Its severity varies and is represented by stage 1 (mild), characterized by an increase in SCr ≥ 0.3 mg/dL from baseline; stage 2 (moderate), characterized by an increase between 2.0 and 2.9 times the baseline level; and stage 3 (severe), characterized by an increase ≥ 3 times the baseline level, SCr ≥ 4.0 mg/dL, or initiation of RRT, according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria⁽⁸⁾. These indicators reflect acute impairment of renal excretory function and are fundamental to the syndrome clinical diagnosis⁽⁹⁾.

Patients with AKI in the ICU require complex care, such as continuous clinical monitoring, strict fluid balance control, management of fluid and electrolyte disorders, and RRT. In this context, nursing workload plays a central role because it involves continuous surveillance and a high intensity of care, demonstrated by the increased complexity of care associated with a greater demand on nursing staff time, as reflected by high scores on validated instruments such as the Nursing Activities Score (NAS)⁽¹⁰⁻¹²⁾. A study indicates that

high workloads are associated with poorer clinical outcomes, including a higher incidence of adverse events, healthcare-associated infections, prolonged ICU stays, and increased mortality, reinforcing the importance of adequate staffing and the continuous assessment of care demands in critical care settings⁽¹⁰⁾.

Population aging, particularly in developing countries, intensifies the challenges of critical care. Among older adults, the presence of multiple comorbidities, combined with a reduced capacity for tissue regeneration and an attenuated inflammatory response, contributes to greater vulnerability to AKI and poorer clinical outcomes⁽¹¹⁾. This group also tends to require more complex and intensive care, increasing the burden on healthcare systems.

Given this scenario, several prognostic scores have been used to assess clinical severity and guide therapeutic decisions in ICUs. Among them, the Sequential Organ Failure Assessment (SOFA) stands out, as it integrates clinical, laboratory, and physiological variables to estimate the severity of organ dysfunction and patient prognosis⁽¹²⁾.

Despite advances in knowledge regarding AKI, clinical severity, and nursing workload considered separately, studies that integratively analyze the association among these factors and their repercussions on the prognostic outcomes of older patients admitted to ICUs remain limited. Recent reviews point to the need for investigations that integrate clinical and organizational variables, particularly those related to the work of nursing staff, as a strategy to improve patient safety, enhance quality of care, and support institutional policies for healthcare human resource management⁽¹²⁻¹³⁾.

Based on the aforementioned evidence associating greater clinical severity and higher NAS scores with adverse outcomes, we hypothesized that, among older patients admitted to the ICU, greater clinical severity and higher nursing workload would be associated with a higher incidence of AKI and poorer prognostic outcomes (higher mortality, greater need for RRT, and longer length of stay). Confirming or refuting this hypothesis may contribute to improving risk stratification among critically ill older adults, expanding the understanding of the relationship between care complexity and the occurrence of AKI, as well as supporting nursing workforce planning and the development of strategies aimed at preventing AKI and improving clinical outcomes in this population.

In this context, the present study aimed to determine the incidence and association of AKI, clinical severity, and nursing workload with prognostic outcomes in older patients admitted to the ICU, in order to support nursing care planning and the allocation of care resources.

METHOD

Study design

This is a retrospective cohort study, conducted according to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines⁽¹⁴⁾, covering the period from January to December 2023, in a mixed adult ICU of a public teaching hospital in the Central-West region of Brazil, with 19 beds, ten of which were for clinical patients and nine for patients with surgical and coronary conditions.

Population, eligibility, and sample selection

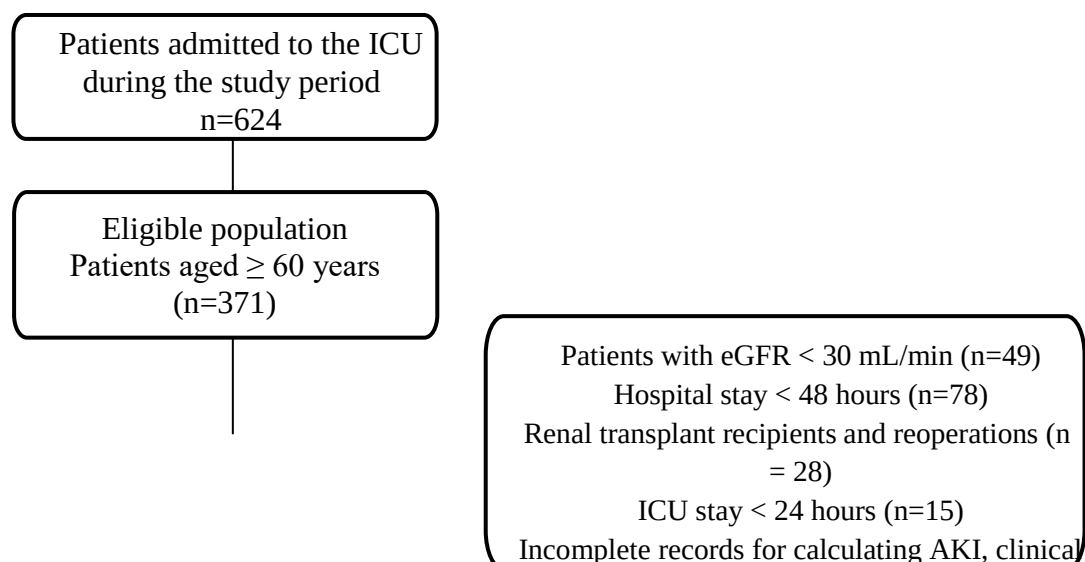
The study population consisted of older patients (≥ 60 years) admitted to the ICU during the study period, according to the definition of the Brazilian Institute of Geography and Statistics.

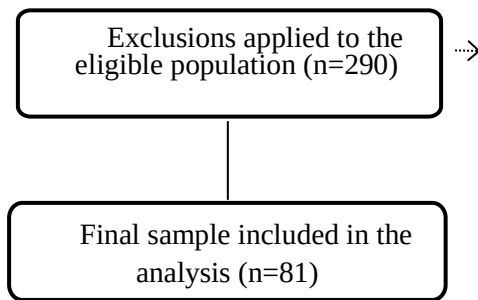
Participants were identified through a systematic review of the ICU's institutional electronic database, supplemented by consultation of physical medical records, allowing the traceability of eligible cases. All patients admitted during the study period were initially listed and assessed according to the eligibility criteria, constituting a consecutive, nonprobability sample.

Patients aged ≥ 60 years, with complete electronic medical records and ICU admission for clinical or surgical conditions, were included. Patients with an estimated glomerular filtration rate < 30 mL/min/1.73 m², calculated using the Chronic Kidney Disease Epidemiology Collaboration equation⁽⁸⁾, readmissions during the study period (with only the first admission considered), kidney transplant recipients, patients with a length of stay of less than 48 hours, medical records with incomplete data, and those undergoing combined surgeries or reoperations were excluded.

The selection process is presented in a flowchart (Figure 1), according to STROBE recommendations⁽¹⁴⁾.

Figure 1 - Sample selection flowchart. Brasília, FD, Brazil, 2023





Source: authors.

Participant follow-up

Patients were followed retrospectively from ICU admission. To analyze the initial clinical course, patients were followed daily during the first 15 days of hospitalization. After this period, follow-up was conducted through weekly reviews of the medical records until the final outcomes, defined as ICU discharge, hospital discharge, or death.

Data collection and study variables

Data were collected retrospectively from electronic and physical medical records by two previously trained researchers using a structured instrument based on scientific evidence^(2,4,13)

The variables were organized into three categories:

- Sociodemographic variables: age, sex, ethnicity, weight, and height;
- Clinical and care-related variables: comorbidities, use of vasoactive drugs, mechanical ventilation, duration of mechanical ventilation, hemodynamic and laboratory parameters;
- Variables related to hospitalization: ICU length of stay, type of admission, and therapeutic interventions.

The independent variables (exposure) included:

- Presence and severity of AKI;
- Severity of organ dysfunction (SOFA);
- Nursing workload (NAS).

AKI was defined and classified according to the SCr criteria established by KDIGO⁽⁸⁾.

Baseline SCr was defined as the lowest value recorded up to 365 days before admission or, in its absence, the lowest value during the first seven days⁽¹⁵⁾.

The severity of organ dysfunction was measured using the SOFA score, calculated daily, with the median value during hospitalization used as the representative measure⁽¹⁶⁾. It

should be noted that SOFA was treated as a continuous independent variable representing clinical severity rather than as an outcome.

Nursing workload was assessed using the NAS, applied daily by nurses, with scores ranging from 0 to 176.8%⁽¹⁷⁾. Higher values indicate greater care demands.

The ICU nursing staff works a 36-hour workweek. The staff consists of 21 nurses and 64 nursing technicians, with staffing per shift consisting of three nurses for the 19 beds and one nursing technician for every two beds.

The dependent variables (outcomes) were:

- Primary outcome: incidence of AKI.
- Secondary outcomes:
 - ICU length of stay;
 - Hospital length of stay;
 - Death;
 - Need for renal support therapy.

Measurement procedure

Laboratory analyses were performed according to institutional routine using a standardized enzymatic method. Laboratory and hemodynamic parameters followed the institution's reference values⁽¹⁶⁾.

NAS data were extracted from the institutional electronic system, ensuring traceability and standardization of the measurements.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences, version 23. Initially, descriptive analysis was performed, with categorical variables expressed as frequencies and proportions and continuous variables as means or medians, according to their distribution assessed using the Kolmogorov–Smirnov test.

Associations between independent variables and outcomes were analyzed using the chi-square or Fisher's exact test for categorical variables and parametric or nonparametric tests according to data distribution⁽¹⁸⁾.

Bivariate inferential analyses were performed to assess the association between AKI, severity of organ dysfunction, and outcomes. Multivariable models were not applied because of the sample size.

Receiver Operating Characteristic (ROC) curve analysis was used exclusively to assess the discriminatory ability of the scores (SOFA and NAS) in relation to the occurrence of specific outcomes, without predictive inference. The area under the curve (AUC) was interpreted according to criteria established in the literature as follows: AUC=0.5 indicates no discriminatory ability; an AUC between 0.7 and 0.8 represents acceptable discrimination; between 0.8 and 0.9, excellent discrimination; and >0.9, outstanding discrimination. The respective 95% Confidence Intervals (95%CI) and p-values were calculated to assess the statistical significance of the curves. A significance level of 5% ($p < 0.05$) was adopted.

Ethical aspects

The study was approved by the Research Ethics Committee *Universidade de Brasília*, School of Health Sciences, under CAAE 61486022.0.0000.8093, in accordance with Resolution 466/2012 of the Brazilian National Health Council. All data were collected retrospectively, ensuring the secrecy and confidentiality of the information.

RESULTS

Among the 81 older patients assessed, males and individuals classified as Brown predominated. Of the total, 32% developed AKI, whereas 67.9% maintained preserved kidney function. The median age was slightly higher in the group with AKI: 70 years (interquartile range: 66–78).

The most frequent comorbidities were hypertension and diabetes mellitus. Septic shock stood out as the main reason for clinical admission, particularly among patients with AKI (23.1%). In this group, the use of furosemide as a diuretic (26.9%) and meropenem as an antibiotic (50.0%) was more frequent.

RRT was required in 23.1% of patients with AKI. In addition, half of these patients (50.0%) received norepinephrine, with an approximate mortality rate of 27%. Invasive mechanical ventilation (IMV) was indicated in 64.0% of patients with AKI for a median duration of five days.

The median ICU stay was six days, and the total hospital length of stay was 15 days (Table 1).

Table 1 – Sociodemographic and clinical characteristics of older adults receiving intensive care according to the presence or absence of acute kidney injury. Brasília, Federal District, Brazil, 2023

Characteristics	Without acute	With acute kidney	Total
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	kidney injury (n=55/67.9%)	injury (n=26/32.0%)	(n=81/100.0%)
Male n(%)	33 (60.0)	14 (53.8)	47 (58.0)
Age (years) Mean $\pm$ SD;	70 $\pm$ 8	71 $\pm$ 8	71 $\pm$ 8
Median (Q1-Q3)	69 (64-74)	70 (66-78)	70 (65-749)
Ethnicity n(%)			
White	10 (18.2)	3 (11.5)	13 (16.0)
Black	2 (3.6)	0 (0.0)	2 (2.5)
Yellow	1 (1.8)	0 (0.0)	1 (1.2)
Mixed-race	33 (60.0)	19 (73.1)	52 (64.2)
Not declared	9 (16.4)	4 (15.4)	13 (16.0)
Comorbidities n(%)			
Denies	2 (3.6)	2 (7.7)	4 (4.9)
Diabetes	24 (43.6)	10 (38.5)	34 (42.0)
Hypertension	41 (74.5)	20 (76.9)	61 (75.3)
Respiratory diseases	8 (14.5)	4 (15.4)	12 (14.8)
Alcoholism	13 (23.6)	3 (11.5)	16 (19.8)
Smoking	26 (47.3)	11 (42.3)	37 (45.7)
Heart disease	13 (23.6)	2 (7.7)	15 (18.5)
Admission type n(%)			
Clinical	31 (56.4)	14 (53.8)	45 (55.6)
Surgical	24 (43.6)	12 (46.2)	36 (44.4)
Reason for hospitalization n(%)			
STEMI	6 (10.9)	1 (3.8)	7 (8.6)
NSTEMI	12 (21.8)	0 (0.0)	12 (14.8)
Myocardial revascularization	3 (5.5)	2 (7.7)	5 (6.2)
perioperative period			
Septic shock	2 (3.6)	6 (23.1)	8 (9.9)
Anterior resection of the rectum	3 (5.5)	1 (3.8)	4 (4.9)
Diuretics n(%)			
Indapamide	4 (7.3)	0 (0.0)	4 (4.9)
Furosemide	8 (14.5)	7 (26.9)	15 (18.5)
Spironolactone	3 (5.5)	1 (3.8)	4 (4.9)
Used ATB(%)	27 (49.1)	21 (80.8)	48 (59.3)
Antibiotics(%)			

Meropenem	4 (7.3)	13 (50.0)	17 (21.0)
Unasyn	4 (7.3)	0 (0.0)	4 (4.9)
Tazocin	2 (3.6)	2 (7.7)	4 (4.9)
Cefuroxime	2 (3.6)	2 (7.7)	4 (4.9)
Cefazolin	5 (9.1)	2 (7.7)	7 (8.6)
Metronidazole	9 (16.4)	2 (7.7)	11 (13.6)
Vancomycin	5 (9.1)	6 (23.1)	11 (13.6)
Amikacin	0 (0.0)	4 (15.4)	4 (4.9)
Ceftriaxone	7 (12.7)	4 (15.4)	11 (13.6)
Vasoactive drugs n(%)			
Dobutamine	9 (16.4)	6 (23.1)	15 (18.5)
Norepinephrine	13 (23.6)	13 (50.0)	26 (32.1)
Vasopressin	4 (7.3)	5 (19.2)	9 (11.1)
RRT n(%)	0 (0.0)	6 (23.1)	6 (7.4)
ICU outcome n(%)			
Death	4 (7.3)	7 (26.9)	11 (13.6)
Clinical discharge	27 (49.1)	12 (46.2)	39 (48.1)
Discharge home	16 (29.1)	5 (19.2)	21 (25.9)
Transferred to another hospital facility	8 (14.5)	2 (7.7)	10 (12.3)
IMV n(%)	11 (20.0)	16 (64.0)	27 (33.3)
IMV duration (days)	5.0±3.5	6.4±14	5.8±5.3
Mean ± SD; Median (Q1-Q3)	4.0 (2.5-6.5)	5.0 (2.0-8.5)	5.0 (2.0-7.0)
ICU stay	8±9	10±7	9±9
Mean ± SD; Median (Q1-Q3)	5 (3-10)	6 (5-13)	6 (3-11)
Hospital stay duration	14±14	27±22	18±17
Mean ± SD; Median (Q1-Q3)	9 (5-18)	15 (8-49)	11 (6-21)

AKI - acute kidney injury; SD - standard deviation; CKD - chronic kidney disease; STEMI - ST-segment elevation myocardial infarction; NSTEMI - non-ST-segment elevation myocardial infarction; ATB - antibiotic; RRT - renal replacement therapy; ICU - Intensive Care Unit; IMV - invasive mechanical ventilation.

Among the older patients with AKI, 21% had moderate to severe kidney impairment, with 11.1% classified as KDIGO stage 2 and 9.9% as KDIGO stage 3. However, most patients maintained preserved kidney function (67.9%), whereas mild AKI (KDIGO stage 1) was observed in 11.1% of cases.

During the follow-up period, the hemodynamic pattern remained stable. Regarding laboratory parameters, a significant increase in urea was observed among patients with AKI, whereas the remaining tests remained within the normal range (Table 2).

The analysis of the scores indicated that the presence of AKI was associated with a higher nursing workload, with a median NAS value of 107%. The SOFA score was also higher, consistent with the clinical severity of patients with AKI, with a median of 6.0 (interquartile range: 3.0–8.0) (Table 2).

There was a statistically significant difference between the groups with and without AKI regarding the following parameters: urea ($p < 0.001$) and potassium ($p=0.003$), both of which were higher in the AKI group; and hematocrit ($p=0.004$), with higher values in the group without AKI. Nursing workload, measured using the NAS, was also significantly higher among patients with AKI ($p=0.006$) (Table 2).

Table 2 – Distribution of laboratory parameters among older adults receiving intensive care according to the presence or absence of acute kidney injury. Brasília, Federal District, Brazil, 2023

Characteristics	Without acute kidney injury (n=55)	With acute kidney injury (n=26)	Total (n=81)	p-value
Mean tax rate (Mean $\pm$ SD; Median (Q1–Q3))	36.5 $\pm$ 0.6 36.4 (36.2–36.7)	36.5 $\pm$ 0.9 36.6 (36.0–36.9)	36.5 $\pm$ 0.7 36.5 (36.2–36.8)	0.463
Mean MAP (Mean $\pm$ SD; Median (Q1–Q3))	85 $\pm$ 15 82 (75–94)	85 $\pm$ 12 83 (75–92)	85 $\pm$ 14 82 (74–92)	0.833
Mean sodium (Mean $\pm$ SD; Median (Q1–Q3))	138.3 $\pm$ 4.7 138 (136–140)	138.4 $\pm$ 4.3 138 (135–141)	138.3 $\pm$ 4.5 138 (135–141)	0.879
Mean urea (Mean $\pm$ SD; Median (Q1–Q3))	40 $\pm$ 16 38 (29–47)	63 $\pm$ 28 55 (47–73)	47 $\pm$ 23 42 (32–54)	<0.001
Mean potassium (Mean $\pm$ SD; Median (Q1–Q3))	4.22 $\pm$ 0.42 4.16 (3.95–4.60)	3.89 $\pm$ 0.40 3.93 (3.69–4.11)	4.11 $\pm$ 0.44 4.09 (3.84–4.40)	0.003
Mean Hct (Mean $\pm$ SD; Median (Q1–Q3))	35 $\pm$ 6 35 (30–40)	31 $\pm$ 6 29 (26–35)	34 $\pm$ 7 34 (28–39)	0.004
PEEP (Mean $\pm$ SD; Median (Q1–Q3))	6.7 $\pm$ 1.2 7 (6–8)	7.4 $\pm$ 1.9 8 (6–8)	7.1 $\pm$ 1.7 8 (6–8)	0.235
Maximum NAS (Mean $\pm$ SD; Median (Q1–Q3))	96 $\pm$ 17 94 (92–106)	106 $\pm$ 11 107 (103–115.0)	99 $\pm$ 16 101 (92–108)	0.006
Maximum SOFA (Mean $\pm$ SD; Median (Q1–Q3))	4.9 $\pm$ 6.7 4.0 (1.0–6.0)	5.7 $\pm$ 3.3 6.0 (3.0–8.0)	5.3 $\pm$ 5.2 5.5 (1.0–7.0)	0.111

AKI - acute kidney injury; Tax - axillary temperature; SD - standard deviation; MAP - mean arterial pressure; Hct - hematocrit; PEEP - positive end-expiratory pressure; NAS - Nursing Activities Score; SOFA - Sequential Organ Failure Assessment.

It was found that non-ST-segment elevation myocardial infarction was more frequent among patients without AKI ($p=0.007$). In contrast, septic shock had a higher incidence in the AKI group ($p=0.012$), as did the use of broad-spectrum antibiotics, such as meropenem ($p < 0.001$) and amikacin ($p=0.009$) ($p=0.009$) (Table 3).

The use of norepinephrine ($p=0.019$) and the need for mechanical ventilation ($p < 0.001$) were also significantly higher among patients with AKI. In addition, ICU length of stay ($p=0.030$) and hospital length of stay ($p=0.015$) were longer in this group, indicating greater clinical complexity and care demands (Table 3).

Table 3 – Association between clinical variables according to the presence or absence of acute kidney injury. Brasília, Federal District, Brazil, 2023

Characteristics	Without acute kidney injury (n=55)	With acute kidney injury (n=26)	p
Male sex n (%)	33 (60.0)	14 (53.8)	0.601
Age (years) (Mean $\pm$ SD; Median (Q1–Q3))	70 $\pm$ 8 69 (64-74)	71 $\pm$ 8 70 (66-78)	0.441
Black ethnicity n (%)	36 (65.5)	19 (73.1)	0.524 ^F
Comorbidities n (%)			
Diabetes mellitus	24 (43.6)	10 (38.5)	0.842
Arterial hypertension	41 (74.5)	20 (76.9)	0.816
Respiratory diseases	8 (14.5)	4 (15.4)	0.999 ^F
Alcoholism	13 (23.6)	3 (11.5)	0.185
Smoking	26 (47.3)	11 (42.3)	0.675
Heart disease	13 (23.6)	2 (7.7)	0.126 ^F
Reason for admission n (%)			
STEMI	6 (10.9)	1 (3.8)	0.420 ^F
NSTEMI	12 (21.8)	0 (0.0)	0.007^F
septic shock	2 (3.6)	6 (23.1)	0.012^F
Diuretics n(%)			
Furosemide	8 (14.5)	7 (26.9)	0.224 ^F
Used antibiotics n (%)	27 (49.1)	21 (80.8)	0.005
Antibiotics n(%)			
Meropenem	4 (7.3)	13 (50.0)	<0.001

Cefazolin	5 (9.1)	2 (7.7)	0.999 ^F
Metronidazole	9 (16.4)	2 (7.7)	0.267 ^F
Vancomycin	5 (9.1)	6 (23.1)	0.161 ^F
Amikacin	0 (0.0)	4 (15.4)	0.009^F
Ceftriaxone	7 (12.7)	4 (15.4)	0.739 ^F
Vasoactive drugs n (%)			
Dobutamine	9 (16.4)	6 (23.1)	0.544 ^F
Norepinephrine	13 (23.6)	13 (50.0)	0.019
Vasopressin	4 (7.3)	5 (19.2)	0.138 ^F
Death n(%)	4 (7.3)	7 (26.9)	0.032^F
IMV n(%)	11 (20.0)	16 (64.0)	<0.001
IMV duration (days) n (%)	5.0±3.5 4.0 (2.5-6.5)	6.4±14 5.0 (2.0-8.5)	0.842
ICU stay (Mean ± SD; Median (Q1–Q3))	8±9 5 (3-10)	10±7 6 (5-13)	0.030
Hospital length of stay (Mean ± SD; Median (Q1–Q3))	14±14 9 (5-18)	27±22 15 (8-49)	0.015

AKI - acute kidney injury; SD - standard deviation; ^FFisher's exact test; STEMI - ST-segment elevation myocardial infarction; NSTEMI - non-ST-segment elevation myocardial infarction; ATB - antibiotic; IMV - invasive mechanical ventilation; ICU - Intensive Care Unit.

The ROC curve for the NAS model, referring to nursing staff workload in relation to AKI severity, demonstrated satisfactory diagnostic performance, with good sensitivity and specificity and a trajectory consistently above the reference line, suggesting good discriminatory ability (AUC=0.718). In contrast, the SOFA score did not show a meaningful association with AKI severity, with an AUC of 0.650.

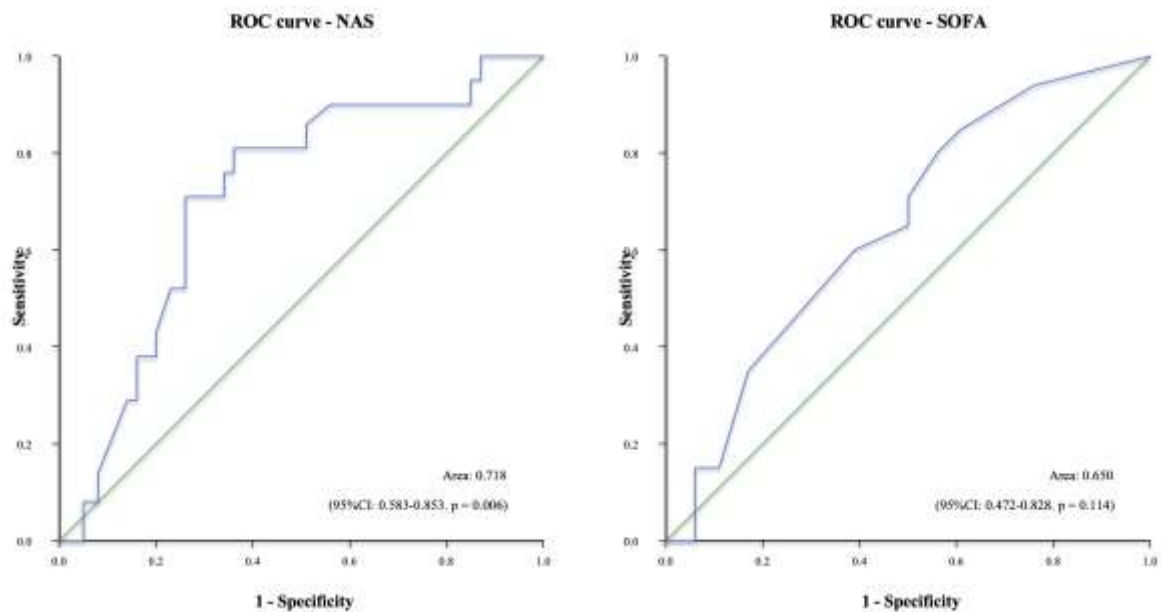


Figure 3 – Diagnostic performance of two models (NAS and SOFA): comparative analysis using ROC curves. Brasília, FD, Brazil, 2023

DISCUSSION

The study demonstrated a higher incidence of moderate to severe AKI among older adults in the ICU, with impaired kidney function in approximately one-quarter of the cases. Complex clinical conditions, such as advanced age, the presence of comorbidities, and AKI itself, require greater time for treatment and competencies for care management from the interprofessional team, particularly nursing staff. From this perspective, nursing workload was significantly higher in cases of AKI. Although the SOFA score was higher in the AKI group, the difference was not statistically significant compared with the group without AKI.

Clinical studies show that older patients are at greater risk of progression from AKI to chronic kidney disease. This risk is possibly related to a reduced capacity for repair after injury. Although the factors responsible for this limitation have not yet been fully elucidated, mechanisms such as impaired angiogenesis, decreased cell proliferation, cellular senescence, and an impaired immune response may contribute to this worsening⁽¹⁸⁻¹⁹⁾.

Aging is considered a factor associated with declining kidney function, particularly among the oldest individuals, as also observed in the present investigation. A prospective cohort study reported a three- to eightfold increase, depending on age, in the frequency of community-acquired AKI among patients older than 60 years⁽¹⁹⁾. In an extensive systematic review of 76 cohorts involving 564,455 patients admitted to ICUs, the reported frequency of AKI was as high as 82.5%⁽²⁰⁾. Although concerning, these statistics are expected given the growth of the older population worldwide⁽²⁰⁻²¹⁾.

The results of this study show that older adults with AKI receiving intensive care had poorer clinical outcomes compared with the group without AKI. The use of norepinephrine was significantly higher in the AKI group (50.0% vs. 23.6%; $p=0.019$), reflecting greater hemodynamic instability and a greater need for vasoactive support among these patients. This is consistent with recent recommendations for maintaining renal perfusion using norepinephrine in septic shock⁽²²⁻²³⁾.

Mortality was also higher among older adults with AKI (26.9%) compared with those without AKI (7.3%), with statistical significance ($p=0.032$). These findings corroborate studies demonstrating AKI as an independent factor associated with mortality in critically ill patients, particularly among older adults^(20,24).

A greater need for IMV was also observed in the AKI group (64.0% vs. 20.0%; $p<0.001$), which may be related to volume overload, uremia, metabolic acidosis, and clinical instability associated with AKI⁽²²⁾. However, the mean duration of IMV did not differ between the groups ($p=0.842$), which may indicate that, although more patients with AKI require ventilatory support, the duration of its use is not necessarily longer.

ICU and hospital lengths of stay were also significantly longer in the AKI group. The mean ICU length of stay was ten days for patients with AKI, compared with eight days in the group without AKI ($p=0.030$), whereas total hospital length of stay was 27 days versus 14 days, respectively ($p=0.015$). These results reinforce that AKI is associated with prolonged hospitalization, greater use of intensive resources, and unfavorable clinical outcomes^(18,22).

The association between AKI and the clinical course of critically ill older patients reinforces the need for prevention, early detection, and specialized management strategies, particularly by nursing teams working in the ICU, which play an essential role in hemodynamic monitoring and the early identification of signs of clinical deterioration⁽²⁵⁾.

The analysis demonstrated that antimicrobial use was significantly more frequent among older adults with AKI (80.8%) than in the group without AKI (49.1%) ($p=0.005$). This finding reinforces the relationship between severe infections and the development of AKI in critically ill patients. Recent studies show that bacterial infections, particularly pneumonia and urinary-source sepsis, are predominant causes of AKI in hospitalized older adults, leading to a greater need for broad-spectrum antibiotic therapy⁽²⁶⁾.

Among the antibiotics used, greater use of meropenem was observed in the AKI group (50.0% vs. 7.3%; $p<0.001$). Meropenem, a broad-spectrum carbapenem, is generally reserved for severe or resistant infections, suggesting greater clinical complexity and potential infection with multidrug-resistant pathogens in this group. Its excessive use, however, is

associated with potential nephrotoxicity and worsening kidney function and has been described as a risk factor for AKI progression in critically ill patients⁽²⁶⁾.

Amikacin was administered exclusively in the AKI group (15.4%; $p=0.009$), reinforcing concerns regarding the use of aminoglycosides in older adults. These drugs are nephrotoxic, particularly in patients with already impaired kidney function, and should be administered with extreme caution and rigorous pharmacokinetic monitoring.

Regarding other antibiotics, such as cefazolin, metronidazole, and vancomycin, there was no statistically significant difference between the groups. However, it should be noted that vancomycin, used in 23.1% of older adults with AKI, also has nephrotoxic potential, particularly when combined with other antibiotics, such as aminoglycosides, or diuretics, or when used in prolonged regimens⁽²⁷⁾. Current studies recommend dose adjustments to mitigate renal risks, especially among older adults⁽²⁸⁾.

These findings highlight the importance of safe antimicrobial prescribing protocols in critical care units, with the active participation of nursing staff in monitoring kidney function and reporting clinical changes early. Nursing plays an essential role in implementing strategies to prevent antimicrobial-associated AKI, such as monitoring urine output, ensuring adequate hydration, and assessing early signs of kidney toxicity⁽²⁶⁾.

Mean hematocrit was lower in the AKI group ($31 \pm 6\%$ vs. $35 \pm 6\%$; $p=0.004$), which may indicate inflammation or blood loss, both common among critically ill patients undergoing multiple procedures. Recent studies show that patients with AKI have a higher prevalence of anemia and lower erythropoietic reserve, which worsens their prognosis⁽²⁹⁾.

Positive end-expiratory pressure was similar between the groups, with no significant difference ($p=0.235$), suggesting that the ventilatory support provided did not differ between patients with and without AKI. However, the nursing workload score (NAS) was significantly higher in the AKI group (106 ± 11 vs. 96 ± 17 ; $p=0.006$), demonstrating a greater workload. This finding corroborates studies showing an association between greater severity (advanced stages of AKI) and increased nursing care demands, indicating an association with human resource management⁽³⁰⁾.

The maximum SOFA score did not differ significantly between the groups (5.7 ± 3.3 vs. 4.9 ± 6.7 ; $p=0.111$), although it was slightly higher in the AKI group. This suggests that SOFA, although useful for assessing organ dysfunction, may have limited discriminatory ability to differentiate the presence or severity of AKI (AUC 0.650; $p>0.05$), reflecting the limitations of this score for this specific purpose.

The ROC curve demonstrated moderate discriminatory ability of the NAS in differentiating patients with greater care complexity associated with AKI (AUC = 0.718; 95%CI 0.583–0.853; $p=0.006$), reinforcing its usefulness as an indicator of nursing workload in critically ill patients. A previous study reported similar AUC values in intensive care settings⁽³⁰⁾.

Conversely, the SOFA score showed limited performance in this analysis, which is consistent with its original purpose of assessing overall organ dysfunction rather than specifically discriminating kidney injury^(16,30). In contrast, the NAS, because it directly reflects care complexity, proved to be more sensitive in capturing differences related to care demands associated with AKI⁽³¹⁾.

These findings reinforce the importance for nursing staff of systematically monitoring clinical and laboratory parameters and the NAS score as indicators of care complexity and clinical severity, contributing to decision-making in the care of critically ill patients.

It should be emphasized that the findings of this study should be interpreted within the context of an observational design, with analyses based on associations between variables and without causal inference or clinical predictive capacity.

This study has some limitations that should be considered when interpreting the results. First, this was a retrospective and observational investigation, which may limit the establishment of causal relationships between the presence of AKI and the clinical variables analyzed. Data collection from physical and electronic medical records may have resulted in documentation bias or incomplete information. The absence of multivariable analyses adjusted for potential confounding factors is a limitation of the study and may have influenced the magnitude of the observed associations.

The sample in this study consisted of patients from a single institution, which may limit the generalizability of the findings to other care settings, particularly those with different profiles of complexity, resource availability, and nursing staff organization. In addition, the small number of patients with AKI may have compromised the statistical power of some analyses, particularly the ROC curves, requiring cautious interpretation of results.

CONCLUSION

A relevant incidence (32%/26) of moderate to high-severity AKI was observed among older patients admitted to the ICU. Patients with AKI had a higher nursing workload, as evidenced by higher NAS values, reflecting greater care complexity. In addition, AKI was associated with unfavorable prognostic outcomes, including prolonged length of stay and a

greater need for advanced support, such as IMV, vasoactive drug use (norepinephrine), antibiotic therapy, and septic shock. These findings reinforce the importance of systematic monitoring of kidney function, clinical severity, and nursing care demands among critically ill older patients, contributing to care planning and resource management in ICUs.

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Data and material availability

The entire dataset supporting the results of this study has been published within the article itself.

Authors' contributions

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