ORIGINAL ARTICLE

Perioperative acute kidney injury after major non-cardiac surgery: risk factors, clinical outcomes, and predictive performance of perioperative scoring systems

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Submitted: 15 February 2026
Revised: 11 April 2026
Accepted: 20 April 2026
Online First: 23 April 2026

Check for updates

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Summary

Background: Perioperative acute kidney injury (AKI) is a serious complication after major non-cardiac surgery, associated with increased mortality, prolonged ICU stay, and the need for renal replacement therapy (RRT).

Objective: To assess the impact of AKI severity and associated risk factors on clinical outcomes after major abdominal surgery and to evaluate the prognostic performance of SPARK, APACHE II, and SOFA scores, including sepsis-associated AKI.

Materials and Methods: This prospective cohort study was conducted in the Surgical ICU of University Hospital Center "Bežanijska Kosa" (Belgrade) from January to June 2024. Thirty adult patients who developed perioperative AKI after major abdominal surgery were analyzed. AKI was defined according to KDIGO criteria, and sepsis according to Sepsis-3. Disease severity was assessed using APACHE II and SOFA scores, and preoperative AKI risk was assessed using the SPARK index.

Results: AKI occurred in 30 operated patients. KDIGO stages were: stage 1 in 26.7%, stage 2 in 30.0%, and stage 3 in 43.3%. In-hospital mortality was 30.0% and occurred exclusively in patients older than 60 years. Mortality was significantly higher in KDIGO stage 3 (61.5% vs. 5.9%, p=0.0016). KDIGO stage 3 and age >60 years were strongly associated with death. SPARK showed good discrimination for severe AKI (AUC≈0.78), while APACHE II demonstrated excellent performance for severe AKI and mortality (AUC≈0.97). RRT use was more frequent in advanced AKI stages.

Conclusions: Perioperative AKI was infrequent but severe, with high mortality driven by KDIGO stage 3 and advanced age. SPARK and particularly APACHE II were useful for risk stratification.

Keywords: acute kidney injury, perioperative period, sepsis

Cite this article as: Sekulic A, Marinkovic O, Milic D. Perioperative acute kidney injury after major non-cardiac surgery: risk factors, clinical outcomes, and predictive performance of perioperative scoring systems; Medicinska istraživanja 2026; DOI: 10.5937/medi0-64977

INTRODUCTION

Acute deterioration of previously stable renal function developing over several hours or days is defined as acute kidney injury (AKI), formerly known as acute renal failure (1). According to the KDIGO (Kidney Disease: Improving Global Outcomes) criteria, which are currently used to define AKI, acute kidney injury is characterized by a rapid decline in renal function manifested by an increase in serum creatinine (SCr) or a reduction in urine output (UO). AKI is defined as an increase in SCr of ≥0.3 mg/dL (≥26.5 μmol/L) within 48 hours, or an increase in SCr to ≥1.5 times baseline occurring within the previous seven days, or a urine output of <0.5 mL/kg/h for at least six hours (2).

Postoperative AKI is associated with increased long-term morbidity, mortality, and healthcare costs. Importantly, this association persists even in patients who achieve complete recovery of renal function, as well as in those with mild renal dysfunction that does not meet the diagnostic threshold for AKI. The mechanisms, pathogenesis, and risk factors for postoperative AKI vary considerably depending on the type of surgical procedure and accompanying perioperative risk factors (3). The reported incidence of postoperative AKI reaches up to 40% overall and up to 35% in patients undergoing major abdominal surgery (4).

Postoperative AKI

In surgical populations, AKI is most commonly reported separately for cardiac and non-cardiac procedures. Identified risk factors include advanced age, male sex, increased body mass index, higher ASA physical status, hypertension, diabetes mellitus, prolonged use of ACE inhibitors/ARBs, hypoalbuminemia, impaired pulmonary function, as well as greater surgical complexity, longer operative duration, and significant intraoperative blood loss. AKI is a common postoperative complication across various surgical populations, with an incidence of approximately 25% among cardiac surgery patients, predominantly presenting as mild AKI (KDIGO stage 1). The risk is particularly pronounced in major vascular, thoracic, and transplant surgeries, where the incidence may reach up to 75%, depending on procedural complexity. Following non-cardiac and intra-abdominal surgery, AKI occurs in 4–7% of cases, mostly in milder stages, while significantly higher rates are observed in trauma patients and critically ill individuals (5–7).

Risk factors for postoperative AKI can be grouped into four major categories: patient-related, surgery-related, anesthesia-related, and postoperative factors. Predisposing factors include advanced age, chronic kidney disease, cardiometabolic comorbidities, sepsis, and exposure to nephrotoxic medications. Surgical and anesthetic factors—such as emergency surgery, procedural extent, intraoperative hypotension, blood loss, inadequate volume and hemodynamic management, and vasopressor use—further increase the risk. In the postoperative period, infections, hemodynamic instability, fluid and electrolyte disturbances, and urinary tract obstruction significantly influence the development and severity of AKI (8–11).

Because therapeutic options for postoperative AKI are limited, perioperative management traditionally focuses on prevention and early diagnosis. Key initial steps include identification of prerenal (hypoperfusion), postrenal (obstruction), and intrinsic renal (ischemic or nephrotoxic) causes. KDIGO guidelines emphasize AKI management according to disease severity. In patients with preserved renal function or mild AKI, treatment focuses on rapid identification and avoidance of nephrotoxic insults, along with optimization of intravascular volume and renal perfusion. As AKI severity progresses, associated acid–base and electrolyte disturbances may require targeted therapy, including renal replacement therapy and/or admission to intensive care units in the most severe cases (12,13).

Pathophysiology of acute kidney injury

Acute kidney injury is a heterogeneous clinical syndrome of multifactorial etiology, most commonly involving oxidative and inflammatory stress, renal hypoperfusion, exposure to nephrotoxins, and iatrogenic factors. In the perioperative setting, hemodynamic instability, anemia, venous congestion, and administration of nephrotoxic agents or intravenous contrast contribute to the development of prerenal and intrinsic forms of AKI, particularly acute tubular injury (14).

Sepsis-associated AKI has a distinct pathophysiology characterized by systemic inflammation, microcirculatory dysfunction, and adaptive cellular responses, and is associated with worse outcomes compared with non-septic AKI. Early recognition and timely treatment of sepsis are critical therapeutic measures, while the optimal timing of initiation of renal replacement therapy remains a subject of ongoing debate (15).

Postoperative AKI is strongly associated with increased short- and long-term mortality, particularly following major abdominal and emergency surgical procedures. Even minor increases in serum creatinine are associated with significantly worse outcomes, underscoring the clinical importance of early recognition and prevention of AKI in surgical patients (16,17).

STUDY OBJECTIVES

The primary objective of this study was to analyze the impact of acute kidney injury (AKI) presence and progression, along with associated risk factors, on clinical

outcomes in patients undergoing major non-cardiac surgical procedures.

Specific aims included:

- Identification of risk factors for the development of AKI;
- Evaluation of the impact of AKI on in-hospital mortality, length of stay in the intensive care unit, and the need for renal replacement therapy (RRT);
- Assessment of variables with independent predictive value for the development of sepsis-associated AKI;
- Comparison of outcomes between patients with septic and non-septic AKI.

The clinical relevance of this study lies in the timely identification of patients at increased risk for sepsis-associated AKI and in providing a scientific basis for improving perioperative protocols to reduce the incidence and severity of this condition.

MATERIALS AND METHODS

This study was conducted in the Surgical Intensive Care Unit (ICU II) of the University Hospital Center Bežanijska Kosa in Belgrade as a prospective cohort study involving patients undergoing major non-cardiac surgical procedures who developed perioperative acute kidney injury (AKI).

A total of 30 patients undergoing major non-cardiac surgery were included. Collected data included demographic characteristics (age, sex), type and urgency of surgery (elective/emergency), development of sepsis, need for renal replacement therapy (RRT), length of ICU stay, and final treatment outcome.

Inclusion criteria comprised patients aged ≥18 years of both sexes who underwent major non-cardiac surgery and developed perioperative AKI defined according to KDIGO criteria, required postoperative treatment in the Surgical ICU, and had complete clinical and laboratory data available.

Exclusion criteria included end-stage chronic kidney disease (stage 5), chronic dialysis or kidney transplantation, cardiac surgery, age <18 years, pre-existing AKI before surgery, and incomplete data.

AKI was defined and staged according to KDIGO criteria, while sepsis was defined in accordance with Sepsis-3 criteria as an increase in SOFA score of ≥2 points from baseline. Renal replacement therapy was initiated based on standard clinical indications in patients with severe AKI.

Disease severity was assessed using the APACHE II score, the degree of organ dysfunction using the SOFA score, and preoperative risk for postoperative AKI was evaluated using the SPARK index (Simple Postoperative AKI Risk Score). All scores were calculated using validated tools based on relevant clinical and laboratory parameters.

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the University Hospital Center "Bežanijska Kosa" (approval No. 3442/3; May 10, 2018). Written informed consent was obtained from all patients or their legal representatives before inclusion.

Statistical analysis was performed using MedCalc software (MedCalc Software Ltd., Ostend, Belgium). Continuous variables are presented as median (range), while categorical variables are presented as absolute numbers and percentages. Differences between groups were analyzed using the Mann–Whitney U test. The Cochran–Armitage test for trend was used to assess a linear trend in the association between ordered age groups and the occurrence of severe acute kidney injury (KDIGO stage 3). The discriminatory ability of the SPARK, APACHE II, and SOFA scores for predicting severe AKI (KDIGO stage 3) was evaluated using receiver operating characteristic (ROC) analysis, and the results are expressed as the area under the ROC curve (AUROC).

Given the limited sample size, all analyses were considered exploratory. Statistical significance was set at $p < 0.05$.

RESULTS

Table 1 presents the demographic characteristics of the study population. The study included 30 patients with perioperative acute kidney injury (AKI) who underwent major non-cardiac surgery. There were 19 men (63.3%) and 11 women (36.7%). The majority of patients, both sexes, were in the>60 years age group (60%). The majority of patients belonged to the age group >60 years (60%), indicating that perioperative AKI in our cohort predominantly affected older individuals. The association between sex and age distribution was analyzed using the Mann–Whitney U test. Age distribution did not differ significantly between men and women (Mann–Whitney U test, $p = 0.694$).

Table 1. Distribution of AKI patients by sex and age groups

Age group (years)	Men, n (%)	Women, n (%)	Total, n (%)
<40	1 (5.3)	0 (0.0)	1 (3.3)
41–50	2 (10.5)	1 (9.1)	3 (10.0)
51–60	5 (26.3)	3 (27.3)	8 (26.7)
>60	11 (57.9)	7 (63.6)	18 (60.0)

*Mann–Whitney U test for the association between sex and age groups, $p = 0.694$.

Note: Percentages for men and women are calculated within columns

Table 2 shows patient distribution across SPARK risk categories (A–D). The incidence of postoperative AKI increased progressively with higher SPARK risk. Half of the patients (50.0%) were classified in the very high-risk category (D). The high-risk category (C) included 20.0%

of patients, whereas the low-risk (A) and moderate-risk (B) categories accounted for 16.7% and 13.3% of the study population, respectively.

Table 2. Distribution of patients according to SPARK risk levels

SPARK risk level	Number of patients (n)	Percentage (%)
A (low risk)	5	16.7
B (moderate risk)	4	13.3
C (high risk)	6	20.0
D (very high risk)	15	50.0
Total	30	100

*Data are presented as absolute numbers (n) and percentages (%).

The discriminatory performance of SPARK, APACHE II, and SOFA scores for predicting severe AKI (KDIGO stage 3) was assessed using ROC analysis **(Figure 1)**. SPARK demonstrated good discrimination (AUROC ≈ 0.78), with higher risk categories associated with an increased incidence of KDIGO stage 3. APACHE II demonstrated excellent discrimination (AUROC ≈ 0.97) with an optimal cut-off of ≥25. In contrast, SOFA showed no meaningful discriminatory ability (AUROC = 0.46), with its ROC curve closely following the line of no discrimination. This is consistent with previous findings indicating that the SOFA score better reflects overall organ dysfunction and sepsis severity rather than isolated prediction of severe AKI. ROC analysis was performed to evaluate the predictive performance of the scoring systems.

The distribution of AKI severity according to surgical urgency is presented in **Table 3**. Most patients across all KDIGO categories underwent emergency surgery. Comparison of KDIGO stage distribution between emergency and elective surgery using the Mann–Whitney U test showed no statistically significant difference (U = 73.5, p = 0.956).

Table 3. Distribution of KDIGO stages according to the type of surgery

KDIGO stage	Emergency surgery, n (%)	Elective surgery, n (%)	Total, n (%)
KDIGO 1	7 (87.5)	1 (12.5)	8 (26.7)
KDIGO 2	6 (66.7)	3 (33.3)	9 (30.0)
KDIGO 3	11 (84.6)	2 (15.4)	13 (43.3)
Total	24 (80.0)	6 (20.0)	30 (100)

*Mann–Whitney U test for comparison of KDIGO stage distribution between emergency and elective surgery, p = 0.956
Note: Percentages for emergency and elective surgery are calculated within rows.

In younger age groups (<40 and 41–50 years), AKI was predominantly mild to moderate, whereas increasing age was associated with a progressive rise in the frequency of more severe AKI. The highest number of patients with severe AKI (KDIGO stage 3) was observed in those older than 60 years, indicating that advanced age is an important factor associated with the development of severe acute kidney injury.

To assess the linear trend between age groups and the occurrence of severe AKI, the Cochran–Armitage test for trend was applied. Although an increase in the frequency of severe AKI with increasing patient age was observed,

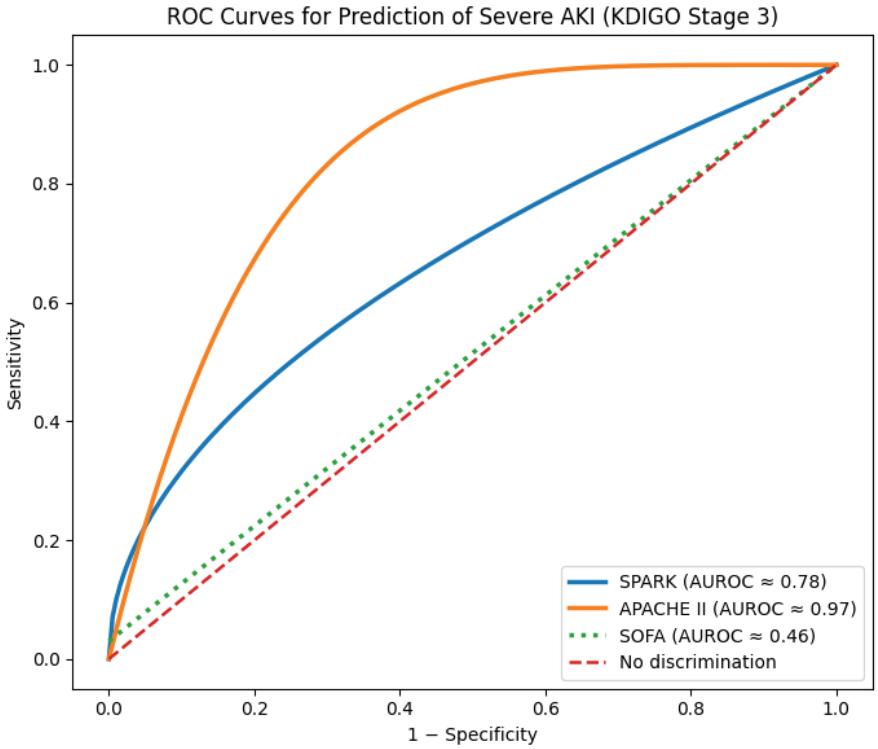

Figure 1. ROC curves of SPARK, APACHE II, and SOFA scores for predicting severe acute kidney injury (KDIGO stage 3). APACHE II showed excellent discrimination (AUROC ≈ 0.97), SPARK demonstrated good discrimination (AUROC ≈ 0.78), while SOFA showed no discriminative ability (AUROC ≈ 0.46). The dashed line indicates no discrimination.

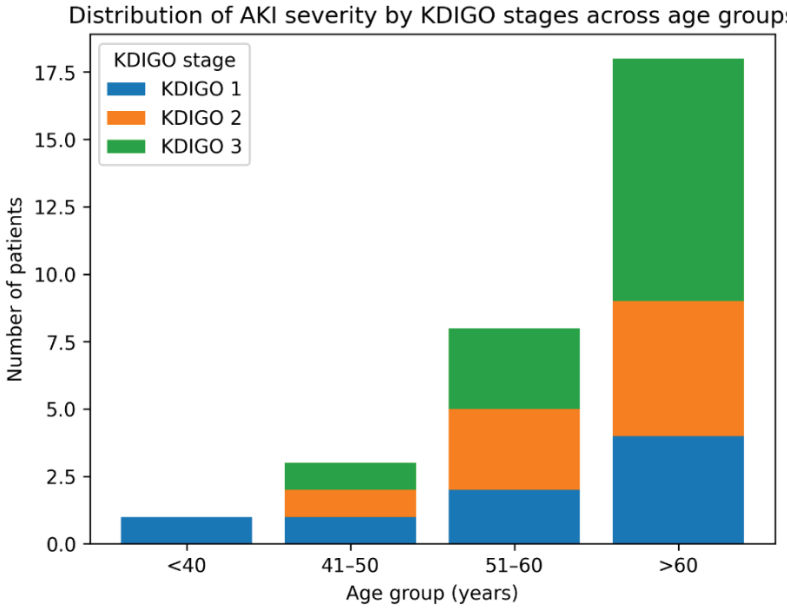

Figure 2 . Distribution of AKI severity by KDIGO stages across age groups
* Cochran–Armitage test to assess the linear trend between age groups and severe AKI, Z = 1.09; p = 0.275

the statistical analysis did not demonstrate a significant linear trend (Z = 1.09; p = 0.275).

The absence of statistical significance is likely attributable to the small overall sample size and the uneven distribution of patients across age categories, particularly in the younger groups. Therefore, these findings should be interpreted as exploratory **(Figure 2)**.

The combined graphical analysis **(Figure 3)** demonstrates a marked increase in mortality with increasing AKI severity, particularly among patients older than 60 years. Across all KDIGO stages, deaths occurred exclusively or predominantly in the older age group, with the highest mortality observed in patients aged >60 years with KDIGO stage 3.

ICU length of stay was expressed as median (range). Survivors had a longer ICU stay compared with non-survivors (9 [1–20] vs 6 [2–10] days), and this difference was statistically significant (Mann–Whitney U test, p = 0.041) **(Table 4)**.

Table 4. ICU length of stay according to outcome

Outcome	n	ICU stay, median (min–max), days	P - value
Survivors	21	9 (1-20)	
Non-survivors	9	6 (2-10)	0.041

*Mann–Whitney U test, p = 0.041
Note: Values are presented as median (min–max).

Continuous renal replacement therapy (RRT) was more frequently used in patients with more severe AKI stages **(Figure 4A)**. However, mortality among patients receiving RRT was similar across KDIGO stages 2 and

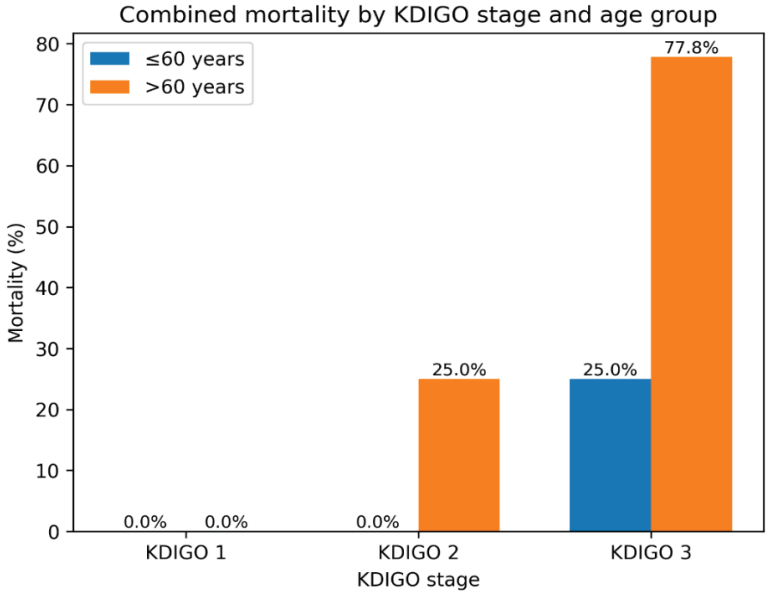

Figure 3. Combined mortality by KDIGO stage and age group

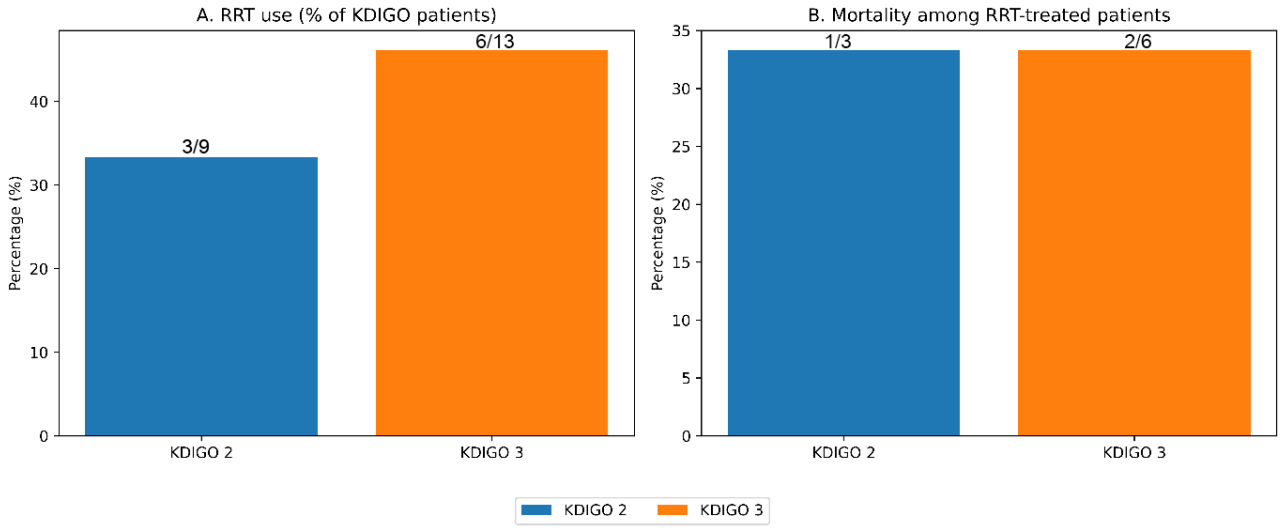

Figure 4. (A) Renal replacement therapy (RRT) utilization according to AKI severity. (B) Mortality among RRT-treated patients by KDIGO stage. RRT use increased with AKI severity, whereas mortality among RRT-treated patients remained identical in KDIGO stage 2 and stage 3 (33.3%).

3, indicating that RRT primarily reflects overall disease severity rather than acting as an independent prognostic factor **(Figure 4B)**. The Cochran–Armitage trend test did not demonstrate a statistically significant trend ($p = 0.410$).

DISCUSSION

Perioperative acute kidney injury (AKI) represents a complex clinical syndrome whose pathogenesis involves hemodynamic disturbances, inflammatory mechanisms, and individual patient vulnerability. This observation is supported by contemporary reviews that emphasize the importance of early identification of high-risk patients and the use of multimodal strategies to prevent AKI (18). In our prospective cohort of patients undergoing major non-cardiac surgical procedures, the incidence of AKI was 4.6%, which is consistent with published data for the general surgical population, where AKI incidence ranges from 1% to 7% depending on the type of surgery and patient comorbidities (15). The high proportion of patients with severe AKI (KDIGO stage 3), accounting for 43.3% of all AKI cases, indicates that the studied population represents a clinically severe and high-risk group.

Our findings highlight a strong relationship between the severity of perioperative AKI and clinical outcomes. Mortality occurred almost exclusively in patients with severe AKI (KDIGO stage 3), whereas patients with mild AKI (KDIGO stage 1) experienced favorable outcomes. These observations are consistent with previous studies and consensus reports demonstrating a clear graded relationship between increasing KDIGO stage and mortality risk (15,16). This relationship underscores the importance of early identification of patients at risk of severe AKI and the implementation of preventive perioperative strategies.

Advanced age emerged as an important factor associated with poorer outcomes. All deaths in our cohort occurred in patients older than 60 years. Although statistical analysis did not demonstrate a significant association between age and AKI severity according to KDIGO stages, a clear trend toward increasing frequency of more severe AKI with advancing age was observed. This is in line with the well-recognized decline in renal functional reserve and increased susceptibility of older patients to perioperative and septic insults (13,16).

The SPARK (Simple Postoperative AKI Risk) score proved to be a useful tool for preoperative identification of patients at increased risk of postoperative AKI. In our study, SPARK demonstrated good discriminatory ability for predicting severe AKI, with a progressive increase in AKI incidence across higher risk categories, consistent with previous validation studies (19,20). However, given the limited sample size, these findings should be interpreted as exploratory.

In contrast to SPARK, the APACHE II score showed excellent discriminatory performance for predicting both mortality and severe AKI. This finding likely reflects the fact that APACHE II integrates multiple parameters of acute organ dysfunction and serves as a marker of overall disease severity rather than isolated renal injury, in accordance with contemporary literature (12,21). Conversely, the SOFA score did not demonstrate significant predictive value for AKI severity in our cohort, which is consistent with its primary role in assessing global organ dysfunction rather than kidney-specific injury (3,13).

Sepsis-associated acute kidney injury (S-AKI) in our study was strongly associated with adverse outcomes. Mortality occurred almost exclusively in patients with severe AKI (KDIGO stage 3), while it was negligible in milder stages. This observation aligns with prior studies reporting substantially higher mortality rates in S-AKI compared with non-septic AKI (22–24).

A substantial proportion of patients with severe AKI required renal replacement therapy (RRT). In our

cohort, RRT was more frequently used in higher AKI stages. However, without a statistically significant linear trend, mortality among RRT-treated patients was similar in KDIGO stages 2 and 3. These findings suggest that RRT primarily reflects the severity of the underlying disease rather than acting as an independent prognostic factor, in agreement with KDIGO and ADQI recommendations (16,25).

Analysis of intensive care unit length of stay revealed that surviving patients had longer ICU stays than non-survivors, a clinically expected finding consistent with previous reports (12). The absence of a clear association between ICU length of stay and AKI severity further underscores the complex interplay between organ dysfunction, therapeutic interventions, and outcomes.

Given the small number of patients and events, all analyses in this study were descriptive and univariate, and the results should be interpreted as observed associations and trends. Nevertheless, the findings provide relevant insights into clinical patterns of AKI severity and outcomes, as well as the performance of prognostic scores in real-world practice. They may serve as a foundation for future, larger-scale studies.

CONCLUSION

Perioperative acute kidney injury following major non-cardiac surgery represents a clinically significant complication. Severe forms of AKI (KDIGO stage 3), particularly in the presence of sepsis and advanced age, were strongly associated with adverse outcomes and increased mortality. In preoperative risk assessment, the SPARK score proved useful for early identification of patients at increased risk for postoperative AKI. In contrast, the APACHE II score demonstrated very good discriminatory performance for predicting mortality and severe AKI. The longer intensive care unit stay observed among survivors likely reflects greater initial disease severity and the need for prolonged supportive therapy rather than the severity of renal injury alone.

Given the limited number of patients and events, the results of this study should be interpreted as exploratory. Nevertheless, they provide a basis for improving perioperative protocols through early identification of high-risk patients, close monitoring, and timely AKI prevention strategies in accordance with KDIGO and ADQI recommendations, as well as for future larger multicenter studies.

Acknowledgment: The authors would like to express their sincere gratitude to the staff of the Department of Anesthesiology and Intensive Care at the University Hospital Medical Center "Bezanijska Kosa", Belgrade, Serbia, where this study was conducted. We particularly acknowledge the physicians, nurses, and all healthcare professionals whose dedicated clinical work and support enabled the collection of data and the successful completion of this research.

Funding information: The authors declare that the study received no funding.

Conflicts of interest: The authors have no conflicts of interest to report in the respective section.

Author contributions: Conceptualization, A.S. and O.M.; Methodology, A.S.; Software, D.M.; Validation, A.S., O.M. and D.M.; Formal Analysis, A.S.; Investigation, A.S. and O.M.; Data Curation, A.S. and D.M.; Writing – Original Draft Preparation, A.S.; Writing – Review & Editing, O.M.; Visualization, D.M.; Supervision, O.M.; Project Administration, A.S.

Ethical approval: The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the University Hospital Center "Bezanijska Kosa" (approval No. 3442/3; May 10, 2018). Written informed consent was obtained from all patients or their legal representatives before inclusion.

REFERENCES

1. Goyal A, Daneshpajouhnejad P, Hashmi MF, Bashir K, John BK. Acute Kidney Injury (Nursing). 2023 Nov 25. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan.
2. Khwaja A. KDIGO clinical practice guidelines for acute kidney injury. Nephron Clin Pract. 2012;120(4):c179-84. doi: 10.1159/000339789. Epub 2012 Aug 7.
3. Ostermann M, Bellomo R, Burdmann EA, Doi K, Endre ZH, Goldstein SL, et al. Conference Participants. Controversies in acute kidney injury: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Conference. Kidney Int. 2020 Aug;98(2):294-309. doi: 10.1016/j.kint.2020.04.020.
4. Gameiro J, Fonseca JA, Neves M, Jorge S, Lopes JA. Acute kidney injury in major abdominal surgery: incidence, risk factors, pathogenesis and outcomes. Ann Intensive Care. 2018 Feb 9;8(1):22. doi: 10.1186/s13613-018-0369-7.
5. Lei SH, Guo GF, Yan T, Zhao BC, Qiu SD, Liu KX. Acute Kidney Injury After General Thoracic Surgery: A Systematic Review and Meta-analysis. J Surg Res. 2023 Jul;287:72-81. doi: 10.1016/j.jss.2023.01.011.
6. Berkowitz RJ, Engoren MC, Mentz G, Sharma P, Kumar SS, Davis R, et al. Intraoperative risk factors of acute kidney injury following liver transplantation. Liver Transpl. 2022 Aug;28(8):1399-1400. doi: 10.1002/lt.26477.
7. Haines RW, Lin SP, Hewson R, Kirwan CJ, Torrance HD, O'Dwyer MJ, et al. Acute Kidney Injury in Trauma Patients Admitted to Critical Care: Development and Validation of a Diagnostic Prediction Model. Sci Rep. 2018 Feb 26;8(1):3665. doi: 10.1038/s41598-018-21929-2.
8. Hobson C, Ozrazgat-Baslanti T, Kuxhausen A, Thottakkara P, Efron PA, Moore FA, et al. Cost and Mortality Associated With Postoperative Acute Kidney Injury. Ann Surg. 2015 Jun;261(6):1207-14. doi: 10.1097/SLA.0000000000000732.
9. O'Connor ME, Kirwan CJ, Pearse RM, Prowle JR. Incidence and associations of acute kidney injury after major abdominal surgery.

Intensive Care Med. 2016 Apr;42(4):521-530. doi: 10.1007/s00134-015-4157-7.

10. Tang Y, Zhu C, Liu J, Wang A, Duan K, Li B, et al. Association of Intraoperative Hypotension with Acute Kidney Injury after Noncardiac Surgery in Patients Younger than 60 Years Old. Kidney Blood Press Res. 2019;44(2):211-221. doi: 10.1159/000498990.
11. Walsh M, Devereaux PJ, Garg AX, Kurz A, Turan A, Rodseth RN, et al. Relationship between Intraoperative Mean Arterial Pressure and Clinical Outcomes after Noncardiac Surgery: Toward an Empirical Definition of Hypotension. Anesthesiology 119 (2013): 507–515. doi:10.1097/ALN.0b013e3182a10e26.
12. Li S, Wang S, Priyanka P, Kellum JA. Acute Kidney Injury in Critically Ill Patients After Noncardiac Major Surgery: Early Versus Late Onset. Crit Care Med. 2019 Jun;47(6):e437-e444. doi: 10.1097/CCM.0000000000003710.
13. Prowle JR, Forni LG, Bell M, Chew MS, Edwards M, Grams ME, et al. Postoperative acute kidney injury in adult non-cardiac surgery: joint consensus report of the Acute Disease Quality Initiative and PeriOperative Quality Initiative. Nat Rev Nephrol. 2021 Sep;17(9):605-618. doi: 10.1038/s41581-021-00418-2.
14. Basile DP, Anderson MD, Sutton TA. Pathophysiology of acute kidney injury. Compr Physiol. 2012 Apr;2(2):1303-53. doi: 10.1002/cphy.c110041.
15. Mikkelsen TB, Schack A, Oreskov JO, et al. Acute kidney injury following major emergency abdominal surgery. BMC Nephrol. 2022;23:94. doi:10.1186/s12882-022-02708-8.
16. Zarbock A, Koyner JL, Gomez H, Pickkers P, Forni L; Acute Disease Quality Initiative group. Sepsis-associated acute kidney injury-treatment standard. Nephrol Dial Transplant. 2023 Dec 20;39(1):26-35. doi: 10.1093/ndt/gfad142.
17. Xu L, Tang L, Zheng X, Yang L. A mild increase in serum creatinine after surgery is associated with increased mortality. J Clin Med. 2024;13(16):4905. doi:10.3390/jcm13164905.
18. Douville NJ, Mathis M, Kheterpal S, Heung M, Schaub J, Naik A, Kretzler M. Perioperative Acute Kidney Injury: Diagnosis, Prediction, Prevention, and Treatment. Anesthesiology. 2025 Jan 1;142(1):180-201. doi: 10.1097/ALN.0000000000005215.
19. Park S, Cho H, Park S, Lee S, Kim K, Yoon HJ, et al. Simple Postoperative AKI Risk (SPARK) Classification before Noncardiac Surgery: A Prediction Index Development Study with External Validation. J Am Soc Nephrol. 2019 Jan;30(1):170-181. doi: 10.1681/ASN.2018070757. Epub 2018 Dec 18.
20. Nan L, Jinwei W, Weijie Z, Shuangling L, Li Y. External Validation of the Simple Postoperative Acute Kidney Injury Risk Index in Patients Admitted to the Intensive Care Unit After Noncardiac Surgery. Anesthesia & Analgesia 140(5):p 1140-1148, May 2025. doi: 10.1213/ANE.0000000000007320
21. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med. 1985;13(10):818–829. doi:10.1097/00003246-198510000-00009.
22. Alobaidi R, Basu RK, Goldstein SL, Bagshaw SM. Sepsis-associated acute kidney injury. Semin Nephrol. 2015;35(1):2–11. doi:10.1016/j.semnephrol.2015.01.002.
23. Kellum JA, Sileanu FE, Bihorac A, Hoste EA, Chawla LS. Recovery after Acute Kidney Injury. Am J Respir Crit Care Med. 2017 Mar 15;195(6):784-791. doi: 10.1164/rccm.201604-0799OC.
24. Bagshaw SM, George C, Bellomo R; ANZICS Database Management Committee. Early acute kidney injury and sepsis: a multicentre evaluation. Crit Care. 2008;12(2):R47. doi: 10.1186/cc6863.
25. Christie E, Pannu N. Dialysis and acute kidney injury: current evidence. Semin Dial. 2014 Mar;27(2):154-9. doi: 10.1111/sdi.12186.

PERIOPERATIVNO AKUTNO OŠTEĆENJE BUBREGA NAKON VELIKIH NEKARDIOHIRURŠKIH OPERACIJA: FAKTORI RIZIKA, KLINIČKI ISHOD I PREDIKTIVNA VREDNOST PERIOPERATIVNIH NUMERIČKO BODOVNIH SISTEMA

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Sažetak

Uvod: Perioperativno akutno bubrežno oštećenje (AKI) predstavlja ozbiljnu komplikaciju nakon velikih nekardiohirurških operacija, povezanu sa povećanim mortalitetom, produženim boravkom u jedinici intenzivne nege i potrebom za renalnom supstitucionom terapijom (RRT).

Cilj: Procena uticaja težine AKI i pridruženih faktora rizika na kliničke ishode nakon velikih abdominalnih hirurških intervencija, kao i evaluacija prognostičke vrednosti SPARK, APACHE II i SOFA skorova.

Materijal i metode: Prospektivna kohortna studija sprovedena je u Hirurškoj jedinici intenzivne nege Kliničko-bolničkog centra „Bežanijska Kosa" (Beograd) od januara do juna 2024. godine. Analizirano je 30 odraslih bolesnika sa perioperativnim AKI nakon velikih abdominalnih operacija. AKI je definisan prema KDIGO kriterijumima, a sepsa prema Sepsis-3 definiciji. Težina bolesti procenjivana je APACHE II i SOFA skorovima, dok je preoperativni rizik za AKI procenjivan SPARK indeksom.

Rezultati: Prema KDIGO klasifikaciji, 26,7% bolesnika bilo je u stadijumu 1, 30,0% u stadijumu 2, a 43,3% u stadijumu 3. Intrahospitalni mortalitet iznosio je 30,0% i registrovan je isključivo kod bolesnika starijih od 60 godina. Mortalitet je bio značajno viši u KDIGO stadijumu 3 u odnosu na stadijume 1–2 (61,5% prema 5,9%; p=0,0016). SPARK je pokazao dobru diskriminativnu sposobnost za teški AKI, dok je APACHE II imao odličnu prognostičku vrednost za teški AKI i mortalitet. RRT je češće primenjivana u uznapredovalim stadijumima AKI.

Zaključak: Perioperativni AKI bio je redak, ali klinički težak, sa nepovoljnim ishodima prvenstveno povezanim sa KDIGO stadijumom 3 i starijom životnom dobi. SPARK i naročito APACHE II korisni su za stratifikaciju rizika.

Ključne reči: akutno bubrežno oštećenje, perioperativni period, sepsa

Primljen: 15.02.2026. I **Revidiran:** 11.04.2026. I **Prihvaćen:** 20.04.2026. I **Online First:** 23.04.2026.

Medicinska istraživanja 2026