PROGNOSTIC VALUE OF URINARY ALBUMIN-TO-CREATININE RATIO IN A SURGICAL PRACTICE

DOI: 10.35805/BSK2025II005

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recieved: 02.06.2025
accepted: 10.06.2025

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Conflict of interest:
The authors declare no conflict of interest.

Keywords:
albumin-to-creatinine ratio, UACR, surgery, urine, proteinuria, correlation, cardiovascular risk, postoperative complications, abdominal operations.

Abstract

Background. The urinary albumin-to-creatinine ratio is a well-established marker of early kidney damage, endothelial dysfunction, and systemic inflammation. Elevated urinary albumin-to-creatinine ratio levels are linked to increased cardiovascular risk and mortality. During surgical stress, urinary albumin-to-creatinine ratio may reflect vascular and inflammatory changes, yet its prognostic value in surgical patients remains insufficiently studied. Objective: To assess the prognostic significance of urinary albumin-to-creatinine ratio in patients undergoing surgical interventions.

Materials and Methods. A retrospective analysis included 171 patients (98 men, 73 women) aged 40–70 years who underwent various surgeries at the National Scientific Center of Surgery named after A.N. Syzganov from March 2022 to March 2025. Random morning urine samples were analyzed for albumin and creatinine, and urinary albumin-to-creatinine ratio was calculated. Measurements were performed using Cobas 303 and 311 analyzers (Roche Diagnostics).

Results. The mean age was 53.2 years. Mean urinary creatinine and albumin were 186.67 mmol/L and 243.73 mg/L, with median values of 9.62 mmol/L and 14.7 mg/L, respectively. Median urinary albumin-to-creatinine ratio was 1.72 mg/mmol; mean was 39.72 mg/mmol, indicating skewness. No significant correlation was found between albumin and creatinine ($\rho = -0.037$; $p = 0.631$). A moderate, non-significant inverse correlation was observed in the high-level subgroup ($n = 6$).

Conclusion. Although overall correlations were not significant, findings suggest that urinary albumin-to-creatinine ratio may have prognostic potential. Further prospective studies are needed, especially in abdominal surgery settings.

Introduction

The urinary albumin-to-creatinine ratio (UACR) is currently recognized as a clinically significant qualitative and quantitative marker of proteinuria, capable of replacing the traditional 24-hour urine protein measurement.[1,2] UACR is widely utilized as a sensitive, non-invasive, and reproducible method for assessing renal function as well as the vascular and inflammatory status of the patient.

Numerous large-scale epidemiological studies have demonstrated that elevated urinary albumin levels are independently associated with an increased risk of cardiovascular mortality, particularly among patients with diabetes mellitus, arterial hypertension, and established cardiovascular disease.[3,4,5] However, the role of UACR as a marker of all-cause mortality risk in the general population, especially among clinically healthy individuals with UACR levels below 30 mg/g, remains controversial.[6] Moreover, the degree of association between albuminuria and all-cause mortality has not yet been thoroughly studied, especially in large prospective cohort investigations.[7,8,9]

The currently available evidence is largely limited to retrospective analyses, small sample sizes, or narrowly defined cohorts with significant comorbidities (e.g., diabetes, hypertension), which reduces the generalizability of these findings to broader clinical populations.[9,10,11,12]

UACR has demonstrated high clinical and prognostic value due to its ability to detect microalbuminuria, considered an early marker of endothelial dysfunction and systemic inflammation. Unlike absolute urinary albumin concentration, which can fluctuate depending on hydration status and urine output, the albumin-to-creatinine ratio helps normalize these variables, providing a more stable and reproducible assessment of proteinuria. This is particularly relevant in outpatient clinical settings and large-scale epidemiological studies.[13,14,15]

Of particular interest is the evaluation of UACR in patients undergoing surgical procedures. Surgical trauma and perioperative stress trigger inflammatory cascades and increase vascular permeability, potentially leading to transient or persistent albuminuria. The presence of microalbuminuria in this patient category is associated with a higher risk of myocardial infarction, stroke, acute kidney injury (AKI), and postoperative mortality. The greatest clinical significance is observed in elderly patients, those with diabetes mellitus, chronic kidney disease, and individuals undergoing cardiac or abdominal surgeries.[16,17,18]

Given these findings and the persisting lack of data on the prognostic value of UACR in predicting postoperative complications in real-world clinical settings—particularly in surgical hospitals—we considered it appropriate to conduct a study aimed at evaluating the prognostic value of urinary albumin-to-creatinine ratio in surgical patients within our institution.

Objective: To evaluate the prognostic significance of UACR in patients undergoing surgical interventions.

Materials and Methods

This study represents a retrospective analysis of archival patient data collected between March 2022 and March 2025 at the surgical clinic of the Joint Stock Company "National Scientific Center of Surgery named after A.N. Syzganov" (NSCS). All included patients underwent various surgical interventions. The study included individuals aged 40 to 70 years who had both urinary albumin and creatinine levels measured, allowing for the calculation of the urinary albumin-to-creatinine ratio (UACR).

From the initial sample, 203 participants were excluded due to incomplete data—specifically, in cases where only one of the two required indicators was available: urinary albumin (n = 87) or urinary creatinine (n = 116). To ensure the accuracy and consistency of the analysis, only patients with simultaneous measurements of both parameters were included, allowing precise calculation of UACR. As a result, data from 171 patients (98 men and 73 women) were included in the final analysis (Figure 1).

Laboratory tests were performed in the clinical diagnostic laboratory using automated biochemical analyzers Cobas 303 and Cobas 311 (Roche Diagnostics, Switzerland), which provide high precision and reproducibility of results. Concentrations of albumin (mg/L) and creatinine (mmol/L) were measured in random morning urine samples. The UACR was calculated as the ratio of albumin to creatinine in the same urine specimen.

According to established diagnostic criteria, microalbuminuria was defined as UACR < 30 mg/g, and macroalbuminuria as UACR between 30 and 300 mg/g. The intra- and inter-laboratory coefficients of variation were 1.2% and 1.3% for urinary albumin, and 0.9% and 1.5% for urinary creatinine, respectively.

Inclusion criteria:

- Hospitalization in the surgical clinic of JSC "NSCS named after A.N. Syzganov";
- Availability of laboratory test results for urinary albumin and creatinine;
- Timeframe: March 2022 – March 2025;
- Underwent various surgical interventions;
- Complete data available for UACR calculation.

Exclusion criteria:

- Patients with acute infectious diseases;

- Patients with severe autoimmune disorders that may affect protein metabolism;
- Absence of either albumin or creatinine measurement in urine.

A total of 171 patients who met the inclusion criteria were analyzed. Among them, 98 (57.3%) were male and 73 (42.7%) were female. The mean age of the participants was 53.2 years, with a slightly higher average age among men. The distribution of mean age by sex is shown in Figure 1.

Ethics approval. The study protocol was approved by the Local Ethics Committee of JSC "NSCS named after A.N. Syzganov" (Approval No. 2, dated 27.11.2024).

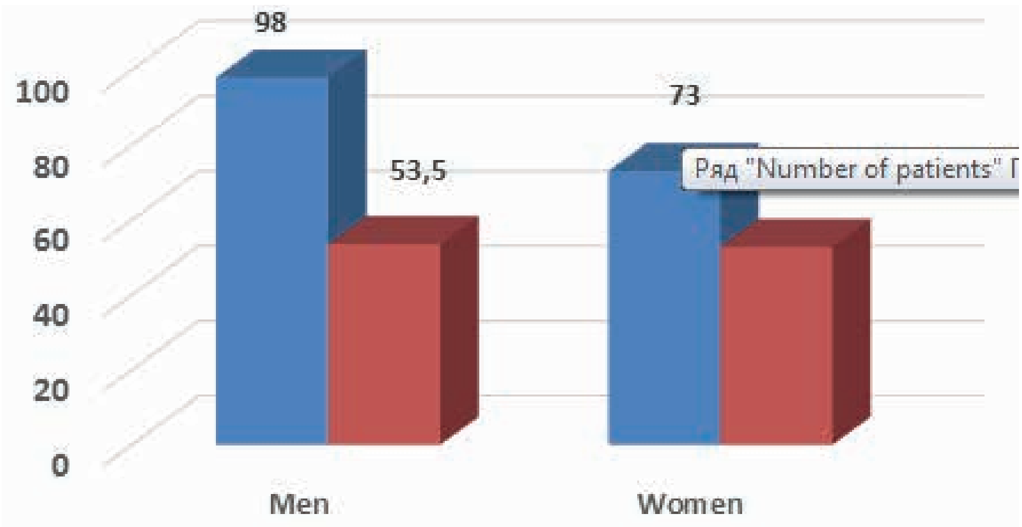
Statistical analysis. To assess the relationship between urinary albumin and creatinine levels, Spearman's correlation coefficient (ρ) was applied, accounting for potential non-normal data distribution. In addition, a stratified analysis was performed by dividing the cohort into subgroups according to clinically justified or empirically derived cutoff values for the studied indicators (low, medium, high). Within each subgroup, separate correlation analysis was carried out between albumin and creatinine levels.Statistical significance was set at $p < 0.05$. All statistical calculations were performed using IBM SPSS Statistics software, version 26.0.

Results

The study included data from 171 patients who met the selection criteria. Of these, 98 (57.3%) were men and 73 (42.7%) were women.

The average age of all participants was 53.2 years. The average age of men was slightly higher than that of women. The distribution of average age by gender is shown in Figure 1.

Figure 1.
Mean age of patients included in the study, stratified by sex (n = 171)



To assess kidney function and the potential risk of cardiovascular complications, three key laboratory parameters were analyzed:
– urinary creatinine concentration,
– urinary albumin concentration,
– and the albumin-to-creatinine ratio (UACR).

Prior to conducting correlation analysis, a summary table of the quantitative characteristics of these indicators was compiled, including mean values, standard deviations, medians, and interquartile ranges, (Table 1).

Table 1.
Comparison of laboratory parameters with reference values in patients (n = 171)

Indicators	**Reference Values**	Mean Value	**Standard Deviation**	**Median in Sample**
Creatinine (mmol/L)	4.4-17.7	186.67	186.67	9.62
Albumin (mg/L)	2-30	243.73	243.73	14.7
UACR (mg/mmol)	>30	39.72	39.72	1.72

Data analysis revealed that the mean values of all three indicators—particularly urinary creatinine and UACR—substantially exceeded the established reference ranges. However, the median values demonstrated the opposite trend:

most patients had values within normal limits, indicating a skewed distribution with the presence of isolated outliers. This highlights the importance of using medians and percentiles for more accurate assessment of patient status.

For better visualization, the obtained values were compared with established reference thresholds.

As shown in the table, urinary creatinine exhibited a wide range of values: the mean concentration was 186.67 mmol/L, with significant variability (ranging from 0.16 to 17,976.0 mmol/L), resulting in a high standard deviation (1649.44). In contrast, the median value was only 9.62 mmol/L, and the interquartile range extended from 5.64 to 15.23 mmol/L, indicating a skewed distribution with pronounced outliers.

Urinary albumin levels ranged from 0.5 to 10,567.3 mg/L. The mean concentration was 243.73 mg/L, the median was 14.7 mg/L, and the standard deviation was 916.98, also suggesting the presence of patients with marked albuminuria.

The albumin-to-creatinine ratio (UACR), a more stable indicator of protein excretion, had a median value of 1.72 mg/mmol, while the mean was 39.72 mg/mmol. The range extended from 0.00 to 1330.89 mg/mmol, reflecting a considerable number of patients with subclinical or overt proteinuria.

Given the high variability in the data, Spearman's correlation analysis was performed to assess the relationship between urinary creatinine and albumin levels. The results are presented in Table 2.

Table 2.
Spearman correlation analysis between urinary creatinine and albumin levels

Indicators	Values	Creatinine	Albumin
Creatinine	Correlation Coefficient	1.000	-0.037
	Two-Tailed Significance (p-value)		0.631
	N	171	171
Albumin	Correlation Coefficient	-0.037	1.000
	Two-Tailed Significance (p-value)	0.631	-
	N	171	171

According to the data presented in Table 2, the results of the correlation analysis did not reveal a statistically significant relationship between urinary creatinine and albumin levels in the overall sample: Spearman's correlation coefficient was $\rho = -0.037$, with a p-value of 0.631 ($n = 171$). This indicates the absence of a reliable association between the studied parameters in the population of surgical patients.

At the same time, considering the presence of a distinct subgroup of patients with markedly elevated levels of both creatinine and albumin in urine, an additional Spearman correlation analysis was performed within this subgroup ($n = 6$), (Table 3).

Table 3.
Spearman Correlation Analysis between Urinary Creatinine and Albumin Levels in the High-Level Subgroup

High Urinary	Values	High Urinary	
		Creatinine Level	Albumin Level
Creatinine Level	Correlation Coefficient	1.000	-0.371
	Two-Tailed Significance, (p value)		0.468
	N	25	6
Albumin Level	Correlation Coefficient	-0.371	1.000
	Two-Tailed Significance, (p value)	0.468	-
	N	6	53

The analysis revealed a moderate negative correlation between the parameters ($\rho = -0.371$); however, this result did not reach statistical significance ($p = 0.468$), likely due to the small sample size. Nonetheless, the findings may indicate a potential trend that warrants further investigation in a larger cohort.

Table 4.
Spearman Correlation Analysis Between Urinary Creatinine and Albumin Levels in the Medium-Level Subgroup

Medium Urinary	Values	Medium Urinary	
		Creatinine Level	Albumin Level
Creatinine Level	Correlation Coefficient	1.000	-
	Two-Tailed Significance (p-value)	-	-
	N	11	0
Albumin Level	Correlation Coefficient	-	1.000
	Two-Tailed Significance (p-value)	-	-
	N	0	53

As shown in Table 4, in the subgroup of patients with urinary creatinine and albumin levels corresponding to the median values of the overall sample, it was not possible to perform a correlation analysis due to the absence of paired observations (n = 0), which are required to calculate Spearman's correlation coefficient. This limits the ability to statistically assess the relationship between these parameters in this patient category. Spearman's correlation analysis between creatinine and albumin levels in urine in the low-level subgroup is presented in Table 5.

Table 5.
Spearman correlation analysis between urinary creatinine and albumin levels in the low-level subgroup

Low Urinary	Values	Low Urinary	
		Creatinine Level	Albumin Level
Creatinine Level	Correlation Coefficient	1.000	-
	Two-Tailed Significance (p-value)	-	-
	N	13	0
Albumin Level	Correlation Coefficient	-	1.000
	Two-Tailed Significance (p-value)	-	-
	N	0	5

In the subgroup of patients with low urinary creatinine and albumin levels, correlation analysis was not performed due to the absence of paired observations (n = 0), which are necessary for calculating Spearman's correlation coefficient. This prevents the assessment of the relationship between the parameters in this patient category.

To further explore the association between urinary creatinine and albumin concentrations, a stratified analysis was conducted across patient subgroups based on the levels of these parameters—high, medium, and low. The results are presented in Table 6.

Table 6.
Correlation analysis among patient subgroups based on urinary creatinine and albumin levels

Groups	Correlation Coefficient (ρ)	p-value	Interpretation
High levels	−0.371	0.468	Moderate correlation, but not statistically significant
Medium levels	—	—	Correlation not possible: no paired observations
Low levels	—	—	Correlation not possible: no paired observations

In the subgroup of patients with high urinary creatinine and albumin levels (n = 6), a moderate negative correlation between the indicators was identified ($\rho = -0.371$). However, this result did not reach statistical significance ($p = 0.468$), likely due to the limited sample size. Nevertheless, the observed trend may suggest a potential inverse relationship between albumin and creatinine levels in cases of marked proteinuria, warranting further investigation in a larger cohort.

In the subgroups with medium and low levels of both parameters, correlation analysis was not performed, as there were no cases in which both albumin and creatinine values simultaneously fell within the corresponding range. Thus, paired observations (n = 0) were lacking, rendering statistical analysis unfeasible for these groups.

Therefore, an interpretation of the relationship between albumin and creatinine is only applicable in the high-value subgroup, where a non-significant tendency toward inverse correlation was observed. For the other categories, the absence of data precluded meaningful analysis.

Discussion

This study did not identify a statistically significant association between urinary albumin and creatinine levels in surgical patients. In the overall sample, Spearman's correlation coefficient was $\rho = -0.037$ ($p = 0.631$). A moderate negative association was observed only in the subgroup with high values of both markers ($\rho = -0.371$; $p = 0.468$), though it also lacked statistical significance. In the medium and low-level subgroups, the analysis was not feasible due to the absence of paired observations.

Nonetheless, several clinically noteworthy cases were identified, including elevated urinary albumin with normal or low urinary creatinine levels, which may indicate early glomerular injury. This observation requires further evaluation and could serve as a reference point for monitoring postoperative complications.[19,20]

Recent scientific literature increasingly considers UACR a sensitive and universal biomarker of inflammation, vascular dysfunction, and organ damage, even in patients without manifest chronic kidney disease (CKD). A number of studies confirm its prognostic value in various clinical contexts.[5,21]

For instance, in a prospective study by *Zhang et al.*, elevated UACR was associated with increased all-cause mortality in elderly patients—even within the normal range of albuminuria.[3] Similarly, *Lees et al.* demonstrated that UACR reliably predicted cardiovascular complications and end-stage renal disease, independent of glomerular filtration rate.[22] *Ohkuma et al.* also found that the combination of elevated UACR and reduced eGFR significantly increased the risk of adverse outcomes in CKD patients.[1]

In surgical practice, UACR is gaining attention as a possible predictor of complications. *Guan et al.* found that among elderly patients undergoing elective non-cardiac surgery, elevated UACR was associated with postoperative delirium, highlighting its relevance to vascular and cognitive status.[17] Several studies have identified UACR as an independent prognostic marker in critically ill and septic patients, including pediatric ICU settings.[16,23]

UACR is also significant in kidney transplantation. *Li Chih-Te et al.* found that UACR in the early post-transplant period predicted graft function.[24] Likewise, *Zhao Wenyana et al.* reported that an increase in proteinuria, including UACR, after acute rejection correlated with reduced graft function and survival.[25]

Einafshar et al. also showed that metabolic and bariatric surgery may positively influence UACR in patients with diabetic nephropathy, acting as a risk-modifying factor.[18]

In contrast to these findings, our study did not confirm the prognostic value of UACR. Possible reasons include:

- the retrospective design and lack of clinical outcome tracking (mortality, AKI, cardiovascular events);
- heterogeneity of surgical procedures (abdominal, vascular, oncological, emergency);
- small sample sizes in stratified subgroups;
- unaccounted factors such as infusion volume, medications, hydration status, or baseline kidney function.

It is also worth noting that the significant physiological variability of urinary creatinine reduces the reliability of absolute values and makes the albumin-to-creatinine ratio (UACR) a more stable and clinically useful parameter. However, to ensure accurate interpretation, UACR should be monitored dynamically and assessed alongside other clinical and laboratory findings, especially in surgical patients.

Limitations. The study had a retrospective design and did not include data on clinical outcomes, which limits the ability to assess the prognostic significance of UACR. High variability of indicators, heterogeneity of surgical interventions, and insufficient power in stratified subgroups are also noted.

What's known? UACR is recognised

as a stable marker of vascular and renal damage and is used to diagnose microalbuminuria and predict cardiovascular complications and CKD.

What's new? For the first time, UACR analysis was performed in surgical patients in Kazakhstan. Significant fluctuations in the indicator and a lack of correlation between albumin and creatinine were identified, which highlights the need for stratified studies.

Conclusion. This study did not identify a statistically significant relationship between urinary albumin and creatinine concentrations in surgical patients. Despite this, the observations in the subgroup with elevated values, combined with supporting international data, suggest that UACR may have potential prognostic value. Further prospective studies are needed that incorporate surgical type, clinical outcomes, and UACR dynamics—particularly in patients undergoing abdominal surgery or at risk for postoperative cognitive and vascular complications.

Acknowledgments. The authors express their sincere gratitude to the management of the Syzganov National Scientific Center of Surgery for their support in organizing the study. Special thanks go to the staff of the clinical diagnostic laboratory for conducting high-precision laboratory analyses, as well as to the specialists of the statistics department for their assistance in processing and interpreting the data.

Authors' Contributions. Development of the concept and design of the study, control of the stages of implementation, approval of the final version of the article: A.A., I.N., Y.S., S.A.: Collection and preparation of clinical and laboratory data, verification of results: A.A., A.G., O.S., B.A.; Statistical processing and interpretation of data: A.A., I.N., O.S., S.A.; Writing the main text of the article (introduction, discussion, conclusion): A.G., A.T.; Writing sections of the article (materials and methods, results): A.A., I.N., Y.S., S.A. All authors participated in reviewing, editing, and approving the final version of the manuscript.

Funding. None.

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