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SuPAR, an emerging biomarker in acute kidney injury in ICU patients

Shaimaa Abdelfattah AbdelSalam [1, *], Mostafa Elnakib [1], Osama Ibrahim Azab [1], Osama Ibrahim Azab [1], Mohamed A. Nasr-Eldin [1, 3, 4] and Amany M Tawfeik [2]

[1] *Military Medical Academy.*
[2] *Department of microbiology and Immunology, Faculty of Medicine, Al-Azhar university, girls.*
[3] *R & D Consultant for Armed Forces Pharmaceutical Factory.*
[4] *R & D Consultant for PANAX Pharma - Egyptian Pharmaceutical Company.*

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Abstract

Acute kidney injury (AKI) is a critical condition with delayed diagnosis when relying solely on plasma creatinine levels. This study investigates the role of soluble urokinase plasminogen activator receptor (SuPAR) as a biomarker for early prediction of AKI in ICU patients. Results from a prospective observational study of 30 patients indicate that elevated SuPAR levels at 24- and 48-hours post-ICU admission strongly correlate with the incidence of AKI, demonstrating superior predictive power compared to traditional markers. These findings suggest that SuPAR measurements could be instrumental in the early detection and management of AKI, potentially improving patient outcomes. The mean age of participants was 51.13 ± 5.61 years; 60% were male. Hypertension (HTN) was the most prevalent comorbidity (43.3%), and the mortality rate was 30% in the entire cohort. No significant differences in age, gender, or medical history were found between AKI and control groups. SuPAR levels were significantly elevated in the AKI group across all time points. At 48 hours, AKI cases had SuPAR levels of 7.25 ng/dL compared to 5.3 ng/dL in controls ($p < 0.001$). A strong positive correlation was observed between suPAR levels and serum creatinine at 24 hours ($r = 0.62$, $p < 0.001$) and 48 hours ($r = 0.678$, $p < 0.001$). suPAR showed potential as a predictive biomarker for AKI progression. Mortality was higher in the AKI group (45.45%) compared to controls (21.05%), but the difference was not statistically significant ($p = 0.225$). The BUN increased from 8.49 mmol/L at 12 hours to 9.21 mmol/L at 48 hours. Serum suPAR levels rose from 5.14 ng/dL to 6.01 ng/dL during the 48-hour interval. No significant differences were identified between the control and AKI groups for age, gender, or medical history. No significant difference was seen between the groups concerning TLC and PLT levels at different time periods. BUN levels were markedly elevated in the AKI group relative to the control group at all time intervals, with the most pronounced disparity after 48 hours (10.93 vs. 8.21 mmol/L), yielding p-values of 0.007, 0.006, and 0.005 after 12, 24, and 48 hours, respectively. Serum creatinine levels were markedly elevated in the AKI group relative to controls at all time intervals. At 12 hours, creatinine levels in the AKI group were 1.22 mg/dL, but in the control group they were 0.85 mg/dL ($p<0.001$). suPAR levels were markedly increased in AKI sufferers relative to controls at all time intervals. At 12 hours, AKI cases exhibited suPAR levels of 5.67 ng/dL compared to 4.84 ng/dL in controls (p-value = 0.008). The disparity escalated after 48 hours, with AKI cases exhibiting 7.25 ng/dL in contrast to 5.3 ng/dL in controls (p-value <0.001).

Keywords: SuPAR; Acute kidney injury (AKI); Serum creatinine; ICU patients

1. Introduction

Acute kidney injury (AKI), formerly known as acute renal failure, is characterized by a swift and frequently reversible decline in kidney function. The condition emerges from prerenal, intrarenal, or postrenal factors, and accurate diagnosis and management can greatly enhance patient outcomes *(Goyal et al., 2023)*. Acute kidney injury (AKI) continues to be a

* Corresponding author: Shaimaa Abdelfattah AbdelSalam

significant clinical challenge, especially in intensive care units (ICUs), where critically ill patients frequently experience this condition. Acute kidney injury, marked by a rapid deterioration in kidney function, is linked to heightened rates of mortality and morbidity, while also placing considerable strain on healthcare systems globally. The timely diagnosis and proficient management of AKI are crucial for enhancing patient outcomes; however, the quest for dependable biomarkers capable of forecasting the onset and severity of AKI has been a formidable challenge. In the pursuit of improved biomarkers, soluble urokinase plasminogen activator receptor (suPAR) has surfaced as a noteworthy instrument *(Abd ElHafeez et al., 2017)*. This essay examines the significance of suPAR as a novel biomarker in acute kidney injury among intensive care unit patients, focusing on its pathophysiological implications, diagnostic and prognostic importance, and its potential to transform kidney management into critical care environments.

1.1. Acute Kidney Injury in ICU Patients: A Growing Concern

Acute Kidney Injury (AKI) is a multifactorial illness characterized by complicated etiologies such as hypoperfusion, sepsis, nephrotoxic drugs, and surgical complications, which are prevalent in Intensive Care Unit (ICU) environments. Research indicates that the incidence of acute kidney injury (AKI) in critically sick patients varies between 20% and 50%, frequently advancing to chronic kidney disease (CKD) or end-stage renal disease (ESRD) if not addressed. Contemporary diagnostic instruments for acute kidney injury predominantly depend on serum creatinine and urine output assessments, which are replete with limitations death *(Singbartl and Joannidis, 2015)*. Serum creatinine is influenced by several non-renal variables and has a lagged increase following significant renal impairment. Thus, there is an immediate necessity for more sensitive and specific biomarkers to facilitate prompt intervention and enhance results. In this context, suPAR has garnered interest for its prospective function in the diagnosis and risk assessment of AKI. suPAR, a soluble variant of the urokinase plasminogen activator receptor (suPAR), is a circulating glycoprotein initially recognized in relation to immunological and inflammatory disorders *(Yoon et al., 2022)*.

1.2. Pathophysiology and Risk Factors

Acute Kidney Injury (AKI) arises from alterations in renal perfusion or injury to renal tissues. Prerenal causes encompass systemic hypoperfusion (e.g., hemorrhage, septic shock), whereas intrarenal factors pertain to glomerular or tubular damage resulting from ischemia or nephrotoxins. Postrenal causes frequently arise from urinary tract blockages, including calculi or neoplasms *(Moresco et al., 2018)*. Acute kidney injury (AKI) occurs in 30–60% of patients in intensive care unit (ICU) settings, correlating with elevated morbidity and death rates *(Abd ElHafeez et al., 2017)*.

1.3. Key predictors of AKI in ICU include

- Chronic hypertension and vasopressor use ***(****Ashine et al., 2024)*.
- Negative fluid balance, linked to organ dysfunction and reduced survival *(Shen et al., 2017)*.
- Invasive mechanical ventilation, associated with renal hypoperfusion and tubular necrosis *(Ameer et al., 2022)*.

1.4. Impact of AKI on ICU Patients

AKI significantly worsens outcomes, including increased mortality (up to 71.7% in ICU AKI cases), longer hospital stays, and higher healthcare costs. Systemic inflammatory responses and oxidative stress from AKI can lead to multi-organ failure *(Singbartl and Joannidis, 2015)*.

1.5. Spar: Pathophysiology and Significance in Acute Kidney Injury

The urokinase plasminogen activator receptor (suPAR) is present on the surfaces of diverse cell types, including immunological cells, endothelial cells, and podocytes in the kidney. It is crucial in modulating immunological responses, cellular adhesion, and the remodeling of the extracellular matrix. In pathological states, suPAR is released from the cell membrane and circulates in the bloodstream as suPAR *(Goyal et al., 2023)*. Increased suPAR levels have been linked to systemic inflammation, vascular injury, and tissue damage. In the context of acute kidney injury (AKI), suPAR has been demonstrated to directly induce kidney damage via its impact on podocyte dysfunction. Podocytes, specialized cells within the glomerulus, are crucial for preserving the kidney's filtration barrier. Research has shown that suPAR attaches to integrins on podocyte membranes, consequently impairing their cytoskeletal integrity and resulting in proteinuria and renal impairment. The molecular connection between suPAR and kidney injury highlights its potential as both a causative agent and a biomarker for acute kidney injury (AKI). Moreover, suPAR levels are increased in circumstances like sepsis, a primary contributor to AKI in ICUs, hence underscoring its significance in this patient demographic *(Workeneh, 2022)*.

1.6. Biomarkers for AKI Detection

Recent advancements in biomarkers have enhanced early AKI diagnosis and management:

- Functional Biomarkers: Cystatin C (CysC), unaffected by muscle mass or age, offers precise renal function assessments *(Ostermann et al., 2021)*.
- Damage Biomarkers: Kidney injury molecule-1 (KIM-1) and neutrophil gelatinase-associated lipocalin (NGAL) detect tubular damage early *(Yi et al., 2021)*.
- Stress Biomarkers: TIMP-2/IGFBP7 predict AKI risk through cell-cycle arrest mechanisms *(Yang et al., 2022)*.

1.7. SuPAR as a Novel Biomarker for AKI

Soluble urokinase plasminogen activator receptor (SuPAR) has emerged as a robust biomarker for AKI due to its links with inflammation, oxidative stress, and apoptosis:

- Elevated SuPAR levels correlate with AKI severity and predict renal outcomes better than traditional markers such as creatinine or BUN *(Jankowski et al., 2023)*.
- In ICU patients, SuPAR levels >8.0 ng/mL indicate heightened mortality risk, underscoring its prognostic value *(Reisinger et al., 2021)*.

Therapeutic Potential: Targeting SuPAR with monoclonal antibodies offers a promising avenue for AKI treatment and prevention *(Hayek et al., 2020)*.

1.8. Diagnostic and Prognostic Significance of suPAR in ICU-Induced AKI

suPAR serves as a biomarker by offering insights into illness risk, progression, and consequences. suPAR has demonstrated potential as a diagnostic tool for identifying patients at risk of developing AKI, possibly well in advance of traditional markers like serum creatinine, which signal renal damage. Numerous studies have shown a significant association between increased suPAR levels and the occurrence of AKI in ICU patients. A prospective cohort research indicated that ICU patients with elevated suPAR levels faced a markedly increased risk of developing AKI, even after controlling for confounding variables such as age, comorbidities, and disease severity. Furthermore, suPAR possesses predictive significance in forecasting the severity and outcomes of AKI. Increased suPAR levels correlate with prolonged kidney damage, greater necessity for renal replacement therapy (RRT), and elevated death rates. suPAR's capacity to categorize patients according to AKI risk and severity may enable doctors to apply customized therapeutic measures, including the prompt commencement of nephroprotective strategies, hydration management, and the avoidance of nephrotoxic medicines *(Ameer et al., 2022; Ashine et al., 2024)*. Another significant advantage of suPAR is its durability in the bloodstream, rendering it a dependable biomarker for clinical assessment. In contrast to other biomarkers that may possess restricted half-lives or necessitate particular handling protocols, suPAR can be readily quantified in plasma or serum with commercially accessible assays. This accessibility significantly improves its practical utility in congested ICU environments.

1.9. Potential Clinical Implementation Issues

SuPAR has enormous potential as an AKI biomarker, but clinical adoption is difficult. Lack of standardized suPAR cut-off values is a major concern, especially in various patient populations with different comorbidities and baseline inflammation. Since suPAR is not kidney-specific and can be high in many inflammatory and viral disorders, recognizing AKI-related suPAR elevations may be difficult. SuPAR testing in clinical practice must also be evaluated for cost-effectiveness. SuPAR tests are simple, but pricing and integration with diagnostic procedures will determine their adoption. Cost-benefit assessments for ICU suPAR testing need more research. SuPAR has shown promise in detecting AKI patients and predicting outcomes, but its relevance in therapeutic approaches is unclear. Large-scale, randomized controlled studies should investigate whether suPAR-based therapies improve AKI outcomes death *(Singbartl and Joannidis, 2015)*.

1.10. The Future Function of suPAR in Critical Care Nephrology

The identification of suPAR as a biomarker for acute kidney injury signifies a transformative change in critical care nephrology. As understanding of its pathophysiological underpinnings and diagnostic significance expands, suPAR may emerge as a fundamental element of customized renal management in intensive care units. Numerous prospective applications of suPAR in clinical practice need consideration. Initially, suPAR may be incorporated into risk prediction models for critically sick patients, facilitating the classification of individuals at elevated risk for AKI. Timely diagnosis of at-risk individuals may enable preventative strategies, including the optimization of hemodynamics, the avoidance

of nephrotoxic medications, and the vigilant monitoring of renal function. Secondly, suPAR may assist in differentiating among various phenotypes of AKI. suPAR-guided evaluations could distinguish between inflammatory AKI, resulting from sepsis or systemic disorders, and merely ischemic or toxic AKI, thereby offering insights for targeted interventions. Ultimately, as precision medicine progresses, suPAR may function as a therapeutic target. Interventions designed to reduce suPAR levels or inhibit its interaction with podocytes may potentially alleviate or avert AKI in high-risk patients. Although these techniques are now in experimental phases, they signify a promising frontier in nephrology and critical care medicine *(Jankowski et al., 2023)*.

2. Patients and Methods

This prospective observational study was conducted over six months (April–October 2024) in the intensive care units of Elmaadi Military Hospital and Kobri El Koba Military Hospital. It aimed to investigate the role of soluble urokinase plasminogen activator receptor (SuPAR) levels in predicting acute kidney injury (AKI) within 48 hours of ICU admission.

2.1. Patient Selection and Groups

A total of 30 patients aged 18–60 years were enrolled. Participants were divided into two groups based on AKI development:

- Control Group: 19 patients (63.33%) who did not develop AKI.
- AKI Group: 11 patients (36.67%) with AKI diagnosed according to Kidney Disease: Improving Global Outcomes (KDIGO) criteria *(Khwaja, 2012)*.
- Inclusion Criteria: Patients aged 18–60 years admitted to the ICU.
- Exclusion Criteria: Included chronic kidney disease, end-stage renal disease requiring dialysis, AKI at admission, ICU stay ≤24 hours, pregnancy, and kidney malignancies.

2.2. Clinical Endpoint and Definitions

The primary endpoint was AKI development, defined by:

- An absolute increase in serum creatinine ≥0.3 mg/dL within 48 hours.
- A ≥50% relative increase in creatinine over 7 days.
- Urine output <0.5 mL/kg/hour for at least 6 hours.

2.3. Stages of AKI were classified as

- **Stage 1:** Creatinine 1.5–1.9 times baseline or a rise ≥0.3 mg/dL within 48 hours.
- **Stage 2:** Creatinine 2.0–2.9 times baseline.
- **Stage 3:** Creatinine ≥3 times baseline, ≥4 mg/dL, or initiation of renal replacement therapy (RRT).

2.4. Study Procedures

2.4.1. Clinical Data Collection

- **Demographics:** Age, gender.
- **Medical History:** Cardiovascular disease, diabetes mellitus, immunosuppression, and family history.

2.4.2. Physical Examination and Anthropometric Measurements

- Body mass index (BMI) categorized per World Health Organization (WHO) standards: normal, pre-obese, or obese.

2.4.3. Laboratory and Biochemical Analysis

- **Routine Investigations:** Blood counts (e.g., platelets, leukocytes), serum creatinine, and BUN were assessed at admission and repeated at 24 and 48 hours.
- **SuPAR Analysis:** Blood samples collected at ICU admission, 24 hours, and 48 hours. SuPAR levels were measured using a double-antibody sandwich ELISA. Sensitivity and specificity thresholds were validated against vendor standards.

2.4.4. Ethical Considerations

- Written informed consent was obtained from participants. For unconscious or non-surviving patients, the local IRB acted as legal guardian. The protocol adhered to the Helsinki Declaration and was approved by the local Ethics Committee of the Medical Military Academy.

3. Results and Discussion

This study aimed to evaluate the role of soluble urokinase plasminogen activator receptor (SuPAR) levels in predicting acute kidney injury (AKI) among critically ill patients. AKI is characterized by a rapid decline in renal function, leading to the accumulation of waste products such as creatinine and urea. Traditional biomarkers, including serum creatinine, often fail to predict AKI onset in a timely manner. SuPAR, a marker of systemic inflammation, has emerged as a promising biomarker for early AKI detection *(Nusshag et al., 2023)*.

3.1. Study Design

This prospective observational study included 30 patients divided into two groups based on AKI development: 19 controls (no AKI) and 11 cases (AKI) as determined by a creatinine increase within 48 hours. Patients were recruited from ICU facilities in Elmaadi Military and Kobri El Koba Military Hospitals.

3.2. Key Findings

3.2.1. Demographics and Comorbidities

- The mean age of the control group was 50.42 ± 6.31 years, while the AKI group averaged 52.36 ± 4.13 years.
- The majority of participants in both groups were male, and hypertension was the most common comorbidity, followed by diabetes mellitus (DM) and coronary heart disease.
- No significant differences were observed between groups in demographic or clinical characteristics.

3.2.2. Laboratory Investigations

- **Blood Urea Nitrogen (BUN):** Significantly higher in AKI patients at all time points, peaking at 48 hours (10.93 vs. 8.21 mmol/L, $p < 0.005$).
- **Serum Creatinine:** Levels increased significantly in AKI cases compared to controls at 12, 24, and 48 hours. At 48 hours, AKI patients had a mean creatinine level of 1.8 mg/dL versus 0.97 mg/dL in controls ($p < 0.001$).
- These results are consistent with findings by Zhang et al. (2024), who demonstrated higher BUN and creatinine levels in sepsis-associated AKI (*Zhang et al., 2024)*.

3.2.3. SuPAR as a Biomarker

- SuPAR levels were significantly elevated in the AKI group across all time points. At 48 hours, AKI cases had SuPAR levels of 7.25 ng/dL compared to 5.3 ng/dL in controls ($p < 0.001$).
- A strong positive correlation was observed between SuPAR and creatinine levels at 24 and 48 hours ($r = 0.62$ and 0.678, respectively, $p < 0.001$).
- SuPAR's predictive power for AKI improved over time, with the area under the curve (AUC) increasing from 0.778 at 12 hours to 0.931 at 48 hours. At 48 hours, SuPAR levels >6.4 ng/mL demonstrated 100% sensitivity and 84.21% specificity for predicting AKI *(Hayek et al., 2020)*.

3.3. Data management and analysis

The study sought to examine the predictors and diagnoses of Acute Kidney Injury (AKI) in a cohort of 30 patients, categorized into two groups: control (non-AKI) and cases (AKI). The results were derived from a statistical study performed with SPSS 27, employing several statistical techniques to evaluate correlations, significance, and diagnostics, as illustrated in Table 1) and Figure 1).

3.3.1. Demographic and Medical Profile

- The mean age of participants was 51.13 ± 5.61 years; 60% were male.
- Hypertension (HTN) was the most prevalent comorbidity (43.3%), and the mortality rate was 30% in the entire cohort.
- No significant differences in age, gender, or medical history were found between AKI and control groups.

3.3.2. Laboratory Investigations

- Significant markers between AKI and controls included:
    - **Serum creatinine:** Elevated in AKI patients at all time points, with levels significantly higher at 12, 24, and 48 hours ($p < 0.001$).
    - **BUN (Blood Urea Nitrogen):** Higher in AKI cases across all time points with significant differences noted ($p = 0.007$, 0.006, and 0.005, respectively).
    - **suPAR (Soluble Urokinase Plasminogen Activator Receptor):** Consistently elevated in AKI cases, peaking at 48 hours with mean levels of 7.25 ng/dL compared to 5.3 ng/dL in controls ($p < 0.001$).

3.3.3. Correlation Analysis

- A strong positive correlation was observed between suPAR levels and serum creatinine at 24 hours ($r = 0.62$, $p < 0.001$) and 48 hours ($r = 0.678$, $p < 0.001$).
- suPAR showed potential as a predictive biomarker for AKI progression.

3.3.4. ROC Curve Analysis for suPAR

- The predictive power of suPAR for AKI increased over time:
    - At 12 hours: AUC = 0.778, sensitivity = 90.91%, specificity = 57.89%.
    - At 48 hours: AUC = 0.931, sensitivity = 100%, specificity = 84.21%.
    - A suPAR level >6.4 ng/mL at 48 hours demonstrated the highest diagnostic accuracy.

3.3.5. Mortality Outcomes

- Mortality was higher in the AKI group (45.45%) compared to controls (21.05%), but the difference was not statistically significant ($p = 0.225$)

This study involved 30 patients at risk for acute kidney injury (AKI), categorized into two groups: controls (those who did not develop AKI) and cases (those with AKI, indicated by elevated creatinine levels after 48 hours). Table 1) presents the demographic characteristics, medical history, and outcomes of the entire study cohort. The average age was 51.13 ± 5.61 years, with a range from 35 to 59 years; male patients constituted 60%, while females comprised 40% as in Figure 1). In terms of medical history, hypertension (HTN) was the most prevalent comorbidity at 43.3%, with a death rate of 30% among patients as represented in Figure 2).

Table 1 Sociodemographic characteristics, medical history and outcome for the study group

		Mean ± SD N (%)	**Range**
Age		51.13 ± 5.61	(35 – 59)
Gender	Male	18 (60%)	
	Female	12 (40%)	
HTN	No	17 (56.67%)	
	Yes	13 (43.33%)	
DM	No	22 (73.33%)	
	Yes	8 (26.67%)	
Coronary heart D	No	24 (80%)	
	Yes	6 (20%)	
Group	Controls	19 (63.33%)	
	Cases (AKI)	11 (36.67%)	
28-day mortality	No	21 (70%)	
	Yes	9 (30%)	

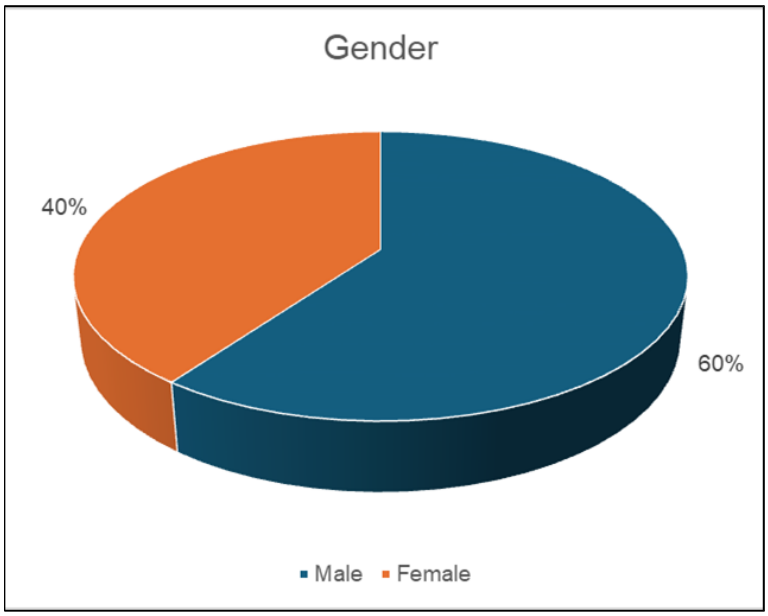

Figure 1 Gender distribution among the whole study group

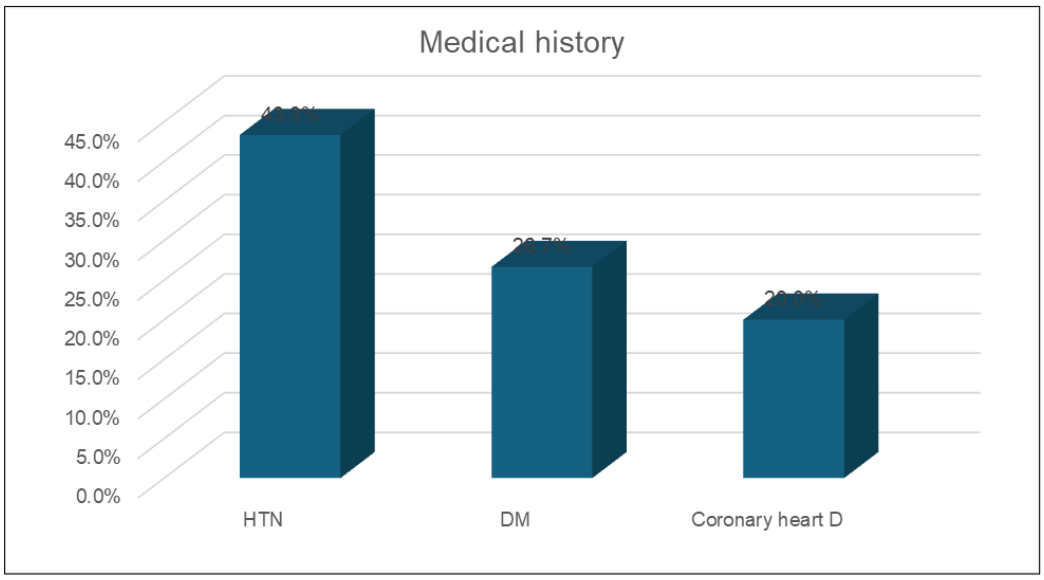

Figure 2 Past medical history among the whole study group

Table 2) displays laboratory investigations conducted among the entire study cohort. TLC exhibited a gradual increase overtime: from 11.4 at 12 hours to 12.18 at 48 hours. Platelet counts (PLT) increased from 115.37 to 125.13 within the same timeframe. Serum creatinine levels exhibited a consistent rise, from 0.99 mg/dL at 12 hours to 1.27 mg/dL at 48 hours. The BUN increased from 8.49 mmol/L at 12 hours to 9.21 mmol/L at 48 hours. Serum suPAR levels rose from 5.14 ng/dL to 6.01 ng/dL during the 48-hour interval.

Table 2 Lab investigations for the study group

		Mean ± SD	**Range**
TLC	12 hrs	11.4 ± 2.75	(7.31 - 16.9)
	24 hrs	11.74 ± 2.78	(7.6 - 17.2)
	48 hrs	12.18 ± 2.79	(8.1 - 17.6)
PLT	12 hrs	115.37 ± 34.13	(58 - 200.1)
	24 hrs	120.1 ± 35.22	(63 - 210)
	48 hrs	125.13 ± 35.78	(68 - 220)
Creatinine (mg/dL)	12 hrs	0.99 ± 0.2	(0.72 - 1.29)
	24 hrs	1.12 ± 0.25	(0.9 - 1.8)
	48 hrs	1.27 ± 0.41	(0.9 – 2.01)
BUN (mmol/L)	12 hrs	8.49 ± 2.18	(5.4 - 14.2)
	24 hrs	8.84 ± 2.2	(5.6 - 14.5)
	48 hrs	9.21 ± 2.24	(5.8 - 14.9)
suPAR (ng/dL)	12 hrs	5.14 ± 0.86	(3.55 - 6.7)
	24 hrs	5.52 ± 1.11	(3.08 - 8)
	48 hrs	6.01 ± 1.4	(2.9 – 8.51)

Table 3**)** presents sociodemographic information, medical history, and outcomes compared to two study cohorts. No significant differences were identified between the control and AKI groups for age, gender, or medical history. Mortality was elevated in the AKI group (45.45%) relative to controls (21.05%), although this disparity was not statistically significant (p-value = 0.225).

Table 3 Sociodemographic characteristics, medical history and outcome between two study groups

		Group		**Test of significance**	
		Controls	**Cases**		
		Mean ± SD N (%)	**Mean ± SD N (%)**	**p-value**	**Sig.**
Age		50.42 ± 6.31	52.36 ± 4.13	0.37	NS
Gender	Male	11 (57.89%)	7 (63.64%)	1.00	NS
	Female	8 (42.11%)	4 (36.36%)		
HTN	No	12 (63.16%)	5 (45.45%)	0.454	NS
	Yes	7 (36.84%)	6 (54.55%)		
DM	No	14 (73.68%)	8 (72.73%)	1.00	NS
	Yes	5 (26.32%)	3 (27.27%)		
Coronary heart D	No	15 (78.95%)	9 (81.82%)	1.00	NS
	Yes	4 (21.05%)	2 (18.18%)		
28-day mortality	No	15 (78.95%)	6 (54.55%)	0.225	NS
	Yes	4 (21.05%)	5 (45.45%)		

Table 4**)** illustrates laboratory investigations involving two research cohorts. No significant difference was seen between the groups concerning TLC and PLT levels at different time periods. BUN levels were markedly elevated in the AKI group relative to the control group at all-time intervals, with the most pronounced disparity after 48 hours (10.93 vs. 8.21 mmol/L), yielding p-values of 0.007, 0.006, and 0.005 after 12, 24, and 48 hours, respectively.

Table 4 Lab investigations between two study groups

		Group		**Student t-test**	
		Controls	**Cases**		
		Mean ± SD	**Mean ± SD**	**p-value**	**Sig.**
TLC	12 hrs	10.85 ± 2.71	12.35 ± 2.69	0.155	NS
	24 hrs	11.18 ± 2.75	12.7 ± 2.69	0.152	NS
	48 hrs	11.6 ± 2.75	13.17 ± 2.7	0.140	NS
PLT	12 hrs	118.9 ± 31.12	109.27 ± 39.62	0.466	NS
	24 hrs	123.21 ± 32.35	114.73 ± 40.77	0.534	NS
	48 hrs	127.89 ± 32.71	120.36 ± 41.81	0.587	NS
BUN (mmol/L)	12 hrs	7.55 ± 1.33	10.11 ± 2.45	0.007	S
	24 hrs	7.87 ± 1.34	10.5 ± 2.45	0.006	S
	48 hrs	8.21 ± 1.36	10.93 ± 2.46	0.005	S

Table 5) depicts the variation in serum creatinine levels (mg/dL) between two research groups at various time intervals. Serum creatinine levels were markedly elevated in the AKI group relative to controls at all-time intervals. At 12 hours, creatinine levels in the AKI group were 1.22 mg/dL, but in the control group they were 0.85 mg/dL ($p<0.001$). By 48 hours, AKI cases exhibited creatinine levels of 1.8 mg/dL, compared to 0.97 mg/dL in controls ($p<0.001$)as represented in Figure 3) .

Table 5 Creatinine difference between two study groups

		Group		**Student t-test**	
		Controls	**Cases**		
		Mean ± SD	**Mean ± SD**	**p-value**	**Sig.**
Creatinine (mg/dL)	12 hrs	0.85 ± 0.09	1.22 ± 0.05	<0.001	S
	24 hrs	0.96 ± 0.05	1.4 ± 0.2	<0.001	S
	48 hrs	0.97 ± 0.06	1.8 ± 0.1	<0.001	S
Pairwise comparison Mean difference (p-value)	12 hrs Vs. 24 hrs	0.103 (<0.001)	0.182 (0.013)		
	12 hrs Vs. 48 hrs	0.117 (<0.001)	0.58 (<0.001)		
	24 hrs Vs. 48 hrs	0.014 (0.019)	0.398 (<0.001)		

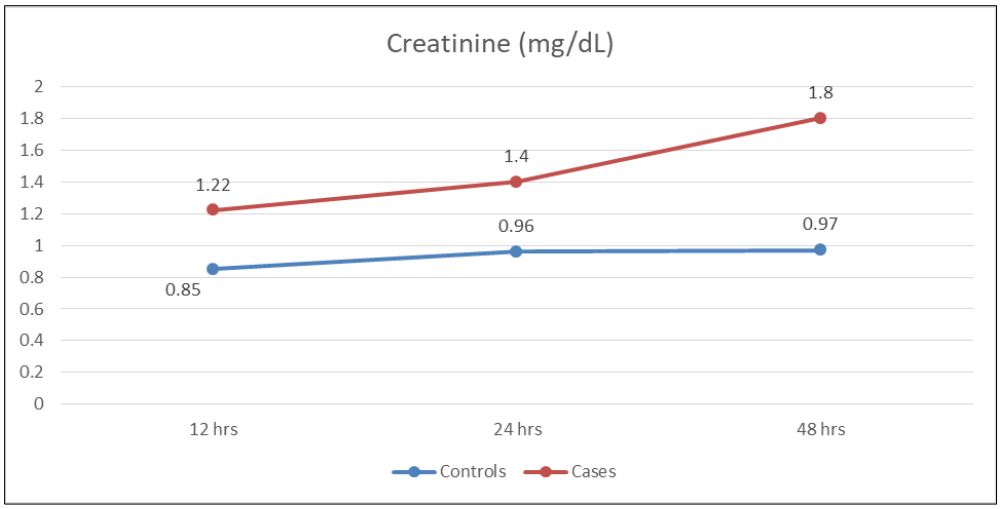

Figure 3 Change in serum level of creatinine (mg/dL) between two study groups across different time points

Table 6) illustrates the variation in blood levels of suPAR (ng/dL) between the two study groups at various time intervals. suPAR levels were markedly increased in AKI sufferers relative to controls at all time intervals. At 12 hours, AKI cases exhibited suPAR levels of 5.67 ng/dL compared to 4.84 ng/dL in controls (p-value = 0.008). The disparity escalated after 48 hours, with AKI cases exhibiting 7.25 ng/dL in contrast to 5.3 ng/dL in controls (p-value <0.001) as depicted in Figure 4).

Table 6 suPAR difference between two study groups

		Group		**Student t-test**	
		Controls	**Cases**		
		Mean ± SD	**Mean ± SD**	**p-value**	**Sig.**
suPAR (ng/dL)	12 hrs	4.84 ± 0.85	5.67 ± 0.58	0.008	S
	24 hrs	4.95 ± 0.92	6.5 ± 0.61	<0.001	S
	48 hrs	5.3 ± 1.24	7.25 ± 0.53	<0.001	S
Pairwise comparison Mean difference (p-value)	12 hrs Vs. 24 hrs	0.116 (0.591)	0.834 (<0.001)		
	12 hrs Vs. 48 hrs	0.462 (0.225)	1.58 (<0.001)		
	24 hrs Vs. 48 hrs	0.346 (0.371)	0.746 (<0.001)		

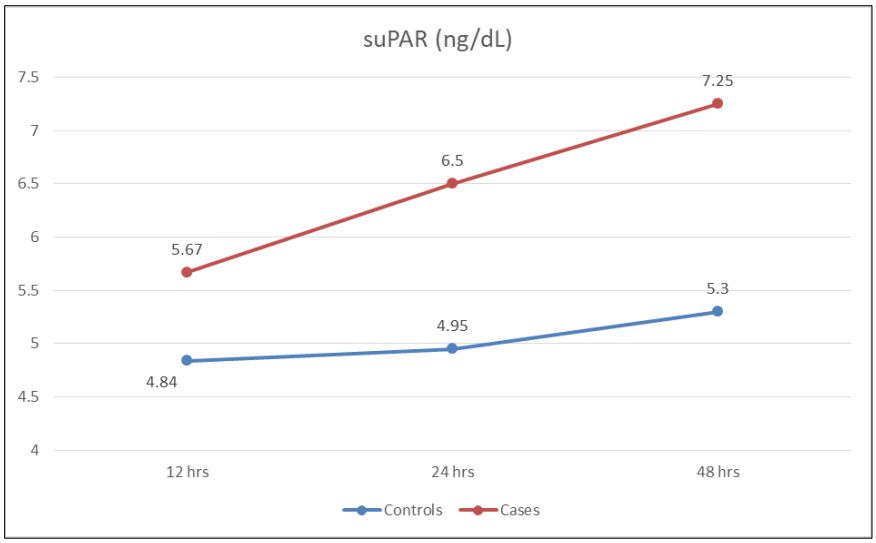

Figure 4 Change in serum level of suPAR (ng/dL) between two study groups across different time points

Table 7) illustrates the connection between suPAR and renal function among the entire study cohort. At 12 hours, no substantial association existed between suPAR and creatinine levels. At 24 and 48 hours, a significant positive association was seen between suPAR and creatinine, with Pearson correlation coefficients of 0.62 and 0.678, respectively (p-value <0.001).

Table 7 Correlation between suPAR and kidney function among the whole study group

SUPAR		**Creatinine (mg/dL)**
12 hrs	Pearson Correlation	-0.032
	p-Value	0.927
	Sig.	NS
24 hrs	Pearson Correlation	0.62
	p-Value	<0.001
	Sig.	S
48 hrs	Pearson Correlation	0.678
	p-Value	<0.001
	Sig.	S

Table 8) displays ROC curve study for suPAR at various time intervals to forecast instances of AKI. suPAR exhibited significant prediction capability for AKI at various time intervals. The area under the curve (AUC) for suPAR was 0.778 at 12 hours, rising to 0.935 at 24 hours and 0.931 at 48 hours. Both sensitivity and specificity enhanced throughout time, with suPAR levels exceeding 6.4 ng/mL at 48 hours demonstrating 100% sensitivity and 84.21% specificity for predicting AKI.

Table 8 ROC curve analysis for suPAR at different time points to predict cases of AKI

	AUC	**95% CI**	**p-value**	**Cutoff value**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
suPAR (ng/mL) after 12 hrs	0.778	0.589 to 0.908	0.001	>4.9	90.91	57.89	55.6	91.7
suPAR (ng/mL) after 24 hrs	0.935	0.782 to 0.992	<0.001	>5.65	100	78.95	73.3	100
suPAR (ng/mL) after 48 hrs	0.931	0.776 to 0.991	<0.001	>6.4	100	84.21	78.6	100

4. Conclusion

In conclusion, suPAR represents a novel and promising biomarker for AKI, particularly in the complex and high-risk environment of ICU patients. Its biological relevance, diagnostic accuracy, and prognostic potential underscore its value in identifying patients at risk for AKI, guiding clinical decision-making, and improving outcomes in critically ill populations. However, as with any new biomarker, suPAR's full integration into clinical practice will require further research to address existing challenges, including standardization, cost-effectiveness, and its role in therapeutic interventions. As the field of critical care nephrology continues to evolve, suPAR may play a pivotal role in transforming the management of AKI and enhancing the care of ICU patients, ultimately reducing the morbidity and mortality associated with this devastating condition. The study followed robust methodologies to evaluate SuPAR as a biomarker for AKI in ICU patients. Its ethical rigor, comprehensive data collection, and adherence to KDIGO standards enhance the study's validity and potential for clinical impact. Further research is recommended to corroborate findings and investigate SuPAR's long-term implications for renal function and ICU outcomes. The study aimed to analyze predictors and diagnostics for Acute Kidney Injury (AKI) among a cohort of 30 patients, divided into two groups: control (non-AKI) and cases (AKI). The findings were based on statistical analysis conducted using SPSS 27, with various statistical tools applied to assess correlations, significance, and diagnostics. SuPAR is a robust biomarker for early prediction of AKI in ICU settings. Its strong correlation with creatinine levels and its high diagnostic accuracy at 48 hours highlight its potential in clinical applications. However, further large-scale studies with extended follow-up durations are necessary to validate these findings and explore the mechanisms underlying SuPAR's role in renal dysfunction

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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