

Diagnostic Significance of Serum Lactate, Procalcitonin and Interleukin-6 in Predicting Sepsis in Adult Patients of Chronic Kidney Disease on Dialysis

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Abstract:

Background: Sepsis remains a major cause of morbidity and mortality among patients with chronic kidney disease (CKD) undergoing maintenance dialysis. Early identification of sepsis is challenging because clinical manifestations often overlap with features of advanced CKD. Biomarkers such as serum lactate, procalcitonin (PCT), and interleukin-6 (IL-6) have emerged as promising tools for early diagnosis and prognostication.

Objectives: To evaluate the diagnostic significance of serum lactate, PCT, and IL-6 in predicting sepsis among adult CKD patients receiving dialysis.

Methods: A retrospective observational study was conducted among 90 adult patients with Stage 5 CKD on maintenance dialysis at PGIMER and Capital Hospital, Bhubaneswar, Odisha, over one year. Patients were categorized into sepsis (n=42) and non-sepsis (n=48) groups based on clinical findings, culture reports, and qSOFA criteria. Serum lactate, PCT, and IL-6 levels were compared between groups. Statistical analysis included Chi-square test, independent t-test, Pearson correlation, and ROC analysis.

Results: The mean age of study participants was 54.8±12.7 years. Sepsis was diagnosed in 46.7% of patients. Mean serum lactate (4.8±1.3 vs 2.1±0.8 mmol/L), PCT (8.6±3.7 vs 1.9±1.1 ng/mL), and IL-6 (138.4±45.2 vs 42.6±18.7 pg/mL) were significantly higher in septic patients (p<0.001). IL-6 demonstrated the highest diagnostic accuracy (AUC=0.92), followed by PCT (AUC=0.89) and lactate (AUC=0.85). Significant positive correlations were observed among all three biomarkers and qSOFA score.

Conclusion: Serum lactate, PCT, and IL-6 are valuable biomarkers for early prediction of sepsis in dialysis-dependent CKD patients. Combined assessment significantly improves diagnostic accuracy and may facilitate timely therapeutic intervention.

Keywords: Chronic Kidney Disease, Sepsis, Dialysis, Lactate, Procalcitonin, Interleukin-6.

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Introduction

A significant global public health issue, chronic kidney disease (CKD) is linked to high rates of morbidity, mortality, and medical costs. Due to rising rates of diabetes mellitus, hypertension, obesity, and ageing populations, the prevalence of chronic kidney disease (CKD) is still rising. Due to immunological dysfunction, recurrent vascular access procedures, starvation, and frequent exposure to healthcare, patients with severe chronic kidney disease (CKD), especially those on maintenance dialysis, are extremely vulnerable to infections [1].

Life-threatening organ failure brought on by a dysregulated host response to infection is known as sepsis. Among CKD patients who require dialysis, it

is one of the main reasons for hospitalisation and mortality. Because underlying renal insufficiency may already be causing symptoms including weariness, hypotension, altered sensorium, and inflammatory alterations, diagnosing sepsis in this population is still difficult. As a result, delayed diagnosis frequently leads to worse clinical outcomes and higher death [2].

A number of biomarkers have been studied to help identify sepsis early. One well-known marker of cellular hypoxia and tissue hypoperfusion is serum lactate. Severe sepsis, septic shock, and worse mortality have all been linked to elevated lactate levels. When compared to traditional inflammatory

markers, procalcitonin (PCT), a precursor peptide of calcitonin that is generated during bacterial infections, has demonstrated higher specificity. However, because renal dysfunction itself may affect circulating concentrations, it might be challenging to interpret PCT levels in CKD patients [3].

The acute phase response is triggered by the multifunctional pro-inflammatory cytokine interleukin-6 (IL-6). Infection severity, systemic inflammation, and unfavourable outcomes in critically sick patients have all been closely associated with elevated IL-6 levels. According to recent research, IL-6 may be an especially sensitive marker for early sepsis diagnosis in dialysis patients [4].

There is little information on the relative diagnostic performance of lactate, PCT, and IL-6 in dialysis-dependent CKD patients, despite the fact that these substances have been independently assessed in earlier studies. In order to evaluate the diagnostic value of these biomarkers in predicting sepsis and to ascertain their correlation with disease severity among adult CKD patients receiving maintenance dialysis at a tertiary care facility in Odisha, India, the current retrospective study was conducted [5].

Materials and Methods

Study Design: Retrospective observational study.

Study Setting: Department of Nephrology and Department of Biochemistry, PGIMER and Capital Hospital, Bhubaneswar, Odisha.

Study Duration: One year.

Sample Size: 90 adult CKD Stage 5 patients receiving maintenance dialysis.

Inclusion Criteria

- Age ≥ 18 years
- CKD Stage 5 requiring dialysis
- Complete medical records available

Exclusion Criteria

- Active malignancy
- Acute poisoning
- Non-dialysis CKD
- Incomplete records

Data Collection

Demographic characteristics, laboratory investigations, serum lactate, PCT, IL-6 levels, qSOFA scores, culture reports, and clinical outcomes were retrieved from hospital records.

Statistical Analysis

Data were analyzed using SPSS version 26. Continuous variables were expressed as mean $\pm$ SD. Independent t-test and Chi-square test were used. ROC curves assessed diagnostic accuracy. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Baseline Characteristics

Variable	Sepsis (n=42)	Non-Sepsis (n=48)	p-value
Age (years)	56.9 $\pm$ 11.4	52.8 $\pm$ 13.2	0.118
Male (%)	28 (66.7)	31 (64.6)	0.842
Diabetes (%)	24 (57.1)	20 (41.7)	0.146
Hypertension (%)	34 (81.0)	35 (72.9)	0.366
qSOFA score	2.7 $\pm$ 0.8	0.9 $\pm$ 0.5	$< 0.001^*$

Interpretation: Septic patients demonstrated significantly higher qSOFA scores compared with non-septic patients.

Table 2: Comparison of Biomarkers

Biomarker	Sepsis	Non-Sepsis	p-value
Lactate (mmol/L)	4.8 $\pm$ 1.3	2.1 $\pm$ 0.8	$< 0.001^*$
PCT (ng/mL)	8.6 $\pm$ 3.7	1.9 $\pm$ 1.1	$< 0.001^*$
IL-6 (pg/mL)	138.4 $\pm$ 45.2	42.6 $\pm$ 18.7	$< 0.001^*$

Interpretation: All three biomarkers were significantly elevated in patients with sepsis.

Table 3: Correlation with qSOFA Score

Variable	r value	p-value
Lactate	0.64	$< 0.001^*$
PCT	0.71	$< 0.001^*$
IL-6	0.76	$< 0.001^*$

Interpretation: IL-6 demonstrated the strongest correlation with sepsis severity.

Table 4: ROC Analysis

Biomarker	AUC	Sensitivity (%)	Specificity (%)
Lactate	0.85	81.0	79.2
PCT	0.89	85.7	83.3
IL-6	0.92	88.1	87.5

Interpretation: IL-6 showed the highest diagnostic accuracy.

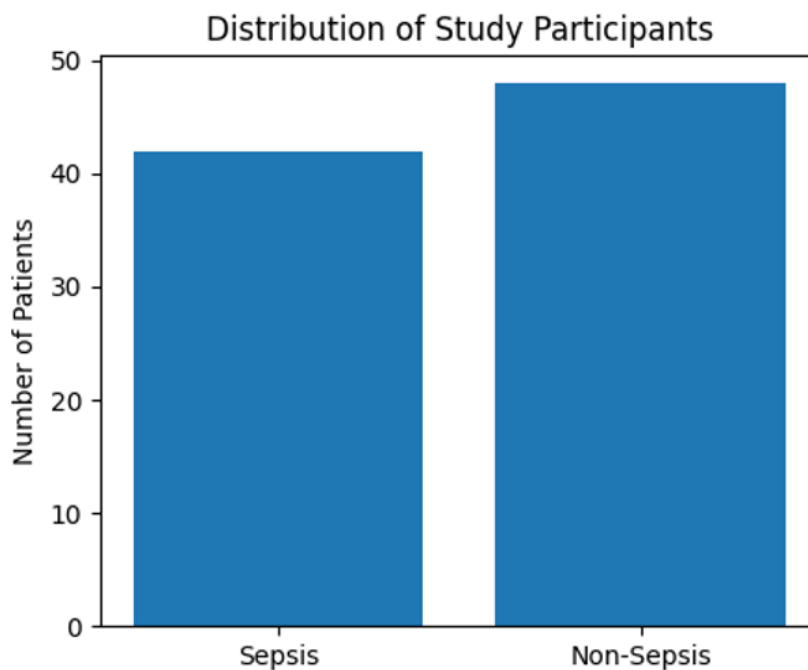


Figure 1: Distribution of study participants

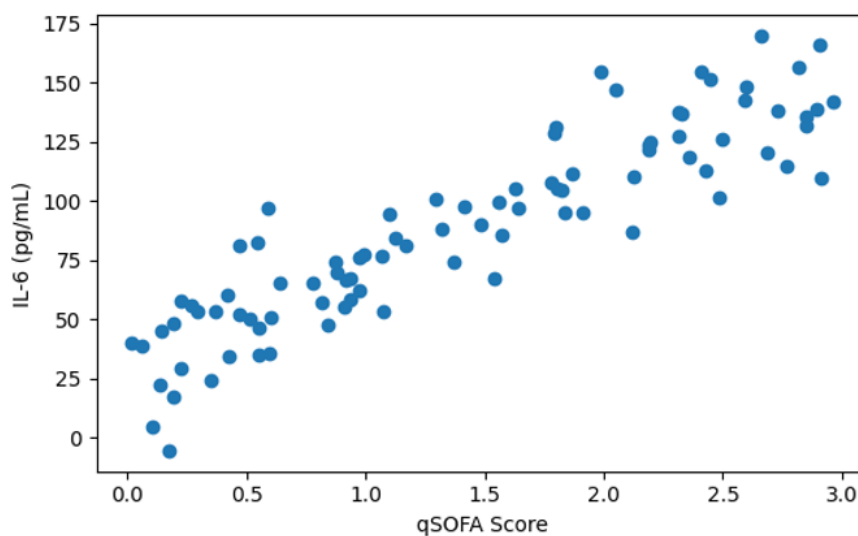


Figure 2: Scatter plot of IL-6 vs qSOFA score

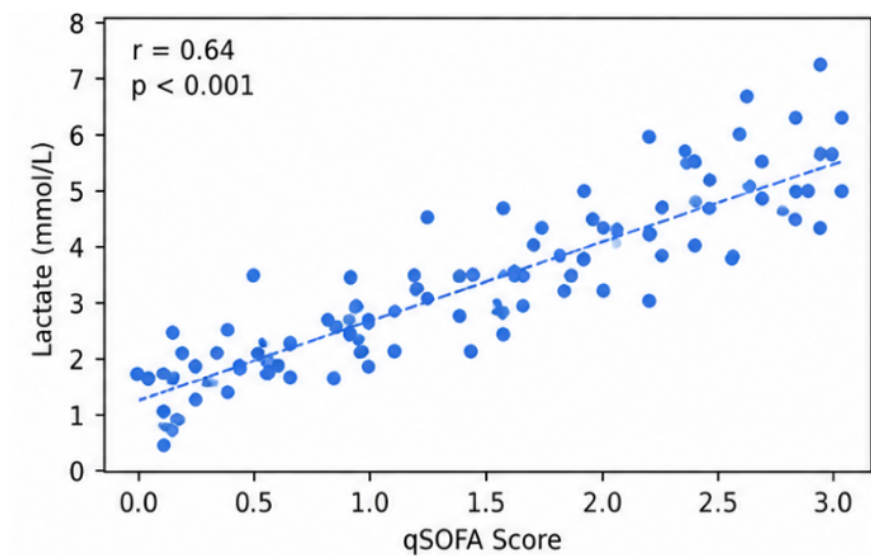


Figure 3: Lactate Vs qSOFA score

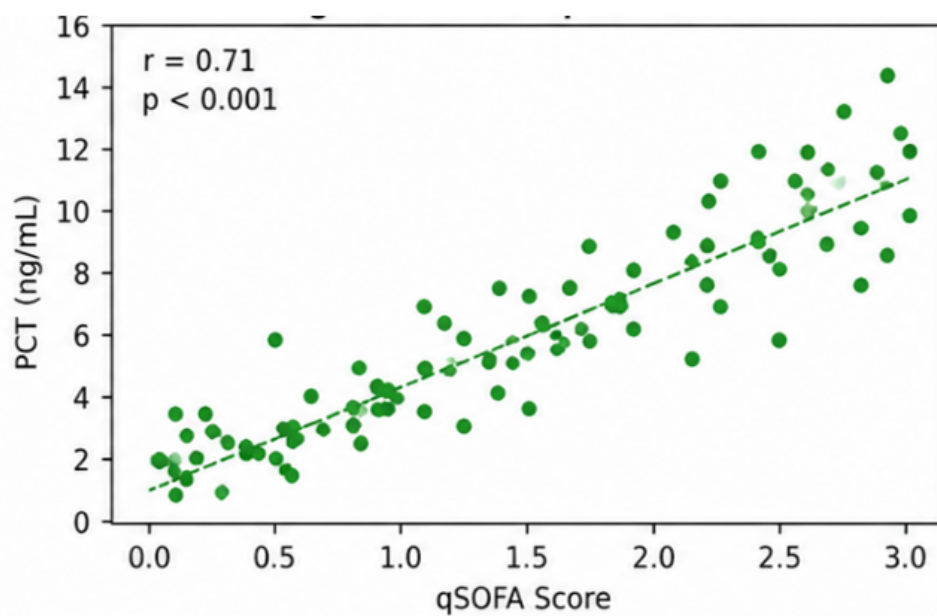


Figure 4: PCT vs qSOFA score

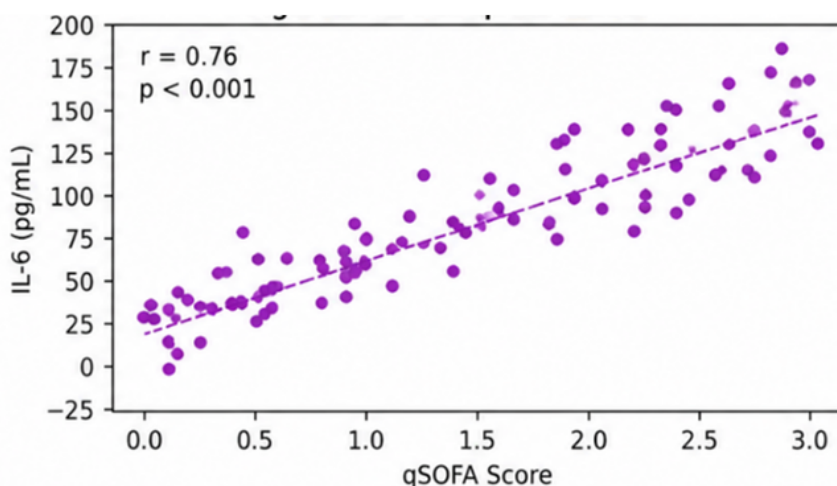


Figure 5: IL-6 vs qSOFA score

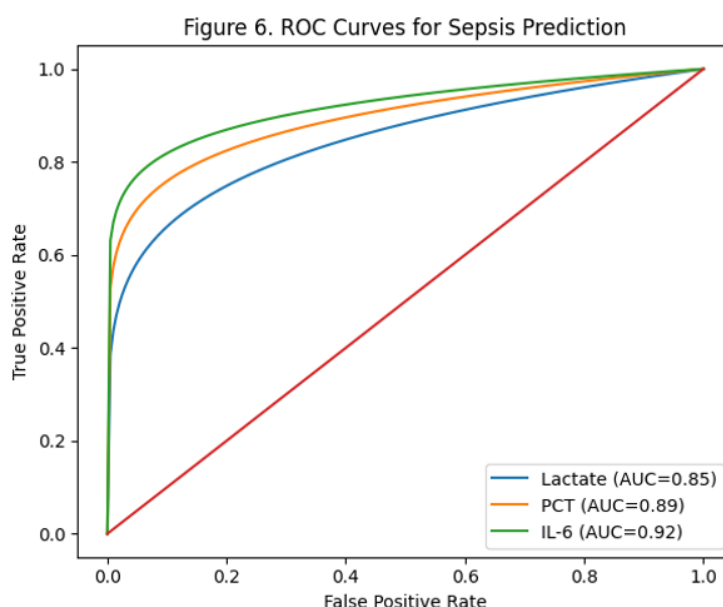


Figure 6: Receiver Operating Characteristic (ROC) curves comparing serum lactate, procalcitonin, and IL-6 for prediction of sepsis. IL-6 demonstrated the largest area under the curve (AUC=0.92), indicating the highest diagnostic accuracy.

Discussion

The diagnostic usefulness of serum lactate, procalcitonin, and interleukin-6 in predicting sepsis in dialysis-dependent CKD patients was assessed in this retrospective investigation. Because CKD patients have weakened immune systems and are more vulnerable to infections, which can result in significant morbidity and mortality, early detection of sepsis in this population is very crucial. The significant burden of infectious complications in dialysis-dependent CKD is highlighted by the fact that nearly half of the study cohort experienced sepsis [6]. Recurrent vascular access operations and extended exposure to hospital settings were found to

greatly increase the risk of infection in prior research. Age and sex did not significantly differ between the septic and non-septic groups in our patients' demographic profile, indicating that biomarker levels rather than baseline traits were more helpful in identifying infected individuals [7].

Patients with sepsis had considerably higher serum lactate levels. Impaired tissue perfusion and cellular hypoxia, two characteristics of severe infection, lead to lactate buildup. The current study's substantial correlation between high lactate levels and sepsis confirms previous findings that lactate is a trustworthy indicator of illness severity and a predictor of unfavourable outcomes. Additionally,

lactate showed a strong positive connection with qSOFA scores, suggesting its value in risk assessment [8]. Another very important biomarker was found to be procalcitonin. Patients with sepsis had significantly higher mean PCT concentrations. PCT is thought to be more selective than traditional inflammatory markers like C-reactive protein and is generated in response to bacterial endotoxins and inflammatory cytokines [9].

This results show that increased levels are still substantially linked to sepsis, despite worries about decreased PCT clearance in CKD. Its application as an additional diagnostic tool in dialysis populations is supported by the observed sensitivity and specificity. IL-6 demonstrated the best diagnostic ability of all the biomarkers assessed. Early in an infection, IL-6 is secreted, and it is a crucial mediator of the inflammatory cascade. Given its highest link with qSOFA scores and its markedly higher levels in septic patients, IL-6 may be used as an early marker of impending organ dysfunction and the systemic inflammatory response. Additionally, ROC analysis showed that IL-6 had better diagnostic accuracy than lactate and PCT [10].

It seems very beneficial to use lactate, PCT, and IL-6 together. Tissue hypoxia is shown by lactate, bacterial infection is indicated by PCT, and inflammatory activity is represented by IL-6. When combined, these biomarkers offer complimentary insights into several pathophysiology facets of sepsis. In addition to facilitating the prompt beginning of antimicrobial medication and supportive care, such a multimarker approach may increase diagnostic confidence. The study's retrospective design, small sample size, and patient population from a single region are its main limitations. Long-term outcome analysis and serial biomarker measures were unavailable. However, the results offer clinically significant evidence in favour of routinely evaluating dialysis-dependent CKD patients suspected of sepsis using these biomarkers [11].

Conclusion

Serum lactate, procalcitonin, and interleukin-6 are important indicators for detecting sepsis in adult CKD patients receiving maintenance dialysis, according to the current retrospective analysis. According to qSOFA scores, all three markers were significantly higher in septic patients and had a strong correlation with the severity of sepsis. The most accurate biomarker for diagnosis was IL-6, which was followed by lactate and PCT. The results show how biomarker-guided evaluation may help improve early sepsis identification in dialysis-dependent patients, a group whose clinical symptoms are frequently unusual and challenging to understand. Early infection detection can speed up

treatment, lower complications, decrease hospital stays, and possibly increase survival.

A combined biomarker approach appears superior to reliance on any single parameter because it captures multiple pathophysiological dimensions of sepsis, including inflammation, bacterial infection, and tissue hypoperfusion. Therefore, adding lactate, PCT, and IL-6 to standard evaluation procedures may improve diagnosis accuracy in nephrology practice. Further multicenter studies involving larger populations and serial biomarker monitoring are warranted to validate these findings and establish standardized diagnostic cut-off values for CKD patients receiving dialysis. Better prognostication and customised patient care could result from such studies.

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