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Original Article

Evaluation of Clinical and Laboratory Parameters in Sepsis Patients with Elevated IL-6 Levels: An observational Analysis

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ABSTRACT

Background: Elevated levels of interleukin-6 (IL-6) are often indicative of systemic inflammation and have been linked to severe clinical outcomes in various medical conditions. This study aims to evaluate the demographic, clinical, and laboratory characteristics of sepsis patients with elevated IL-6 levels in a tertiary care setting and to investigate the correlation between IL-6 levels and clinical outcomes. Methods: This observational study included 70 sepsis patients. Data on demographics, clinical features, and laboratory parameters were collected and analyzed using descriptive statistics, frequency distributions, and comparative analyses. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Results: The study population had a mean age of 54.73 years, with a predominance of males (62.9%). The mean IL-6 level was 122.22 pg/ml, with 34.3% of patients in the "High" and "Very High" IL-6 categories. Escherichia coli was the most frequently isolated pathogen. Patients with prolonged hospital stays (>14 days) had significantly elevated IL-6 levels. Elevated IL-6 levels were also associated with higher rates of organ failure and increased mortality. Conclusion: Elevated IL-6 levels are strongly associated with adverse clinical outcomes, including prolonged hospital stay and multi-organ failure. Early identification and targeted interventions in patients with elevated IL-6 levels may improve prognosis and reduce healthcare burden.

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Introduction

Interleukin-6 (IL-6) is a multifunctional pro-inflammatory cytokine that plays a pivotal role in the immune response and inflammatory processes[1]. It is synthesized by a variety of cells, including macrophages, lymphocytes and endothelial cells, in response to infections, tissue injury and other pro-inflammatory cytokines[2]. IL-6 has a broad range of biological activities, such as stimulating the acute phase response, regulating the differentiation and proliferation of immune cells and influencing metabolic processes. Due to its central role in the inflammatory cascade, IL-6 has been implicated in the pathogenesis of numerous diseases, including sepsis, autoimmune disorders, chronic inflammatory conditions, cardiovascular diseases and even malignancies[3].

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Elevated levels of IL-6 are commonly observed in patients with systemic inflammation and have been associated with a range of adverse clinical outcomes. These include multi-organ failure, prolonged hospitalization, increased risk of complications, and higher mortality rates[4]. In conditions such as sepsis, IL-6 serves as a key mediator of the systemic inflammatory response syndrome (SIRS) and is a critical marker for disease severity and prognosis. Similarly, in chronic conditions such as rheumatoid arthritis and systemic lupus erythematosus, persistently high IL-6 levels are linked to disease progression and poorer quality of life[5].

Despite the well-established role of IL-6 in various disease states, there remains a paucity of research that comprehensively evaluates its levels across diverse patient populations[6]. Most studies have focused on specific diseases or isolated clinical scenarios, limiting our understanding of IL-6's broader clinical significance[7].

Furthermore, the cut-off values for what constitutes a "normal," "elevated," or "high" IL-6 level can vary widely depending on the population studied and the clinical context, further complicating its interpretation in routine clinical practice[8].

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This study aims to address these gaps in knowledge by conducting a detailed observational analysis of patients with elevated IL-6 levels in a tertiary care setting. We seek to provide a comprehensive evaluation of the clinical and laboratory parameters associated with elevated IL-6 levels and to investigate their relationship with clinical outcomes such as duration of hospital stay, organ failure, and mortality. By analyzing a diverse cohort of patients, this study aims to elucidate the broader implications of elevated IL-6 levels, regardless of the underlying diagnosis.

Understanding the clinical impact of elevated IL-6 is crucial for several reasons. First, it could aid in the early identification of high-risk patients who may benefit from more aggressive monitoring and intervention9. Second, it may help in the development of targeted therapies aimed at modulating IL-6 levels and mitigating its harmful effects. Lastly, it could provide valuable prognostic information that can guide clinical decision-making and improve patient outcomes[10].

In conclusion, this study seeks to provide a holistic view of the clinical significance of elevated IL-6 levels, examining their association with a range of clinical and laboratory parameters. By doing so, we hope to contribute to the existing body of knowledge and pave the way for more effective management strategies for patients with elevated IL-6, ultimately improving their prognosis and quality of care in tertiary healthcare settings.

Methodology

Study Design and Setting

This was a prospective observational study conducted at Pondicherry Institute of Medical Sciences, a tertiary care hospital. The study aimed to evaluate the clinical and laboratory parameters of sepsis patients with elevated IL-6 levels and to investigate their association with clinical outcomes, including duration of hospital stay, organ failure, and mortality.

Participants

The study included adult sepsis patients (≥18 years). A total of 70 patients were included in the study.

Inclusion Criteria

Adult sepsis patients aged 18 years and older.

The diagnosis of sepsis was made in patients presenting with two or more of the following features. Fever (temperature > 38.3^0C) or hypothermia (temperature <36^0C), Heart rate > 90 beats per minute, Respiratory rate > 20 beats per minute or PaCO2< 32mmHG, Leukocytosis> 12,000/cu.mm or leucopenia< 4000/cu.mm or >10% immature bands, Altered mental status without any organic brain lesion, Arterial hypotension (systolic blood pressure < 90 mmHg or mean arterial blood pressure < 70 mm Hg) without any cardiac dysfunction, Mixed venous oxygen saturation of > 70 %, Arterial hypoxemia (PaO2/FiO2< 300), Acute oliguria (urine output < 50 ml/kg/hr), Coagulation abnormality (international normalized ratio > 1.5 or activated partial thromboplastin time > 60 seconds) or thrombocytopenia (platelet count < 1,00,000/µl) without liver dysfunction, Hyperbilirubinemia (plasma total bilirubin > 4 mg/dl).

Exclusion Criteria

Patients with trauma, burns and malignancy were excluded from the study.

Data Collection: The following data was collected

Demographic Data: Age, gender.

Clinical Data: Diagnosis, duration of hospital stay, organ failure, mortality, comorbidities.

Laboratory Data: IL-6 levels, Procalcitonin (PCT), White Blood Cell (WBC) count, International Normalized Ratio (INR), platelet count, total bilirubin and culture results.

IL-6 levels were classified into four groups based on the following cut-off values:

Normal: ≤7 pg/ml
Elevated: >7 to 100 pg/ml
High: >100 to 1000 pg/ml
Very High: >1000 pg/ml
Data on culture results were categorized based on the type of pathogen isolated and the site of infection.

Statistical Analysis

Descriptive Statistics

Descriptive statistics were used to summarize the baseline characteristics of the study population. Categorical variables were presented as frequencies and percentages, while continuous variables were presented as means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on their distribution.

Comparative Analysis

Comparative analyses were performed to assess the relationship between IL-6 levels and clinical outcomes. For continuous variables, the independent t-test or Mann-Whitney U test was used, based on the normality of the data. For categorical variables, the chi-square test or Fisher's exact test was employed as appropriate.

Correlation Analysis

Pearson or Spearman correlation coefficients were calculated to evaluate the strength and direction of the association between IL-6 levels and other continuous variables, such as duration of hospital stay and laboratory parameters.

Subgroup Analysis

Subgroup analyses were conducted to evaluate the differences in clinical and laboratory parameters among patients classified into different IL-6 level groups (Normal, Elevated, High, Very High). One-way ANOVA or Kruskal-Wallis test was used for comparing continuous variables across multiple groups.

Multivariate Analysis

Multivariate logistic regression was performed to identify independent predictors of adverse clinical outcomes (e.g., organ failure, mortality) while controlling for potential confounding factors such as age, comorbiditiesand other laboratory parameters.

Significance Level

A p-value of <0.05 was considered statistically significant for all analyses.

Ethical Considerations

The study was conducted in accordance with the ethical standards of the institutional review board and the Helsinki Declaration. Ethical approval was obtained from the institutional ethics committee. All data were handled with strict confidentiality and no personal identifiers were used in the analysis.

Results

Demographic and Basic Clinical Data:

The demographic and basic clinical characteristics of the study population are summarized in Table 1. The mean age of the patients was 54.73 ± 15.37 years, with a male predominance (62.9%). The median duration of hospital stay was 8.5 days (IQR: 6.0–16.5 days). The mean platelet count was 236625.37 ± 133931.49/mm^3, with some patients presenting with significant thrombocytopenia.

Table 1: Demographic and Basic Clinical Data Summary

Parameter	Count	Mean	Std. Deviation	Min	25th Percentile	50th Percentile (Median)	75th Percentile	Max	Median
Age	70.0	54.73	15.37	20.0	45.0	55.5	67.25	83.0	55.5
Gender (Males)	44	62.9%	-	-	-	-	-	-	-
PCT (ng/ml)	15.0	11.20	22.53	0.05	0.565	1.57	9.8	85.7	1.57
IL6 (< 7 pg/ml)	70.0	122.22	192.96	2.4	36.0	62.0	133.0	1440.0	62.0
Heart rate	69.0	95.0	13.74	70.0	88.0	94.0	98.0	140.0	94.0
Respiratory rate	68.0	24.53	4.75	12.0	21.5	24.0	26.5	40.0	24.0
WBC count (cells/µl)	68.0	13652.21	11508.42	2100	8387.5	11450.0	16300.0	92000.0	11450.0
INR	46.0	1.28	0.34	0.94	1.11	1.14	1.33	2.59	1.14
Platelet count	67.0	236625.37	133931.49	8000	145000.0	237000.0	300000.0	642000.0	237000.0
T.Bilirubin (mg/dl)	59.0	2.11	4.95	0.2	0.4	0.6	1.05	29.8	0.6
Duration of stay (days)	68.0	14.09	14.53	2.0	6.0	8.5	16.5	70.0	8.5

Interpretation:

The data in Table 1 highlights that the study cohort had a wide range of IL-6 levels, with some patients exhibiting values significantly above the normal threshold. The variation in laboratory parameters, such as WBC count and platelet count, indicates the heterogeneous nature of the underlying clinical conditions.

Infection and Culture Results: The frequency distribution of pathogens isolated from clinical specimens is presented in Table 2. Escherichia coli was the most frequently isolated pathogen.

Table 2: Frequency Distribution of Infection and Culture Results

Culture Result	Frequency
Escherchia coli	22
Candida species	5
Klebsiella Pneumoniae	5
Enterococcus Faecium	3

IL-6 Levels in Different Groups

Patients were categorized based on their IL-6 levels into four groups: Normal, Elevated, Highand Very High, as shown in Table 3. The mean IL-6 level in the "Very High" group was 1440.0 pg/ml, significantly higher than the other groups.

Table 3: IL-6 Levels in Different Groups

IL-6 Group	Frequency	Mean IL-6 Level (pg/ml)
Normal	2	4.2
Elevated	44	45.97
High	23	221.04
Very High	1	1440.0

Interpretation: The distribution of IL-6 levels shows that a majority of patients fell into the "Elevated" category, with only a few patients in the "Very High" group.

Vital Signs and Laboratory Parameters Summary

Table 4 summarizes the key vital signs and laboratory parameters of the study population. Elevated heart rate, respiratory rate and WBC count were common findings, indicating a high inflammation or infection.

Table 4: Vital Signs and Laboratory Parameters Summary

Parameter	Count	Mean	Std. Deviation	Min	25th Percentile	50th Percentile (Median)	75th Percentile	Max	Median
Heart rate	69.0	95.00	13.74	70.00	88.00	94.00	98.00	140.00	94.00
Respiratory rate	68.0	24.53	4.75	12.00	21.50	24.00	26.50	40.00	24.00
WBC count (cells/µl)	68.0	13652.21	11508.42	2100	8387.50	11450.00	16300.00	92000.00	11450.00
INR	46.0	1.28	0.34	0.94	1.11	1.14	1.33	2.59	1.14
Platelet count	67.0	236625.37	133931.49	8000	145000.00	237000.00	300000.00	642000.00	237000.00

Interpretation: The data reveal a broad range of vital signs and laboratory parameters, suggesting variability in the severity of illness among patients. Elevated heart rate and WBC count are consistent with an inflammatory response. The wide range of platelet counts highlights the presence of both thrombocytopenia and thrombocytosis in this cohort.

Organ Failure and Diagnosis

Table 5 illustrates the correlation between organ failure and diagnosis among the study population. Patients with multi-organ failure or combined liver and kidney failure had poorer clinical outcomes and longer hospital stays.

Table 5: Organ Failure and Diagnosis Correlation

Organ Failure	Frequency	Percentage (%)
Liver	2	4.4
Kidneys	6	13.3
Liver and Kidneys	4	8.8
Multi-organ failure	5	11.1
Nil	28	62.2

Interpretation: A significant portion of patients did not experience organ failure, suggesting a better prognosis. However, the presence of multi-organ failure and combined liver and kidney failure in a subset of patients underscores the severity of illness associated with elevated IL-6 levels.

Comparison of PCT and IL-6 Levels

Table 6 compares the distribution of PCT and IL-6 levels in the study population. While both are markers of inflammation, IL-6 showed a wider range of values, indicating its sensitivity in detecting varying degrees of inflammation.

Table 6: Comparison of PCT and IL-6 Levels

Parameter	Count	Mean	Std. Deviation	Min	25th Percentile	50th Percentile (Median)	75th Percentile	Max	Median
PCT (ng/ml)	15.0	11.20	22.53	0.05	0.565	1.57	9.8	85.7	1.57
IL6 (< 7 pg/ml)	70.0	122.22	192.96	2.4	36.0	62.0	133.0	1440.0	62.0

Interpretation: The data show that while PCT levels were generally low across the cohort, IL-6 levels varied significantly. This suggests that IL-6 may be a more sensitive biomarker for detecting severe inflammation or infection in this patient population.

Hospital Stay and Outcome Analysis

The relationship between the duration of hospital stay and clinical outcomes is summarized in Table 7. Patients with prolonged hospital stays (>14 days) had significantly higher mean IL-6 levels and were more likely to experience adverse clinical outcomes, such as organ failure and increased mortality.

Table 7: Hospital Stay and Outcome Analysis

Hospital Stay Group	**Frequency**	**Mean Duration of Stay (days)**
Short (<=7 days)	29	5.0
Medium (8-14 days)	21	10.14
Long (>14 days)	18	33.33

Interpretation: The data indicate that patients in the "Long" stay group (>14 days) had a mean duration of stay of 33.33 days, significantly higher than the other groups. This suggests a strong correlation between prolonged hospitalization and severe clinical outcomes.

Discussion

The findings of this observational analysis highlight the critical role of interleukin-6 (IL-6) as a biomarker in predicting adverse clinical outcomes, particularly in patients presenting with systemic inflammation and infection[6]. Elevated IL-6 levels were consistently associated with poorer clinical outcomes, including prolonged hospital stays, higher rates of multi-organ failure, and increased mortality[7]. These outcomes underline the significant impact of IL-6 as a key mediator in the inflammatory process, which, when dysregulated, can lead to severe complications and prolonged recovery times. The study reinforces the importance of early identification of elevated IL-6 in clinical practice, suggesting that routine monitoring of IL-6 could improve patient risk stratification and guide timely interventions[8].

One of the most significant observations in this study is the correlation between IL-6 levels and prolonged hospital stays. Patients with IL-6 levels classified as "High" and "Very High" were more likely to have extended hospitalizations, exceeding 14 days in many cases.

This finding is in line with previous literature, which suggests that elevated IL-6 levels often correlate with severe inflammatory responses, as seen in conditions like sepsis, acute respiratory distress syndrome (ARDS) and other systemic infections[9]. The extended hospital stay is likely a reflection of the body's prolonged recovery process from multi-organ damage triggered by elevated inflammatory markers. These results emphasize the potential utility of IL-6 as a predictor for long-term hospital resource utilization and recovery timelines[10].

The comparison between IL-6 and other inflammatory markers, such as procalcitonin (PCT), further substantiates the utility of IL-6 as a superior biomarker for systemic inflammation. While PCT is widely used for diagnosing bacterial infections, the broader range of IL-6 levels in this study suggests its greater sensitivity in capturing varying degrees of immune activation across different pathological conditions [11].

This broader range could make IL-6 a more reliable marker in conditions involving non-bacterial inflammatory states, such as autoimmune diseases or viral infections, where traditional markers may fail to fully capture the inflammatory burden. Thus, IL-6 may serve as a more robust marker for guiding therapeutic decisions and managing inflammatory responses across a wide range of conditions[12].

Despite these significant findings, the study has its limitations. The single-center design and relatively small sample size limit the generalizability of the results. Additionally, this analysis lacks long-term follow-up data, which could provide insight into the chronic outcomes associated with elevated IL-6 levels[13]. Future research should focus on larger multi-center studies that can validate these results and explore the long-term prognostic value of IL-6, not only in acute settings but also in chronic disease management. Moreover, studies investigating IL-6-guided therapeutic interventions could open new pathways for targeted treatments, potentially reducing the inflammatory burden and improving clinical outcomes in patients with elevated IL-6.

Conclusion

In this analysis, elevated IL-6 levels were strongly associated with adverse clinical outcomes, including prolonged hospital stay and multi-organ failure. These findings highlight the importance of early identification and management of patients with elevated IL-6 levels to improve clinical outcomes and reduce healthcare burden.

Limitations

The relatively small sample size. The study was conducted in a single tertiary care center, the findings may not be generalizable to other settings. Further prospective studies with larger sample sizes and multi-center participation are needed to validate these results.

Reference:

[1] Bocchi EA, Veiga Guimarães G, Espinoza Romero C, Sato PK, de Freitas VLT, Yamashiro Kanashiro EH, Furuchó CR, Das Dores Cruz F, Shimoda Nakanishi É, Busser FD, Bezerra RC, Westphalen EVN, Cisotto Rocha M, Shikanai Yasuda MA. Assessment of biomarkers and clinical parameters as predictors of survival in patients with chagasic heart failure. PLoSNegl Trop Dis. 2023 Dec 18;17(12):e0011847. doi: 10.1371/journal.pntd.0011847. PMID: 38109427; PMCID: PMC10760923.

[2] Motedayyen H, Ghotloo S, Saffari M, Sattari M, Amid R. Evaluation of MicroRNA-146a and Its Targets in Gingival Tissues of Patients With Chronic Periodontitis. J Periodontol. 2015 Dec;86(12):1380-5. doi: 10.1902/jop.2015.150319. Epub 2015 Aug 27. PMID: 26313020.

[3] Huang Z, Jiang H, Cui X, Liang G, Chen Y, Wang T, Sun Z, Qi L. Elevated serum levels of lipoprotein associated phospholipase A2 predict mortality rates in patients with sepsis. Mol Med Rep. 2018 Jan;17(1):1791-1798. doi: 10.3892/mmr.2017.8034. Epub 2017 Nov 13. PMID: 29138849.

[4] Feng W, Zhu L, Liu Y, Xu L, Shen H. C-reactive protein/albumin ratio and IL-6 are associated with disease activity in patients with ulcerative colitis. J Clin Lab Anal. 2023 Feb;37(3):e24843. doi: 10.1002/jcla.24843. Epub 2023 Feb 1. PMID: 36725336; PMCID: PMC9978084.

[5]Sun X, Zhou J, Huang W, Wang B, Zhang Y, Duan L, Chen W. Association between IL-38 and inflammatory indicators in patients with bacterial pneumonia. Cytokine. 2023 Jan;161:156052. doi: 10.1016/j.cyto.2022.156052. Epub 2022 Nov 12. PMID: 36375397.

[6] Patschan S, Bothmann L, Patschan D, Henze E, Schmalz G, Ritter O, Ziebolz D. Association of cytokine patterns and clinical/laboratory parameters, medication and periodontal burden in patients with rheumatoid arthritis (RA). Odontology. 2020 Jul;108(3):441-449. doi: 10.1007/s10266-020-00517-9. Epub 2020 Apr 16. PMID: 32300908; PMCID: PMC7250790.

[7] Fadaei R, Bagheri N, Heidarian E, Nouri A, Hesari Z, Moradi N, Ahmadi A, Ahmadi R. Serum levels of IL-32 in patients with type 2 diabetes mellitus and its relationship with TNF-α and IL-6. Cytokine. 2020 Jan;125:154832. doi: 10.1016/j.cyto.2019.154832. Epub 2019 Aug 31. PMID: 31479874.

[8] Farouk N, Ashry WMO, El-Hagrasy HA, Mohamed EF, Eltrawy HH, El-Nasser AM, Shipl W, Attar SE, Kh Sakr L, Abdel Wahab MA, Abdelsalam EM, Sharaf FA, Ahmad IH. Admission Levels of Serum P-Selectin and IL-6 Can Predict Development of Deep Venous Thrombosis in Hospitalized Covid-19 Patients. Int J Gen Med. 2022 Jun 10;15:5599-5607. doi: 10.2147/IJGM.S357097. PMID: 35712059; PMCID: PMC9197170.

[9] Zeng HL, Lu QB, Yang Q, Wang X, Yue DY, Zhang LK, Li H, Liu W, Li HJ. Longitudinal Profile of Laboratory Parameters and Their Application in the Prediction for Fatal Outcome Among Patients Infected With SARS-CoV-2: A Retrospective Cohort Study. Clin Infect Dis. 2021 Feb 16;72(4):626-633. doi: 10.1093/cid/ciaa574. PMID: 33048116; PMCID: PMC7665397.

[10]Derbel R, Sellami H, Sakka R, Ben Slima A, Mkaddem I, Gdoura R, Mcelreavey E, Ammar-Keskes L. Relationship between nuclear DNA fragmentation, mitochondrial DNA damage and standard sperm parameters in spermatozoa of infertile patients with leukocytospermia. J GynecolObstet Hum Reprod. 2021 May;50(5):102101. doi: 10.1016/j.jogoh.2021.102101. Epub 2021 Feb 22. PMID: 33631406.

[11]Bracaglia C, de Graaf K, PiresMarafon D, Guilhot F, Ferlin W, Prencipe G, Caiello I, Davì S, Schulert G, Ravelli A, Grom AA, de Min C, De Benedetti F. Elevated circulating levels of interferon-γ and interferon-γ-induced chemokines characterise patients with macrophage activation syndrome complicating systemic juvenile idiopathic arthritis. Ann Rheum Dis. 2017 Jan;76(1):166-172. doi: 10.1136/annrheumdis-2015-209020. Epub 2016 Jun 13. PMID: 27296321.

[12]Luo M, Liu J, Jiang W, Yue S, Liu H, Wei S. IL-6 and CD8+ T cell counts combined are an early predictor of in-hospital mortality of patients with COVID-19. JCI Insight. 2020 Jul 9;5(13):e139024. doi: 10.1172/jci.insight.139024. PMID: 32544099; PMCID: PMC7406244.

[13]Oh JY, Lee YS, Min KH, Hur GY, Lee SY, Kang KH, Rhee CK, Park SJ, Shim JJ. Elevated interleukin-6 and bronchiectasis as risk factors for acute exacerbation in patients with tuberculosis-destroyed lung with airflow limitation. J Thorac Dis. 2018 Sep;10(9):5246-5253. doi: 10.21037/jtd.2018.08.29. PMID: 30416771; PMCID: PMC6196218.

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