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COMPARATIVE STUDY OF SEQUENTIAL ORGAN FAILURE ASSESSMENT, QUICK SEQUENTIAL ORGAN FAILURE ASSESSMENT, AND SYSTEMIC INFLAMMATORY RESPONSE SYNDROME CRITERIA IN EARLY SEPSIS DETECTION AMONG INTENSIVE CARE UNIT PATIENTS

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Abstract

Background: *Sepsis is a life-threatening condition associated with high morbidity and mortality among critically ill patients. Early recognition is essential to prevent progression to multi-organ failure. The Sequential Organ Failure Assessment (SOFA), Quick Sequential Organ Failure Assessment (qSOFA), and Systemic Inflammatory Response Syndrome (SIRS) criteria are widely used tools for early detection; however, their comparative diagnostic performance in ICU settings remains controversial.*

Objective: *To compare the diagnostic accuracy of SOFA, qSOFA, and SIRS criteria in early detection of sepsis among ICU patients.*

Methodology: *This hospital-based comparative cross-sectional study included 150 adult ICU patients with suspected or confirmed infection. Clinical and laboratory parameters were collected within the first 24 hours of admission to calculate SOFA, qSOFA, and SIRS scores. Diagnostic performance was evaluated using sensitivity, specificity, odds ratios, and receiver operating characteristic (ROC) curve analysis. Statistical analysis was performed using SPSS version 27.*

Results: *Among the participants, 70.7% were diagnosed with sepsis. SOFA demonstrated the highest sensitivity (86.8%) with good specificity (75.0%) and showed the strongest association with sepsis (OR = 19.714; 95% CI: 8.143–47.728; $p < 0.001$). qSOFA exhibited perfect specificity (100%) and positive predictive value (100%) but lower sensitivity (60.4%). SIRS showed moderate sensitivity (70.8%) and lower specificity (50.0%). ROC analysis revealed an area under the curve (AUC) of 1.000 for qSOFA, 0.854 for SIRS, and 0.830 for SOFA, indicating strong discriminative ability among the scoring systems.*

Conclusion: *SOFA demonstrated the most balanced diagnostic performance for early sepsis detection in ICU patients. While qSOFA is highly specific and effective for identifying high-risk cases, its lower sensitivity limits its standalone use. SIRS showed comparatively lower diagnostic precision. Organ dysfunction-based assessment using SOFA is recommended for timely and accurate identification of sepsis in critically ill populations.*

INTRODUCTION

Sepsis is a life-threatening condition caused by a dysregulated host response to infection and remains a major global health challenge (1). It is a leading cause of morbidity and mortality among critically ill patients, affecting all age groups, particularly the elderly, immunocompromised individuals, and those with chronic illnesses such as diabetes, renal disease, and cardiovascular disorders (2). According to the World Health Organization, approximately 49 million people develop sepsis annually, resulting in nearly 11 million deaths, accounting for almost 20% of global mortality. The burden is especially high in low- and middle-income countries due to limited healthcare resources, delayed diagnosis, and inadequate management. However, even in high-income countries, sepsis remains a leading cause of ICU admission and hospital mortality (3).

Patients admitted to intensive care units (ICUs) are particularly vulnerable to sepsis due to multiple comorbidities and exposure to invasive procedures such as mechanical ventilation, central venous catheterization, and surgical interventions (4). These factors increase the risk of hospital-acquired infections and progression to severe sepsis. Sepsis in ICU patients is associated with high mortality, prolonged hospitalization, increased healthcare costs, and long-term complications, including post-sepsis syndrome characterized by cognitive, psychological, and physical impairments (4). The clinical course of sepsis is often unpredictable, with subtle early signs that can rapidly progress to multi-organ failure, highlighting the importance of early detection. Early identification of sepsis is crucial, as delays in diagnosis and treatment are strongly associated with poor outcomes, including organ dysfunction, prolonged ICU stay, and increased mortality (5). However, early recognition remains challenging due to the heterogeneous clinical presentation of sepsis, ranging from mild physiological changes to rapid deterioration. Therefore, reliable and timely diagnostic tools are essential to identify sepsis early and guide appropriate clinical management(6).

The introduction of the Sepsis-3 definition in 2016 redefined sepsis as "life-threatening organ dysfunction caused by a dysregulated host response to infection," emphasizing the role of organ dysfunction rather than systemic inflammation alone(7). This shift highlighted the need for more accurate and clinically relevant tools for early diagnosis and risk stratification in critically ill patients. Over time, several scoring systems have been developed to aid in the early detection and assessment of sepsis, among which the Systemic Inflammatory Response Syndrome (SIRS), Sequential Organ Failure Assessment (SOFA), and quick Sequential Organ Failure Assessment (qSOFA) are most widely used(8). SIRS criteria, introduced in 1992, are based on simple clinical and laboratory parameters, including temperature, heart rate, respiratory rate, and white blood cell count. Although SIRS is highly sensitive and easy to apply, it lacks specificity, as many non-infectious conditions can also fulfill its criteria, leading to potential overdiagnosis(9).

In contrast, the SOFA score provides a comprehensive evaluation of organ dysfunction by assessing six organ systems: respiratory, cardiovascular, neurological, hepatic, renal, and coagulation. It has been shown to correlate strongly with disease severity, ICU mortality, and length of hospital stay. However, its reliance on laboratory investigations limits its use in rapid bedside assessment and resource-limited settings(10).

The qSOFA score was introduced as a simplified bedside tool to facilitate rapid screening, particularly outside ICU settings. It includes three parameters: hypotension (systolic blood pressure ≤100 mmHg), tachypnea (respiratory rate ≥22/min), and altered mental status(12). While qSOFA is quick and easy to use, studies have shown that it has lower sensitivity for early sepsis detection and may fail to identify patients in the initial stages of disease. Additionally, qSOFA is considered more useful for predicting poor outcomes rather than diagnosing sepsis. Despite the widespread use of these scoring systems, there is ongoing debate regarding their effectiveness in

early sepsis detection(13). SIRS is considered sensitive but lacks specificity, SOFA provides better prognostic accuracy but requires laboratory data, and qSOFA offers rapid assessment but may miss early cases. These differences highlight the need for comparative evaluation to determine the most effective tool for early identification of sepsis, particularly in ICU settings where timely diagnosis is critical. Furthermore, limited studies have compared all three scoring systems simultaneously within the same ICU population, especially in low- and middle-income countries(14). Variations in healthcare infrastructure, resource availability, and clinical practices necessitate local evaluation of these tools to determine their applicability and effectiveness(11).

Therefore, this study aims to compare the diagnostic performance of SOFA, qSOFA, and SIRS criteria for early detection of sepsis among ICU patients. The findings of this study may help guide clinicians in selecting the most appropriate screening tool, improve early diagnosis, and enhance patient outcomes in critical care settings.

LITERATURE REVIEW

A retrospective study was conducted in the Izmir Tepecik training and research hospital infectious diseases and clinical microbiology clinic to assess the diagnostic and prognostic power of sequential organ failure assessment (SOFA), quick SOFA (qSOFA), systemic inflammatory response symptoms (SIRS), and qSOFA plus lactate (qSOFA+L) in patients diagnosed with sepsis between January 1, 2013 and December 31, 2017. Our clinic treated 976 patients with sepsis who met the HSBC admission criteria. The average age was 72.5 ± 13.7 years. Women were 52.7% of the group. Out of the total cases,37.4% were hospitalized. In-hospital mortality among them was 52.3% which is higher than ED mortality which was 12.5%. A critical finding of the study was that higher scores in qSOFA and qSOFA+L (≥2) were significantly associated with elevated mortality in the ED setting, suggesting their relevance as bedside tools for risk stratification in acute care scenarios. However, no statistically significant difference was identified between the SIRS, qSOFA, and qSOFA+L criteria in predicting in-hospital mortality, suggesting that these approaches have limited predictive power in long-term inpatient outcomes. (12)

SOFA score is the most reliable prognostic scores as compared to the others. It showed good discriminative ability for diagnosing sepsis, as evidenced by an AUC of 0.89 for its ROC curve. A SOFA scores greater than 11 demonstrated a sensitivity of 100% and negative predictive value of 100% in diagnosing sepsis. Having a low SOFA score means that patients are unlikely to suffer from sepsis. This improves triaging. In addition, the SOFA score could be useful to predict emergency (AUC=0.75) and hospital mortality (AUC=0.72). In a study, SOFA with a score above 11 predicted deaths in ED (emergency department) with a sensitivity of 63.5% and specificity of 78.8%. Similarly, a SOFA score of more than 9 predicted in-hospital death with 65.8% sensitivity and 75.5% specificity. As per SOFA score findings, it appears superior to other commonly used scores in the diagnosis and predicts outcome of sepsis. This holds especially true in an ICU, for example, and also an ED. The SOFA score is a recommended tool to manage sepsis. By becoming aware of its possible broader application in the critically ill population, early recognition and clinical application can be enhanced (13).

A retrospective analysis of 13,780 surgical patients who were admitted to intermediate care, intensive care or both from 2012 to 2018 compared the three different criteria of Sequential Organ Failure Assessment, quick Sequential Organ Failure Assessment and Systemic Inflammatory.

Response Syndrome to detect infection and predict mortality. Intermediate care, intensive care, and combined admissions had suspected infections 18.3%, 35.5%, and 62.0% observed respectively None of the scores predicted infection. The rapid sequential organ failure assessment (SOFA) best predicts mortality for intermediate care patients, whereas the sequential organ failure assessment (SOFA) is better at predicting mortality value in patients with intensive care involvement patients. The study concluded that despite their

poor performance for early infection detection, the two scores provide prognostic information in specific contexts; qSOFA in intermediate care and SOFA in critical care (17).

Sepsis detection is important to improve outcomes, especially in intensive and intermediate care units. Well-known scoring systems consist of the Sequential Organ Failure Assessment, Quick Sequential Organ Failure Assessment and Systemic Inflammatory Response Syndrome criteria. In a retrospective study of 13,780 (surgical patients), none of the above tools accurately predicted suspected infection, although they were different in mortality prediction. According to the study, Quick Sequential Organ Failure Assessment is recommended for use in patients requiring intermediate care. In contrast, Sequential Organ Failure Assessment is recommended for critically ill intensive care unit patients. Findings revealed that while scoring systems are useful tools that can offer insights into prognosis, their specific interpretation and value is very context dependent. In particular, the value of the Systemic Inflammatory Response Syndrome in sepsis evaluation is limited (14).

. A retrospective cohort study was conducted at the Medical Intensive Care Unit, Oslo University Hospital Ullevaal, Norway, from January 1, 2006, to December 31, 2013, for a period of 8 years. Adult patients with severe pneumococcal sepsis (confirmed by positive blood cultures for S. pneumoniae) and respiratory failure requiring invasive mechanical ventilation were included in the study. A total of 38 patients were identified, 31 patients had complete admission data. The aim was to evaluate and compare the sensitivity of SIRS and qSOFA criteria at the moment of hospital admission to detect sepsis in quickly evolving patients with septic shock. The study's findings revealed that septic patients were identified much more at admission via SIRS criteria as compared to qSOFA. Almost all patients were identified using SIRS criteria; however, qSOFA failed to identify a sizeable number at presentation. There was a significant difference in sensitivity between qSOFA and SIRS. Notably, the combination of the two criteria improved detection rates for all patients' sepsis on admission (15).

METHODOLOGY

This hospital-based comparative cross-sectional study was conducted in the Intensive Care Units (ICUs) of Lady Reading Hospital and Khyber Teaching Hospital, Peshawar, over a period of six months. A sample size of 150 patients was calculated using Cochran's formula with a 95% confidence level, 5% margin of error, and an estimated sepsis prevalence of 25%. Participants were selected using a convenient sampling technique. Adult patients (≥18 years) admitted to the ICU with suspected or confirmed infection were included, while patients with incomplete data, non-infectious conditions, transfers from other ICUs, or those discharged or deceased within 24 hours were excluded. Data was collected within the first 24 hours of ICU admission using a standardized proforma.

Demographic details, clinical parameters including vital signs and Glasgow Coma Scale, and laboratory findings such as white blood cell count, platelet count, creatinine, bilirubin, and PaO_2/FiO_2 were recorded. SOFA, qSOFA, and SIRS scores were calculated for each patient. Clinical outcomes including ICU mortality, length of stay, need for mechanical ventilation, and development of organ dysfunction were also documented. Ethical approval was obtained from the Institutional Review Board, and informed consent was secured from patients or their legal guardians. Confidentiality of patient data was strictly maintained. Data was analyzed using SPSS version 27. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Diagnostic performance of SOFA, qSOFA, and SIRS was evaluated using sensitivity, specificity, and area under the curve (AUC). Chi-square and independent t-tests were applied where appropriate, with $p < 0.05$ considered statistically significant.

RESULTS

A total of 150 patients were included in the study. The mean age of the participants was 58.69 ± 9.24

years. The study population comprised an equal number of males and females, with 50% being male and 50% being female.

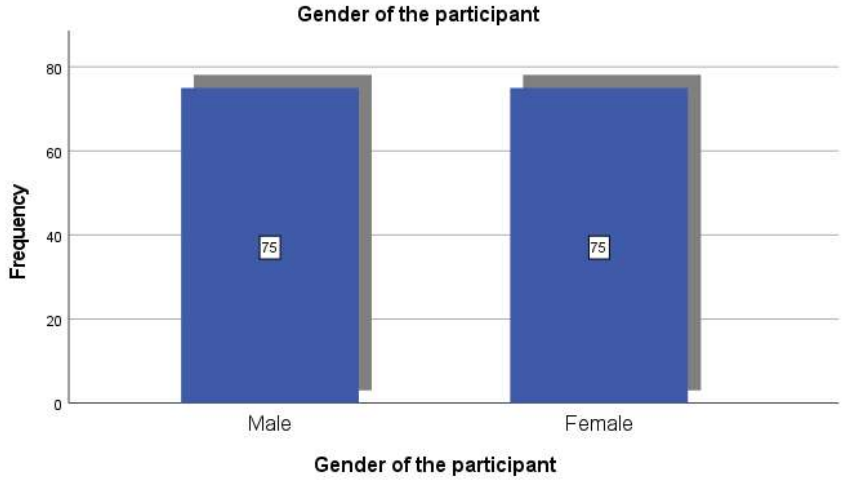

Figure 1 Gender of the participants

The mean body temperature at ICU admission was 101.16 ± 2.08°C, while the mean heart rate was 109.22 ± 25.37 beats per minute. The average respiratory rate was 21.70 ± 4.19 breaths per minute, and the mean systolic blood pressure was 97.53 ± 19.03 mmHg. Neurological status assessed by the Glasgow Coma Scale showed a mean score of 14.13 ± 1.20, and the mean oxygen saturation (SpO_2) was 94.00 ± 4.04%. There were no missing values for any of the recorded parameters.

Table 1: Descriptive Statistics of Demographic and Clinical Parameters of ICU Patients

Parameter	Mean ± SD
Age (years)	58.69 ± 9.24
Temperature (°C)	101.16 ± 2.08
Heart Rate (bpm)	109.22 ± 25.37
Respiratory Rate (breaths/min)	21.70 ± 4.19
Systolic BP (mmHg)	97.53 ± 19.03
Glasgow Coma Scale (GCS)	14.13 ± 1.20
SpO_2 (%)	94.00 ± 4.04

Among the study participants, Diabetes Mellitus was the most prevalent comorbidity, affecting 73.3% of patients. Ischemic heart disease was observed in 64.7%, followed by chronic lung disease in 57.3% and chronic kidney disease in 42.7% of the population. Hypertension was the least common, present in 28.0% of patients.

Table 2: Distribution of Comorbidities Among ICU Patients

Comorbidity	Percent
Diabetes Mellitus	73.3%
Ischemic Heart Disease	64.7%
Chronic Lung Disease	57.3%

Chronic Kidney Disease	42.7%
Hypertension	28.0%

The laboratory analysis revealed that the mean white blood cell (WBC) count was 18,406.67 ± 23,797.27 $\times 10^9$/L, indicating leukocytosis in many patients. The mean platelet count was 99,366.67 ± 91,140.16 $\times 10^9$/L, showing considerable variability among participants. Hepatic and renal functions were assessed with a mean serum bilirubin of 1.26 ± 0.74 mg/dL and serum creatinine of 1.73 ± 1.18 mg/dL, respectively. The mean PaO_2/FiO_2 ratio was 353.87 ± 174.81, reflecting moderate variations in oxygenation, and the mean urine output over 24 hours was 375.20 ± 196.28 mL. These findings indicate considerable heterogeneity in organ function among ICU patients.

Table 3: Distribution of qSOFA Components and Total qSOFA Score

qSOFA Component / Score	Frequency	Percent
RR ≥22 breaths/min	106	70.7%
SBP ≤100 mmHg	65	43.3%
GCS <15	64	42.7%
Total qSOFA Score		
0	44	29.3%
1	42	28.0%
2	10	6.7%
3	54	36.0%
qSOFA Positive (≥2)	64	42.7%
qSOFA Negative (<2)	86	57.3%

The total SOFA score demonstrated a wide range among ICU patients. The most frequent score was 0 (36.0%), indicating no organ dysfunction in over one-third of patients. Among those with organ dysfunction, a score of 4 (20.0%) was most common, followed by 9 (12.7%). Higher SOFA scores indicating severe multi-organ dysfunction were less frequent, with 6.0% of patients scoring. 15. Overall, 68.7% of patients were classified as SOFA positive (score ≥2), while 31.3% were SOFA negative.

Figure 2: Total SOFA Score

SENSITIVITY, SPECIFICITY, PREDICTIVE VALUES, AND ODDS RATIOS OF SIRS, QSOFA, AND SOFA

SOFA positivity demonstrated the strongest association with sepsis, with an OR of 19.714 (95% CI: 8.143–47.728), the highest sensitivity (86.8%), and good specificity (75.0%), making it the most effective tool for early identification. qSOFA showed perfect specificity (100%) and PPV (100%), indicating that all qSOFA-positive patients had sepsis, but its lower sensitivity (60.4%) suggests that some septic patients may be missed. SIRS had moderate sensitivity (70.8%) and lower specificity (50.0%), reflecting a higher false-positive rate but still useful for screening purposes. These results indicate that SOFA is the most balanced and reliable scoring system, while qSOFA is highly specific, and SIRS is moderately sensitive. (Table 4.10)

Table 4.: Sensitivity, Specificity, Predictive Values, and Odds Ratios of SIRS, qSOFA, and SOFA

Scoring System	Positive (%)	Negative %)	Odds Ratio (OR)	95% CI	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
SIRS	97 (64.7)	53 (35.3)	2.419	1.173 – 4.991	70.8	50.0	77.3	41.5
qSOFA	64 (42.7)	86 (57.3)	2.048	1.649 – 2.542	60.4	100.0	100.0	51.2
SOFA	103 (68.7)	47 (31.3)	19.714	8.143 – 47.728	86.8	75.0	89.3	70.2

ROC CURVE ANALYSIS FOR DIAGNOSTIC PERFORMANCE OF SOFA, QSOFA, AND SIRS

A total of 150 ICU patients were analyzed, including 106 (70.7%) sepsis-positive and 44 (29.3%) sepsis-negative cases. ROC curve analysis showed that qSOFA had an Area Under the Curve (AUC) of 1.000, indicating perfect diagnostic accuracy. SIRS demonstrated very good performance with an AUC of 0.854, while SOFA

showed good diagnostic accuracy with an AUC of 0.830. Overall, qSOFA exhibited the highest discriminative ability for early sepsis detection, followed by SIRS and SOFA. (Table 4.10.1)

Table 5: ROC Curve Analysis for Diagnostic Performance of SOFA, qSOFA, and SIRS

Variable	Total Sample (N)	Sepsis Positive (n=106)	Sepsis Negative (n=44)	Area Under Curve (AUC)
qSOFA	150	106 (70.7%)	44 (29.3%)	**1.000**
SIRS	150	106 (70.7%)	44 (29.3%)	**0.854**
SOFA	150	106 (70.7%)	44 (29.3%)	**0.830**

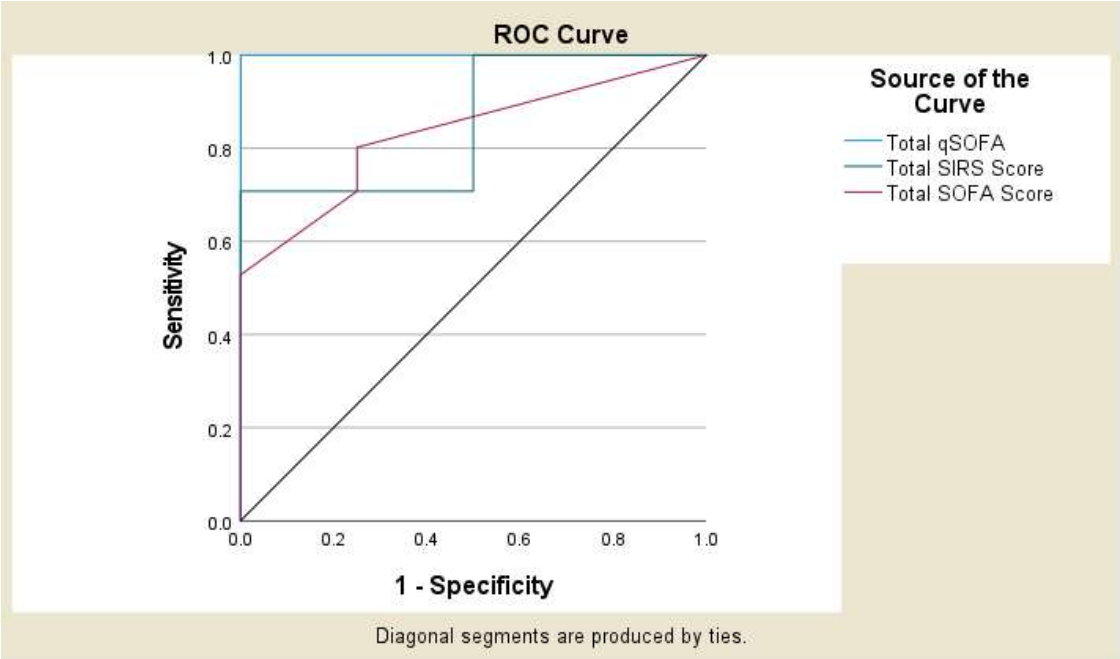

Figure 3: Roc Curve analysis for diagnostic performance of Sofa, qsofa, and Sirs

DISCUSSION

The present study evaluated and compared the diagnostic performance of the Sequential Organ Failure Assessment (SOFA), quick Sequential Organ Failure Assessment (qSOFA), and Systemic Inflammatory Response Syndrome (SIRS) criteria for early detection of sepsis among ICU patients. The findings demonstrated that although all three scoring systems showed statistically significant associations with sepsis, their diagnostic performance differed considerably. Overall, SOFA provided the most balanced clinical performance, qSOFA demonstrated very high specificity, and SIRS showed moderate sensitivity but limited specificity. These findings are interpreted below in light of existing literature.

The results indicate that the average age of the participants was around 59 years, showing that sepsis affected middle-to-older aged adults. The immune system becomes weaker, and the chronic disease burden increases with age. Therefore, age is a known risk factor for sepsis. Findings similar to ours have also been reported by Khan and Aslam (2022), who found that septic patients are older people. Data from around the world also show that the incidence and mortality rates of sepsis increase with age (Rudd et al., 2020). Findings of this study show equal gender distribution, which is in contrast to some

international reports showing male predominance (Rudd et al., 2020). Sex alone is not an independent determiner of sepsis risk among two critically ill individuals. However, gender differences in sepsis can be attributed to regional health profiles and patterns of comorbidity. (16)

The abnormal vital parameters recorded at ICU admission including elevated temperature, tachycardia, increased respiratory rate, and reduced systolic blood pressure reflect systemic inflammatory response and early circulatory compromise. These findings correspond to the original SIRS-based conceptualization of sepsis (Bone et al., 1992). However, subsequent research has demonstrated that vital sign abnormalities lack specificity because similar changes occur in non-infectious inflammatory conditions (Mignot-Evers et al., 2021). This limitation explains the moderate specificity of SIRS observed in our study. The presence of altered mental status, reflected in reduced Glasgow Coma Scale scores, is clinically significant. Altered mentation is a core component of qSOFA and is strongly associated with poor outcomes (Singer et al., 2016). Jaruwatthanasunthon et al. (2022) similarly found that reduced GCS significantly contributed to qSOFA predictive accuracy. (17)

The study's finding of high prevalence of diabetes mellitus and ischemic heart diseases has clinical relevance. Metabolic and cardiovascular diseases make the host immunocompromised and susceptible to severe infection. Khan and Aslam (2022) also reported a high frequency of comorbidities in cases of sepsis which were linked with mortality. Adegbite et al. (2021) systematics review further proved that comorbid disease burden alters sepsis severity and diagnostic scores outcomes, particularly in low and middle-income countries. As a result, the high burden of comorbid conditions in our cohort will have contributed to disease severity and the good performance of organ dysfunction-based scoring systems. (18)

In our study the clinical parameters at the time of ICU admission reflect marked physiological derangement which includes high temperature, tachycardia, high respiratory rate and low systolic blood pressure. As the participants in this study were patients with probable sepsis, characterized by a systemic inflammatory response and early cardiovascular decompensation, the finding is not surprising. In addition, the Glasgow Coma Scale (GCS) was 14.13 among the majority of patients indicating mild neurologic disability. This aligns with the minor neurological alterations that are imminent given the early stage of an infectious presentation. Results obtained in the present study are in concordance with Kilinc Toker et al. (2021) organ dysfunction-based conceptual framework.

The elevated white blood cell count observed in this study indicates systemic inflammatory activation, while thrombocytopenia and elevated creatinine reflect multi-organ involvement. These laboratory abnormalities form essential components of the SOFA score and represent the pathophysiological foundation of the Sepsis-3 definition, which emphasizes organ dysfunction (Singer et al., 2016). Kilinc Toker et al. (2021) demonstrated that SOFA outperformed SIRS and qSOFA largely because it incorporates objective laboratory markers of organ failure. Similarly, Koch et al. (2020) reported superior prognostic performance of SOFA in ICU populations where comprehensive laboratory evaluation is feasible.

CONCLUSION

In our study, SOFA may exhibit the most balanced and consistent clinical efficacy of the three scores within patients. Patients in the study were at risk for sepsis; SOFA has shown high reliability for the early detection of sepsis. The inability of qSOFA to function independently is due to its high specificity but low sensitivity. It can function as an additional screening instrument. The SIRS was found to have low accuracy. It is a screening for inflammation only. The criteria for the assessment of sepsis must be based primarily on organ dysfunction so that the critically ill patients in ICU are identified accurately and timely.

RECOMMENDATIONS

It is suggested that the SOFA score should be regularly used in ICU patients for early diagnosis

of sepsis as it has a balanced and reliable diagnostic performance. The qSOFA score can be used as a rapid bedside assessment in high-risk patients but should be complemented with systematic assessment of organ dysfunction. SIRS may help identify systemic inflammation, but it should not be solely used for diagnosis. Strengthening standardized protocols for sepsis screening as well as regular clinical training can further improve timely recognition and management of sepsis condition.

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