Original Research Article

Comparison of SOFA and APACHE II in Predicting Mortality, Morbidity in Cases of Acute Poisoning and Correlation with Biomarkers of Severity

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Abstract

Introduction: The aim of this research was to compare SOFA and APACHE II scores for the ability to predict mortality and morbidity among patients of acute poisoning. The secondary aim was to relate these scores with biomarkers of severity to determine their prognostic value. Acute poisoning is one of the most important health problems across the globe, a major contributor to the emergency admissions leading to increased morbidity and mortality. Prognosticating measures like SOFA and APACHE II are essential in prioritizing the patients and planning their management. This study assesses their relative roles in predicting the outcome in patients with acute poisoning presenting to the emergency of a tertiary care hospital in Northern India.

Materials & Methods: This was a prospective observational study conducted at a tertiary care centre in Northern India, where 85 patients who had acute poisoning were recruited. The severity score tools were applied and they were compared with the severity markers. The performance of the scores was assessed and the sensitivity and the specificity were analyzed using Receiver Operating Characteristic (ROC) curve analysis.

Results: The SOFA score has been proven to best APACHE II in terms of predictive accuracy. Both scoring systems were found to correlate significantly with NLR, Serum Amylase, and Lactate, with SOFA exhibiting greater sensitivity and specificity.

Conclusion: SOFA serves better in predicting mortality amongst cases of acute poisoning than APACHE II. Strong correlations with critical biomarkers further reinforce the clinical significance of SOFA score.

Keywords: SOFA, APACHE II, Acute Poisoning, Morbidity, Mortality

Introduction

Acute poisoning is one among the significant public health challenges, particularly in low- and middle-income countries, where easy access to toxic substances like pesticides, household chemicals, and pharmaceuticals contributes to high rates of both accidental and intentional poisonings. Globally, the

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World Health Organization (WHO) estimates that approximately 100,000 deaths occur annually due to poisoning, with a substantial portion of these cases occurring in Southeast Asia and Sub-Saharan Africa[1]. In India, the burden of acute poisoning is especially pronounced in rural and agricultural areas, where the extensive use of pesticides, such as organophosphates and aluminium phosphide, poses a significant risk[2].

The clinical management of poisoning cases is complex, as the prognosis can vary widely depending on the type and quantity of the substance ingested, the time to treatment, and the patient's physiological response. Poisoning often leads to multi-organ failure, and the accurate prediction of patient outcomes is critical to determining the level of care required. In this context, scoring systems like the Sequential Organ Failure Assessment (SOFA) and Acute Physiology and Chronic Health Evaluation II (APACHE II) are commonly used in critical care settings to assess illness severity and predict mortality.

SOFA assesses the extent of organ dysfunction, with a particular focus on respiratory, cardiovascular, hepatic, coagulation, renal, and neurological function, while APACHE II evaluates a combination of physiological variables, such as blood pressure, temperature, oxygenation, and hematologic parameters etc.[3,4]. Neutrophil to lymphocyte ratio is a biomarker of severity which was used to predict the outcome in organophosphorus poisoning[5]. Serum amylase level was also used to assess the outcome in organophosphorus and paraquat poisoning.[5,6] Similarly serum lactate level was also used to predict outcome of patients in organophosphorus and aluminium phosphide poisoning [7,8].

This study was conducted to compare the prognostic accuracy of SOFA and APACHE II in predicting mortality and morbidity among patients with acute poisoning admitted to a tertiary care hospital in Northern India. It also addresses the limitations of previous researches by comparing the SOFA and APACHE II scoring systems as prognostic tools for all types of acute poisoning cases presenting in the emergency department. Our study sought to evaluate the feasibility of using one scoring system for determining patient outcomes across various types of acute poisonings. Also, it aimed to correlate the SOFA and APACHE II scores with biomarkers of severity, including Neutrophil-Lymphocyte ratio, serum lactate, and serum amylase levels, which can provide additional insights into the severity of poisoning.

Materials and Methods

Study Design and Population This prospective observational study was conducted over an 18-month period at a tertiary care centre in Northern India. A total of 85 patients were included in the study, the sample size was calculated based on a previous study by Silakhori et al[9], utilizing the diagnostic accuracy of SOFA and APACHE II. The power and level of significance was 80% and 5% respectively[9].

The inclusion criteria required patients to be 18 years or older and admitted with a diagnosis of acute poisoning. Patients with pre-existing chronic conditions, such as heart disease or chronic kidney disease, or those with mixed poisonings (more than one type of toxin) were excluded from the study to maintain a focused study population.

Data Collection and Parameters

Upon admission, detailed demographic data, including age, gender, and residential status (urban or rural), were recorded. Clinical parameters, such as heart rate, blood pressure, respiratory rate, oxygen saturation, and requirement for ventilatory support, were also documented. Laboratory parameters, including Neutrophil-Lymphocyte Ratio (NLR), Serum Amylase, and Serum Lactate, were collected as part of the routine blood investigations.

SOFA and APACHE II scores were calculated at the time of admission using validated scoring systems. The SOFA score assesses organ function across six domains (respiratory, cardiovascular, hepatic, coagulation, renal, and neurological), while APACHE II is a more complex scoring system that evaluates physiological variables, including age, chronic health status, and additional acute physiological disturbances.

Statistical Analysis

All statistical analyses were performed using SPSS software (version 26.0). Descriptive statistics were used to summarize demographic and clinical characteristics. Continuous variables were expressed

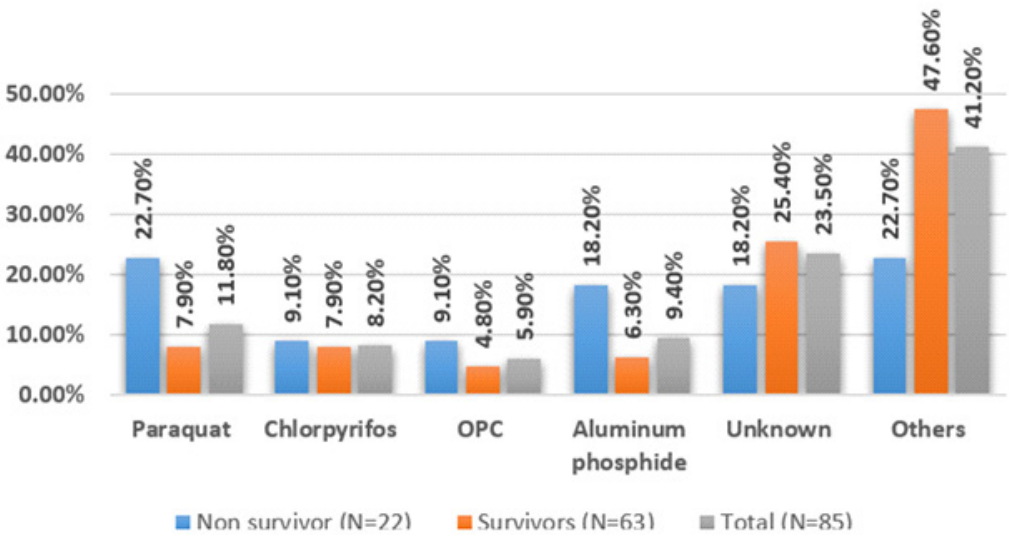
as means and standard deviations, while categorical variables were represented as percentages. The Student's t-test was used to compare continuous variables between survivors and non-survivors, and the chi-square test was used for categorical variables. Receiver Operating Characteristic (ROC) curve analysis was employed to evaluate the predictive accuracy of SOFA and APACHE II scores, and the area under the curve (AUC) was calculated for both scoring systems. Correlations between SOFA/ APACHE II scores and biomarkers were assessed using Pearson correlation coefficients.

Results

Demographic details of the patients who were enrolled.

Table 1: Demographic Characteristics and Age Distribution of Patients

Parameter	Non-survivor (N=22)	Survivor (N=63)	Total (N=85)
Mean Age (years)	35.8 ± 10.6	29.5 ± 11.7	30.8 ± 11.5
Female (%)	7 (31.8%)	19 (30.2%)	26 (30.6%)
Male (%)	15 (68.2%)	44 (69.8%)	59 (69.4%)
Urban (%)	12 (54.5%)	37 (58.7%)	49 (57.6%)
Rural (%)	10 (45.5%)	26 (41.3%)	36 (42.4%)



The most common poison consumed was "Others" (41.2%) which included miscellaneous agents like paracetamol, benzodiazepine, corrosives, tricyclic antidepressants, glyphosate. It was followed by unknown poisons (23.5%), paraquat (11.8%), aluminum phosphide (9.4%), chlorpyrifos (8.2%), and OPC (5.9%). In the non-survivor subgroup, 22.7% consumed paraquat and "Others," while in the survivor subgroup, 47.6% consumed "Others." The difference in paraquat and "Others" consumption between the survivor and non-survivor subgroups was statistically significant (**p=0.045** and **p=0.033**, respectively)

Figure 1: Types of Poisoning Agents and Mortality rate

Vital Signs on Admission

Non-survivors had significantly oxygen saturation compared to survivors, while the rest of the parameters did not show statistical significance with mortality

Table 2: Vital Signs on Admission in Survivors vs. Non-survivors

Variable	Non survivor (N=22)	Survivor (N=63)	Total (N=85)	p-value
Heart Rate (beats/min)	102.1 ± 25.8	92.7 ± 25.1	94.8 ± 25.7	0.072
Respiratory Rate (breaths/min)	21.9 ± 6.7	21.5 ± 6.2	21.6 ± 6.3	0.788
Oxygen Saturation (%)	86.8 ± 12.7	93.1 ± 6.2	91.0 ± 8.5	0.003
Capillary Blood Glucose (mg/dL)	112.5 ± 67.8	109.4 ± 49.7	110.2 ± 53.6	0.807
Temperature (Celsius)	37.2 ± 1.4	37.3 ± 1.4	37.3 ± 1.4	0.777
Arterial pH	7.27 ± 0.19	7.31 ± 0.16	7.30 ± 0.16	0.222
History of Organ Insufficiency	4 (18.2%)	4 (6.3%)	8 (9.4%)	0.101

Ventilation, Inotropic Support, and Hospital Stay. The requirement for mechanical ventilation, inotropic support, and longer ICU stays was higher among non-survivors, highlighting the severity of poisoning in these patients.

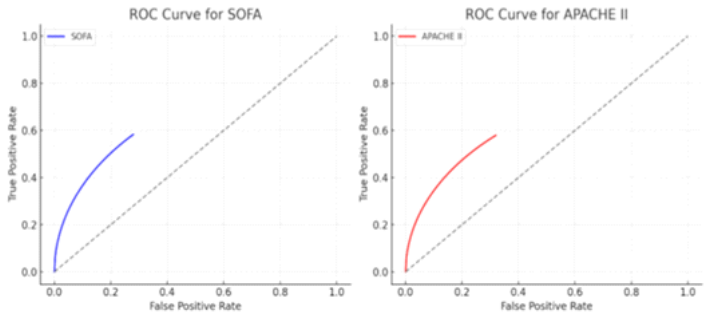
Table 3: Ventilation, Inotropic Support, and Hospital Stay in Survivors vs. Non-survivors

Variable	Non survivor (N=22)	Survivor (N=63)	Total (N=85)
Inotrope Support	16 (72.7%)	21 (33.3%)	37 (43.5%)
Mechanical Ventilation	14 (63.6%)	17 (27.0%)	31 (36.5%)
Days of Invasive Ventilation	4.2 ± 4.3	3.9 ± 3.6	4.0 ± 3.8
Days of Non-Invasive Ventilation	3.5 ± 4.7	3.2 ± 4.0	3.3 ± 4.2

SOFA vs. APACHE II in Predicting Mortality SOFA demonstrated superior predictive accuracy compared to APACHE II, with higher sensitivity and specificity for mortality prediction.

Table 4: Analysis of SOFA and APACHE II

Metric	SOFA	APACHE II	p-value
AUC (95% CI)	0.83 (0.75-0.90)	0.78 (0.69-0.85)	<0.001
Sensitivity (%)	84	79	
Specificity (%)	72	68	
Positive Predictive Value (%)	58	54	
Negative Predictive Value (%)	89	86	



The area under the curve (AUC) for the SOFA score was 0.83 (95% CI: 0.75-0.90), and for the APACHE II score, it was 0.78 (95% CI: 0.69-0.85). The difference in AUC between the two scores was statistically significant (p<0.001). The SOFA score had a sensitivity of 84%, specificity of 72%, positive predictive value (PPV) of 58%, and negative predictive value (NPV) of 89%. The APACHE II score had a sensitivity of 79%, specificity of 68%, PPV of 54%, and NPV of 86%.

Figure 2: Receiver-operation characteristic Curve showing the comparative efficacy of SOFA and APACHE II in predicting the mortality and morbidity in patients of acute poisoing

Discussion

This study aimed to compare the performance of the Sequential Organ Failure Assessment (SOFA) and Acute Physiology and Chronic Health Evaluation II (APACHE II) scoring systems in predicting mortality among patients with acute poisoning. The results demonstrated that SOFA compared to APACHE II was a more reliable predictor of mortality. SOFA's higher sensitivity (84%) and specificity (72%), along with its stronger correlation with key biomarkers such as serum lactate and Neutrophil-Lymphocyte Ratio (NLR), makes it an important and invaluable tool in clinical settings where rapid assessment of patient outcomes is essential.

The significance of the study lies in its focus on high risk population of acute poisoning patients, where early identification of those at higher risk of mortality can drastically improve outcomes through timely interventions. Poisoning often leads to multi-organ failure, which is the core of the SOFA score assessment. This is particularly evident in cases of pesticide poisoning, such as organophosphates and aluminum phosphide, which accounted for a significant proportion of the poisoning cases in this study. Aluminum phosphide, in particular, is known for its high fatality rate due to rapid onset of cardiovascular and metabolic failure, which aligns with the study's finding that aluminum phosphide poisoning had the highest mortality rate among the agents involved. This is supported by other studies showing similar fatal outcomes in aluminum phosphide poisoning, where SOFA was used to track organ dysfunction as a result of systemic toxicity and shock [8,9]

SOFA's emphasis on assessing the extent of organ dysfunction gives it an advantage in poisoning cases where the progression to multi-organ failure can be rapid. Poisoning can disrupt multiple physiological systems simultaneously, which SOFA is well-equipped to capture through its focus on respiratory, cardiovascular, hepatic, and renal systems. Cardiovascular collapse, often seen in cases of pesticide poisoning, is a leading cause of mortality in these patients, and the ability to track this parameter in real time makes SOFA particularly valuable in triaging the patients.

Compared to SOFA, APACHE II's overall predictive power was lower, with an Area Under the Curve (AUC) of 0.78 compared to SOFA's 0.83. APACHE II's approach of incorporating broader physiological parameters, such as chronic health conditions and age, may be less suited to poisoning cases where acute, rapid deterioration could be the primary concern. While APACHE II provides a more holistic view of patient health, it may not capture the nuances of sudden, poisoning-related organ dysfunction as effectively as SOFA.[10]

One of the key findings of this study is the strong correlation between SOFA scores and biomarkers, particularly Serum Lactate, amylase levels and NLR. Elevated Serum Lactate levels were significantly associated with increased mortality, reinforcing its role as a critical marker of metabolic dysfunction and tissue hypoxia in acute poisoning cases. Lactate, a product of anaerobic metabolism, is often elevated in conditions of systemic hypoxia and poor perfusion, both of which are common in severe poisoning. The close correlation between high SOFA scores and elevated Lactate levels suggests that metabolic disturbances are a crucial aspect of the prognosis in poisoned patients. This aligns with previous studies that have identified lactate as an important prognostic marker in other critical conditions, such as sepsis and trauma, where organ failure is a leading cause of death [11,5]

Similarly, the NLR, a marker of systemic inflammation, was found to correlate strongly with both SOFA and APACHE II scores. This is consistent with the understanding that inflammation plays a significant role in the progression of multi-organ failure in poisoning cases. The immune response to toxins can exacerbate tissue damage, leading to further organ dysfunction and higher mortality rates.[12]. The study's findings suggest that the inclusion of biomarkers such as Lactate and NLR alongside clinical scoring systems like SOFA can enhance the predictive accuracy of these tools. This has practical implications for the management of poisoned patients, as real-time measurement of these biomarkers could be integrated into routine ICU assessments to identify patients at higher risk of deterioration.

The findings of this study have several important implications for clinical practice. Given the focus of SOFA on organ dysfunction and its strong correlation with key biomarkers, it can be used to triage patients more effectively in emergency department. In resource-limited settings, where access to advanced diagnostics may be limited, the simplicity of SOFA makes it a particularly valuable tool.[2] The study also highlights the need for early intervention in high-risk poisoning cases. Patients who required mechanical ventilation or inotropic support had significantly higher mortality rates than those who did not, indicating that the need for intensive interventions is a strong predictor of poor outcomes. The identification of high-risk patients based on SOFA scores and biomarker levels could enable clinicians to initiate more aggressive treatments earlier in the clinical course, potentially improving survival rates and also helps in prognosticating the patient and their relatives. This aligns with global trends in critical care, where early identification of organ dysfunction is increasingly recognized as a key determinant of patient outcomes.[13]

Another important implication of this study is SOFA's applicability in resource-limited settings. Poisoning is a major public health issue in low- and middle-income countries, where the use of pesticides and other toxic substances is widespread. In such settings, the availability of complex diagnostic tools may be limited, and the ability to make rapid, data-driven decisions is crucial. SOFA's reliance on easily measurable clinical parameters makes it a practical option for these environments. Moreover, its strong correlation with biomarkers like Lactate and NLR, which can be measured with relatively simple laboratory tests, further enhances its utility in these settings.[14]

In our study, SOFA score demonstrated superior predictive accuracy and correlated better with biomarkers, such as lactate and NLR, particularly in severe or rapidly deteriorating cases. Similar to this research, researches by Kim et al[15] on organophosphate poisoning, by Zhang et al[16] on critically illmultiorgan failure patients and by Beigmohammadi et al[17] on ICU admitted COVID-19 patients, highlighted the advantages of SOFA compared to APACHE II. SOFA score was deemed to be better for acute poisonings, organ failure, and cases with rapid clinical deterioration. Conversely, the APACHE II score has shown better predictive power in specific poisoning types, particularly aluminum phosphide and paraquat poisoning, as evidenced by studies conducted by Pannu et al[10]. and Lee et al[18], Fengjun et al[19]. respectively.

While this study establishes SOFA as a superior tool compared to APACHE II for predicting mortality in acute poisoning cases, further research is needed to validate these findings across different types of poisonings and in larger, multi-center trials. The integration of additional biomarkers, such as procalcitonin or C-reactive protein (CRP), could also be explored to further enhance the predictive accuracy of SOFA. Additionally, the role of serial SOFA measurements in tracking the progression of organ dysfunction over time warrants further investigation.[15]

Conclusion

This study highlights the superior performance of SOFA over APACHE II in predicting mortality in acute poisoning cases. SOFA's higher sensitivity and specificity, along with its stronger correlation with key biomarkers such as Serum Lactate and NLR, make it a more reliable prognostic tool. The results suggest that SOFA is particularly valuable in cases where multi-organ failure occurs rapidly, as is often the case in severe poisonings involving agents like aluminium phosphide.

The study is limited by its single-centric design and relatively small sample size, which may affect the generalizability of the results. It did not incorporate serial SOFA or APACHE II measurements to evaluate the progression of organ dysfunction over time. Other commonly used biomarkers, such as CRP and procalcitonin, were not included in the study outcomes.

Given its simplicity and real-time assessment of organ dysfunction, SOFA can be effectively used in both high-resource and resource-limited settings to guide clinical decision-making. The findings also underscore the importance of integrating biomarker data, particularly Serum Lactate and NLR, with clinical scoring systems to improve the accuracy of

prognosis and optimize patient outcomes. Further research is needed to validate these findings across different types of poisonings and to explore the potential of combining SOFA with additional biomarkers for more precise risk stratification.

Ethical Clearance: Institutional ethical committee of Government Medical College & Hospital 32, Chandigarh approved this study on 7.11.22 ref no.GMCH/IEC/796R/2022/219

Conflicts of Interest: None

Source of funding: Nil

List of abbreviations:

APACHE II: Acute Physiology and Chronic Health Evaluation II

SOFA: Sequential Organ Failure and Assessment

ROC: Receiver Operating Curve

WHO: World Health Organization

NLR: Neutrophil and Lymphocyte Ratio

OPC: Organo phosphorous poisoning

AUC: Area Under Curve

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