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Original Research

Comparison of PIRO vs. SOFA scores in predicting mortality in septic patients admitted to ICU

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Abstract
Aim: To compare PIRO vs. SOFA scores in predicting mortality in septic patients admitted to ICU.
Material and Methods: This prospective observational study was conducted in the department of Anesthesia and Critical Care at Sher-i-Kashmir Institute of Medical Sciences**,** Srinagar during 2018 to 2020 among 200 patients admitted in ICU having sepsis fulfilling inclusion criteria. The PIRO and SOFA scores were calculated from the individual data elements collected in the ICU and recorded on the charts. The most abnormal value recorded in the ICU was used in the score calculations, with the exception of Glasgow Coma Scale score for the SOFA score, which was the best presedation value recorded (as per convention). Blood pressure following IV crystalloid bolus was used for the PIRO score. All data were abstracted into structured proformas by a single investigator.
Results: During the course of this study, a total of 95 patients out of the 200 patients in the study group died, majority had sepsis or septic shock and the overall mortality at 21 days was 47.5%. Among patients admitted to the ICU (n = 200), the PIRO score was superior to the SOFA score: AUC 0.58 versus 0.45. The mean score was high in PIRO group (15.34+/-4.114) as compared to SOFA score (10.52+/-3.560). It was also found that platelet counts <1.5 lakhs, creatinine levels >1.8mg/dl. GCS < 9, age group > 56 years, pneumonia, heart rate >120beats/min, lactate levels > 2mmol and systolic blood pressure < 90 mmHg on admission to ICU had an influence on the 21day mortality rates and the comparison was statistically significant with p-value <0.05.
Conclusion: PIRO model, taking into account comorbidities and septic source as well as physiologic status, performed better than SOFA for predicting mortality in Surgical ICU patients with sepsis and septic shock.
Keywords: PIRO, SOFA, Mortality, Sepsis, ICU

Introduction: The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) recently re-defined Sepsis as a life-threatening organ dysfunction caused by a dysregulated host response to infection leading to life-threatening single or multiple organ dysfunction (MOD), most commonly cardiovascular, pulmonary, renal, and brain dysfunction. Septic shock is defined as persistent hypotension requiring vasopressors to maintain mean arterial pressure (MAP) of 65mmHg or higher, serum lactate of greater than 2mmol/L (18mg/dl), in spite of adequate fluid resuscitation.[(1)]Sepsis occurs in 5–10% of all hospitalized patients and is the most common cause of mortality in ICUs, being fatal in at least 20–30% of patients affected. Sepsis remains the world's most neglected medical emergency. Sepsis strikes an estimated 30 million people worldwide every year, with 6 million estimated deaths. Indian incidence is estimated to be about 7,50,000 cases per year. Sepsis is costly with regards to healthcare resources, as care for sepsis consumes up to 45% of total ICU costs and has become the leading healthcare expense for hospitalized patients.[(2-4)]Early, accurate identification of patients with sepsis is critical to improving outcomes through better targeted medical management yet remains challenging. There is no single "gold standard" diagnostic test for sepsis and case definitions vary widely. In recent years, clinical outcomes, including survival, have improved in sepsis patients, at least in high-income countries, mostly due to international guidelines established over the past 20 years.[(5-7)] These initiatives, such as the "Surviving Sepsis Campaign", have promoted increased awareness of sepsis, early diagnosis in patients at risk, and protocolized management.[(5,7)] However, clinical outcomes remain poor for many patients with sepsis, especially in those presenting with MOD or developing it during the first few days of ICU stay.Severity scoring systems have been used for critically ill patients in ICU, and have implications for patient disposition and outcome. The Sequential Organ Failure Assessment or SOFA score was developed to assess the acute morbidity of critical illness at a population level and has been widely validated as a tool for this purpose across a range of healthcare settings and environments. The SOFA score has become an integrated tool

in a wide range of aspects of critical care since its development in the early 1990s, and it is now widely employed in the daily monitoring of acute morbidity in critical care units. Standardization between different evaluators in widespread centers is the key to detect response to treatment if the SOFA score is to be used as an outcome in sepsis clinical trials.[8]PIRO is a conceptual classification system in which a number of demographic, clinical, biological and laboratory variables are used to stratify patients with sepsis in 4 categories which include a total of 9 characterized risks, according to Predisposition, Insult/Infection, Response, or Organ Dysfunction.[9] In recognition of these factors, the Predisposition Insult Response and Organ failure (PIRO) model has been proposed to reflect each of these domains. We therefore aimed to compare the PIRO and SOFA scores for predicting outcome in high-risk sepsis patients in an adult ICU setting.

Aim and Objectives

1. To determine the accuracy of PIRO vs. SOFA scores in predicting mortality in septic patients admitted to ICU.
2. To determine whether any other confounding factor influences mortality in ICU.

Material and Methods: This prospective observational study was conducted in the department of Anesthesia and Critical Care at **Sher-i-Kashmir Institute of Medical Sciences,** Srinagar during 2018 to 2020.
Sample size: A total of 200 patients admitted in ICU having sepsis fulfilling inclusion criteria.

Inclusion Criteria

1. Age ≥ 18 years.
2. Both genders
3. Sepsis patients who had 2 or more SIRS criteria**.**

- (SIRS criteria: Temperature: <36℃ or >38℃. Heart rate: >90 beats/min. Respiratory rate: >20 breaths/min. WBC count: <4000 cells/mm^3, >12000 cells/mm^3, or >10% immature band forms.)

Exclusion Criteria

1. Patient refusal.
2. Age <18 years.
3. Patient admitted from other ICUs.
4. All patients with limits on life sustaining interventions.

Study Protocol: The PIRO and SOFA scores were calculated from the individual data elements collected in the ICU and recorded on the charts. The most abnormal value recorded in the ICU was used in the score calculations, with the exception of Glasgow Coma Scale score for the SOFA score, which was the best presedation value recorded (as per convention). Blood pressure following IV crystalloid bolus was used for the PIRO score. All data were abstracted into structured proformas by a single investigator.

Statistical methods: The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Statistical software SPSS (version 20.0) and Microsoft Excel were used to carry out the statistical analysis of data. Continuous variables were expressed as Mean± SD and categorical variables were summarized as percentages. Student's independent t-test and analysis of variance (ANOVA) were employed for comparison of continuous variables. The method of analysis was to compare the area under the receiver operator characteristic (ROC) curves (AUC) for each of the two scoring systems. Descriptive statistics were presented, with the Wilcoxon rank-sum test used for continuous data comparisons, and chi-square test for categorical data. A p-value of less than 0.05 was considered statistically significant.

Results: A total of 200 participants with sepsis were incorporated in the study including 129 males and 71 females. Also, 56+years was the most common age group. Patients admitted from both medical and surgical departments were included, with majority of the patients being admitted from the Emergency room. In this study, 7 patients had COPD, 16 patients were suffering from some sort of malignancy, 13 patients were nursing home residents and were on oxygen support prior to being admitted to ICU and 7 patients had chronic liver disease. During the course of this study, a total of 95 patients out of the 200 patients in the study group died, majority had sepsis or septic shock and the overall mortality at 21 days was 47.5%. The most frequent site of infection was respiratory tract (42.5%), followed by blood stream (27.5%), skin or soft tissue (7%), urinary tract (5%), and others (10%). A clinical source was not identified in 8% of these cases. The infecting organism was identified in 54% of cases, with a slight predominance of Gram-negative organisms. The Predisposition, Insult/Infection, Response, and Organ dysfunction (PIRO) scoring model performed better than the Sequential Organ Failure Assessment (SOFA) for predicting mortality in Surgical ICU patients with sepsis and septic

shock. The ROC (receiver operator characteristic) curves for the PIRO and SOFA scores for 21-day mortality with pair wise comparisons of the AUC (area under curve) were as follows: PIRO versus SOFA, p > 0.05; (Figure 1). A sensitivity analysis stratified by ICU admission showed similar performance of each of the scores. However, among patients admitted to the ICU (n = 200), the PIRO score was superior to the SOFA score: AUC 0.58 versus 0.45. The mean score was high in PIRO group (15.34+/-4.114) as compared to SOFA score (10.52+/-3.560). There is a positive correlation between PIRO and SOFA scores and correlation is statistically significant p-value <0.05 (Table 1).

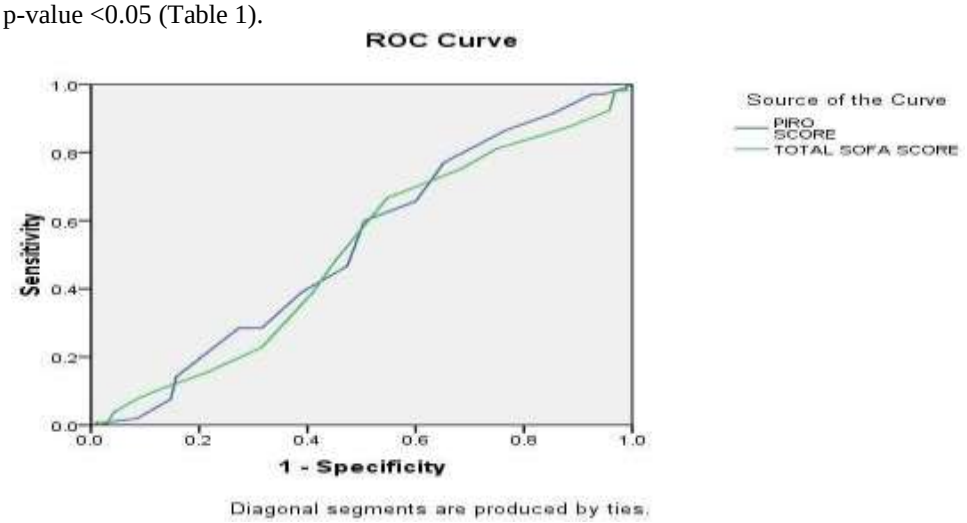

Figure 1: **The ROC (receiver operator characteristic) curves for the PIRO and SOFA scores for 21-day mortality**

Descriptive Statistics

	Mean	Std. Deviation	N
PIRO ...	15.34	4.114	200
TOTAL SOFA SCORE	10.52	3.560	200

Correlations

		PIRO SCORE	TOTAL SOFA SCORE
PIRO SCORE	Pearson Correlation	1	.525**
	Sig. (2-tailed)		.000
	N	200	200
TOTAL SOFA SCORE	Pearson Correlation	.525**	1
	Sig. (2-tailed)	.000	
	N	200	200

**. Correlation is significant at the 0.01 level (2-tailed).

Table 1: Showing the mean scores of PIRO vs SOFA scores and the correlation between them

Amongst the 200 patients in our study, 128 patients had a platelet count of <1.5 lakhs on admission to ICU, and their 21 day mortality percentage was 60.16% as compared to 25% 21 day mortality percentage among the 72 patients with platelet count >1.5 lakhs on admission to ICU. This comparison was statistically significant with a p-value 0.001. Similar results were revealed for creatinine and GCS. Amongst the 200 patients in our study, 85 patients were having pneumonia on admission to ICU, and their 21 day mortality percentage was 81.18% as compared to 22.60% 21 day mortality percentage among the 115 patients with no pneumonia on admission to ICU. This comparison was statistically significant with a p-value of 0.001 (Table 2).

Table 2: 21 day mortality of patients with platelet count, creatinine, pneumonia and age

Platelet Count <1.5lakh	N	21day Mortality	Mortality %	P-Value
No	72	18	(25%)	0.001
Yes	128	77	(60.16%)	
Creatinine Level				
<1.8mg/Dl	179	78	43.57%	0.001
>1.8mg/Dl	21	17	80.95%	
GCS				
>9	171	74	43.27%	0.003
<9	29	21	72.41%	
Pneumonia				
No	115	26	22.60%	0.001
Yes	85	69	81.18%	
Lactate				
<2mmol	82	25	30.49%	0.005
>2mmol	118	70	59.32%	
Age				
<56	171	71	41.52%	0.007
>56	29	24	82.76%	
COPD				
No	193	91	47.15%	0.197
Yes	7	4	57.14%	

106 patients were having heart rate >120 b/min on admission to ICU and their 21 day mortality percentage was 57.55%, as compared to 36.17% 21 day mortality among the 94 patients with heart rate <120 b/min on admission to ICU. This comparison was statistically significant with a p-value 0.002 (table 3).

Table 3: 21 day mortality of patients with hemodynamic variables

Heart Rate >120b/Min	N	21day Mortality	Mortality %	P-Value
No	94	34	36.17%	0.002
Yes	106	61	57.55%	
SBP				
<90	128	71	55.47%	0.002
>90	72	24	33.33%	
Respiratory Rate >20b/M				
No	17	5	29.41%	0.11
Yes	183	90	49.18%	

Discussion: Evaluation and management of sepsis patients requires clinical judgement. For assessment of severity of sepsis many scoring systems have been developed in last decades, used in both accident and emergency and critical care setting which have implications on the management of patients, admission decision and admission type. These risk prediction scores provide very important tool for clinicians by allowing uniform standardization and objective estimations of mortality for both research and clinical decision making purposes. Many severity scoring systems have been used for critically ill patients in ICU and have implications for patient disposition and outcomes. One of the characteristics of a clinical scoring system is that it needs to apply

commonly used and easily available predictive indicators. Both SOFA and PIRO scoring systems used in our study fulfill these criteria.

In our study, 200 patients having sepsis or septic shock were included, among these 129 were males and 71 were females. Most common age group was 56 and above, while ER was the most common source of admission for these patients. Our descriptive study showed that the mean score was high in PIRO group (15.34+/-4.114) as compared to SOFA score (10.52+/-3.560). There was a positive correlation between PIRO and SOFA scores and correlation was statistically significant with p-value <0.05.Stephen P.J. Macdonald et al[10] reported with a mortality rate of 20% in sepsis patients and an AUC of 0.86 in the external validation of their PIRO model in ED.

In our study, which predominantly consisted of patients with severe sepsis and septic shock, with an associated higher mortality rate of 47.5%, performance of PIRO model was comparable with an AUC of 0.58. Many other studies have evaluated the utility of the PIRO model in ICU sepsis.*de Groot B, de Deckere ER* et al[11] found that PIRO score added little value over clinical judgement in guiding adequate disposition towards or the ICU. *de Groot B, Lameijer J* et al[12] found that the accuracy and discriminative performance of the PIRO score and clinical judgement are similar, but better than the sepsis category. *Chen YX et al[13]* found that PIRO is helpful for risk stratification and prognostic determinations in septic patients in the ED. In their study of ICU sepsis patients, the PIRO model had an AUC of 0.82 for 28-day mortality. The authors stated that the "O" (organ failure) element of the score was as useful as the entire score, but they excluded patients with metastatic malignancy and liver disease, which are elements of the PIRO model.

For the admission SOFA score, we found a 21-day mortality AUC of 0.45. This is comparable to the AUC of 0.75 for admission SOFA score to predict in-hospital mortality found in a study by Jones AE et al[14] of 248 ED patients with septic shock. The SOFA, however, takes no account of age and comorbidity which are known to be independent drivers of mortality in sepsis[15,16]. While our data confirm that organ failure is an important factor in predicting worse outcome, it is unsurprising that the PIRO, which takes into account age, comorbidity and the source of infection, outperformed the SOFA for 21-day mortality prediction. We found the PIRO model to have better sensitivity for mortality. While the SOFA and PIRO do have some common variables, the PIRO model is more complex, requiring 13 variables compared to eight for the SOFA score. The clinical utility of a more complex model in practice remains to be demonstrated. Our findings are consistent with those of Howell et al[17] in demonstrating a PIRO score of >15 is associated with particularly high mortality risk. Finally, the PIRO model may be a means of stratifying admission into clinical trials of interventions in sepsis, so that meaningful intergroup comparisons can be made. Other PIRO models have been used to determine mortality in septic patients in the ICU. Chen and Li[16] developed and validated a PIRO based model for assessment of community acquired pneumonia in China with AUC of 0.82 in the validation cohort (17% overall 28-day mortality).

During our study, we compared 21 days mortality among patients with multiple factors used in both the scoring systems PIRO and SOFA to determine whether any of these confounding factors independently influenced mortality in ICU, it was found that platelet counts <1.5 lakhs, creatinine levels >1.8mg/dl. GCS < 9, age group > 56 years, pneumonia, heart rate >120beats/min, lactate levels > 2mmol and systolic blood pressure < 90 mmHg on admission to ICU had an influence on the 21day mortality rates and the comparison was statistically significant with p-value <0.05. These findings were comparable to a study conducted by Patricia C. Liaw et al[18] who found that variables of three biological indicators (cfDNA, Lactate and Creatinine) had positive estimated coefficients, indicating that higher values of these variables were associated with greater hazards of dying. In contrast, the estimated coefficients for the corresponding variables of Protein C, Platelets, and GCS were negative, indicating the opposite association with the hazard of dying. The estimated coefficients of chronic lung disease, previous brain injury and duration of stay were also positive, suggesting that the presence of these preconditions as well as advanced Age were associated with higher hazards of dying. Maheshwari K et al[19] evaluated associations of MAPs below various thresholds and in-hospital mortality and found that, for every one unit increase in time-weighted average mean arterial pressure (TWA-MAP) < 65 mmHg, the odds of in-hospital mortality increased 11.4%. Fanny Vardon-Bounes, et al[20] found that, thrombocytopenia was associated with an increase in the rate of mortality. Laterre Pierre-Francois et al[21] investigated community-acquired pneumonia (CAP) as a cause of severe sepsis and concluded that CAP associated with a high Pneumonia Severity Index score, bacteremia, or an intense coagulation and inflammatory response requiring intensive care unit care were indicators of a high risk of death from severe sepsis.

Limitations:

- Case selection was the main limiting factor in our study. This was a planned subgroup analysis of sepsis patients within a larger study of patients presenting with sepsis and septic shock and was not representative of the scale of severity of sepsis in the ICU.
- All ICU sepsis studies have patient selection issues to some extent, given the lack of a reliable case definition. Cases were selected using an objective case definition.

- The risk scores were not calculated in real time in the ICU and were not used to guide clinical care.

Conclusion: The SOFA score uses only physiological and laboratory variables and does not consider host factors such as age and comorbid disease burden, which are important drivers of mortality in sepsis. Whereas PIRO model, taking into account co-morbidities and septic source as well as physiologic status, performed better than SOFA for predicting mortality in Surgical ICU patients with sepsis and septic shock. These findings have implications for identifying and managing high-risk patients and for the design of clinical trials in sepsis.

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