

# Sequential Organ Failure Assessment (SOFA) Score as a Predictor of Outcome in Patients Admitted in a Medical ICU

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## ABSTRACT

**Objective:** To assess the efficacy of Sequential Organ Failure Assessment score (SOFA) as a determinant of outcome in critically ill medical patients.

**Study Design:** Prospective observational cohort study

**Place and Duration of Study:** This study was conducted at Medical ICU of Civil Hospital Karachi from June 2014 to December 2014.

**Materials and Methods:** The study was conducted on 152 patients admitted in the Medical ICU. The SOFA score was calculated on admission and thereafter daily until ICU discharge or death. The primary outcome measure was ICU mortality. The initial SOFA score, the SOFA scores at 48 and 72 hours, the mean and highest SOFA scores and the trend of SOFA score during the initial 48 hours were correlated with mortality.

**Results:** The overall ICU mortality rate was 35.5 % (n=54). Patients with an initial SOFA score of  $\leq 9$  had a mortality rate of 28.9%, while patients with an initial SOFA score of  $\geq 10$  had a mortality rate of 88.2 %. The SOFA scores at 48 and 72 hours also showed significant association with mortality. The mortality rates of patients having a score of  $\leq 9$  at 48 and 72 hours were 25.6% and 20% respectively while the mortality rates of those with a score of  $\geq 10$  at 48 and 72 hours were 91.3% and 93.8% respectively. A sharp rise in mortality was seen when the Highest SOFA score during the entire ICU stay exceeded 7. Patients having a mean SOFA score of greater than 5 had a mortality rate of 66.7% regardless of length of stay. Univariate Logistic Regression Analysis revealed that the Highest SOFA score had closest correlation with mortality followed by Mean SOFA score, SOFA at 48hours, and SOFA at 72 hours. The biggest area under the receiver operating characteristic curve (AUROCC) was seen for the Highest SOFA score followed by SOFA at 72 hours, Mean SOFA score and SOFA at 48hours. Analysis of the changes in SOFA score during the first 48 hours depicted a mortality rate of 54.9% when the score increased, 27.6% when the score decreased and 23.3% when it did not change.

**Conclusion:** The serial evaluation of SOFA score proved to be a convenient and efficient tool to predict mortality in the critically ill ICU patients.

**Key Words:** SOFA score, ICU mortality, Outcome

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## INTRODUCTION

While managing critically ill patients, the clinician's decisions are frequently based upon the predicted outcome of the patient. Outcome prediction is also utilized to perform clinical studies and to assess ICU performance.<sup>1</sup> Such information can also be useful to counsel the patients' relatives. For this reason several scoring systems have been developed to assess the severity of illness in critically ill patients. Some of the commonly employed scoring systems are Acute Physiology and Chronic Health Evaluation (APACHE II & III),<sup>2</sup> Multiple Organ Dysfunction Score (MODS),<sup>3</sup> Simplified Acute Physiology Score (SAPS II),<sup>4</sup> Mortality Prediction Model (MPM)<sup>5</sup> and Sequential

Organ Failure Assessment Score (SOFA).<sup>6</sup>

The *Sepsis-related Organ Failure Assessment score* (SOFA) was originally devised in 1994 to describe the degree of organ dysfunction associated with sepsis by the European Society of Intensive Care Medicine.<sup>6</sup> However later studies demonstrated comparable efficacy of this scoring system in non-septic patients as well. Hence the acronym "SOFA" was changed to *Sequential Organ Failure Assessment Score*.<sup>7</sup> The SOFA score is calculated by assessing the function of six organ systems, namely the cardiovascular, respiratory, hepatic, renal, coagulation and the central nervous system. Each system is assigned a score from 0 (normal) to 4 (most abnormal). Thus a patient can have a total score ranging from 0 to 24. The SOFA score is calculated upon admission to the hospital and thereafter daily until discharge or death. Although SOFA was originally not designed to predict outcome, several studies have demonstrated a clear relationship between

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organ dysfunction and mortality.<sup>8</sup> Hence the SOFA score was also validated to predict mortality in critically ill patients.<sup>9-13</sup>

A lot of research has been done internationally on the efficacy of SOFA scoring system but very scarce data has been reported on this subject from Pakistan. The aim of this study was to validate the efficacy of SOFA scoring system in our population and to compare the results with internationally published data.

## MATERIALS AND METHODS

This was a prospective observational study conducted in the Medical ICU at Civil Hospital Karachi from June 2014 to December 2014. We included all the patients admitted in the Medical ICU during the study period. Patients who were admitted in the ICU for less than 24 hours and those who were transferred from other hospitals were excluded. The SOFA score was calculated for each patient on admission and then daily until discharge from ICU or death. For sedated or intubated patients the assumed GCS value was taken as judged by the clinician. Out of the total 9162 values 49 were missing. These missing values were replaced by the mean of the preceding and subsequent values.

The Mean SOFA score was calculated by dividing the total score of all ICU days by the duration of stay. The change in SOFA score in the first 48 hours (Delta SOFA 48) and the Highest SOFA score during the entire ICU stay were also noted. The primary outcome measure was the survival status after 28 days of ICU admission. Based on their survival status the patients were divided into two categories; survivors and non-survivors. All the data was recorded on a pre-designed proforma by the primary investigators with the help of post-graduate students.

Statistical analysis was performed through SPSS version 16.0 and a *p* value <0.05 was considered statistically significant. For various SOFA parameters the odds ratio with 95% confidence interval was calculated using univariate logistic regression model

with ICU outcome as the dependent variable. The chi-squared test was used to evaluate the statistical significance of categorical variables. The results are presented as mean (SD). The area under the receiver operating characteristic curve (AUROCC) was calculated for the different SOFA variables to evaluate their efficacy to predict mortality.<sup>14</sup>

## RESULTS

Table 1 shows the calculation of SOFA score. The demographic characteristics of the study population are summarized in Table 2. The study included 152 patients with a mean age of 38 ±16.36 years. There were 86 male and 66 female patients. The overall mortality was 35.5% (n=54) and the mean ICU stay was 10.75 days (range 1-97).

Figure 1 shows the correlation between the mortality rate and the various SOFA derivatives. The initial SOFA score was significantly related to the survival status (Figure 1A). Patients with an initial SOFA score of ≤ 9 had mortality rate of 28.9%, while patients with an initial SOFA score of ≥ 10 had mortality rate of 88.2%. The SOFA scores at 48 and 72 hours of admission correlated almost identically with mortality (Figure 1B & 1C). At 48 hours of admission, patients with a SOFA score of ≤ 9 had mortality rate of 25.6%, while patients with a score of ≥ 10 had mortality rate of 91.3%. At 72 hours of admission, patients with a SOFA score of ≤ 9 had mortality rate of 20%, while patients with a score of ≥ 10 had mortality rate of 93.8%. The mortality association of Highest and Mean SOFA score was also analyzed. A sharp rise in mortality can be seen when the Highest SOFA score exceeded 7 (Figure 1D). A mean SOFA score of >5 correlated with a mortality rate of 66.7% (Figure 1E). The mortality association of change in SOFA score during the initial 48 hours showed that the mortality rate was 54.9% when the score increased, 27.6% when the score decreased and 23.3% when it did not change (Figure 1F).

**Table No.1: Sequential Organ Failure Assessment (SOFA) score calculator.**

SOFA score	0	1	2	3	4
<b>Respiration</b> PaO <sub>2</sub> /FIO <sub>2</sub> SaO <sub>2</sub> /FIO <sub>2</sub>	>400	<400 221-301	<300 142-220	<200 67-141	<100 <67
<b>Coagulation</b> Platelet count 10 <sup>3</sup> /mm <sup>3</sup>	>150	<150	<100	<50	<20
<b>Liver</b> Bilirubin (mg/dL)	<1.2	1.2-1.9	2.0-5.9	6.0-11.9	>12.0
<b>Cardiovascular<sup>b</sup></b> Hypotension	No hypotension	MAP <70	Dopamine ≤5 or dobutamine (any dose)	Dopamine >5 or norepinephrine ≤0.1	Dopamine >15 or norepinephrine >0.1
<b>CNS</b> Glasgow Coma Score	15	13-14	10-12	6-9	<6
<b>Renal</b> Creatinine (mg/dL) or urine output (mL/d)	<1.2	1.2-1.9	2.0-3.4	3.5-4.9 or Urine output <500	>5.0 or Urine output <200

MAP, mean arterial pressure; CNS, central nervous system; PaO<sub>2</sub>, partial pressure of oxygen; FIO<sub>2</sub>, fraction of inspired oxygen; SaO<sub>2</sub>, peripheral arterial oxygen saturation. <sup>a</sup>PaO<sub>2</sub>/FIO<sub>2</sub> ratio was used preferentially. If not available, the SaO<sub>2</sub>/FIO<sub>2</sub> ratio was used; <sup>b</sup>vasoactive medications administered for at least 1 hr (dopamine and norepinephrine dose in ug/kg/min).

Table 3 lists the results of Univariate Logistic Regression Analysis, with ICU death as the outcome variable of interest. The Highest SOFA score was found to correlate most closely with mortality followed by Mean SOFA score, SOFA at 48hours, and SOFA at 72

hours. The trend of SOFA score in the first 48 hours and initial SOFA score also correlated significantly but to a lesser extent. The Length of Stay in ICU did not significantly affect mortality.

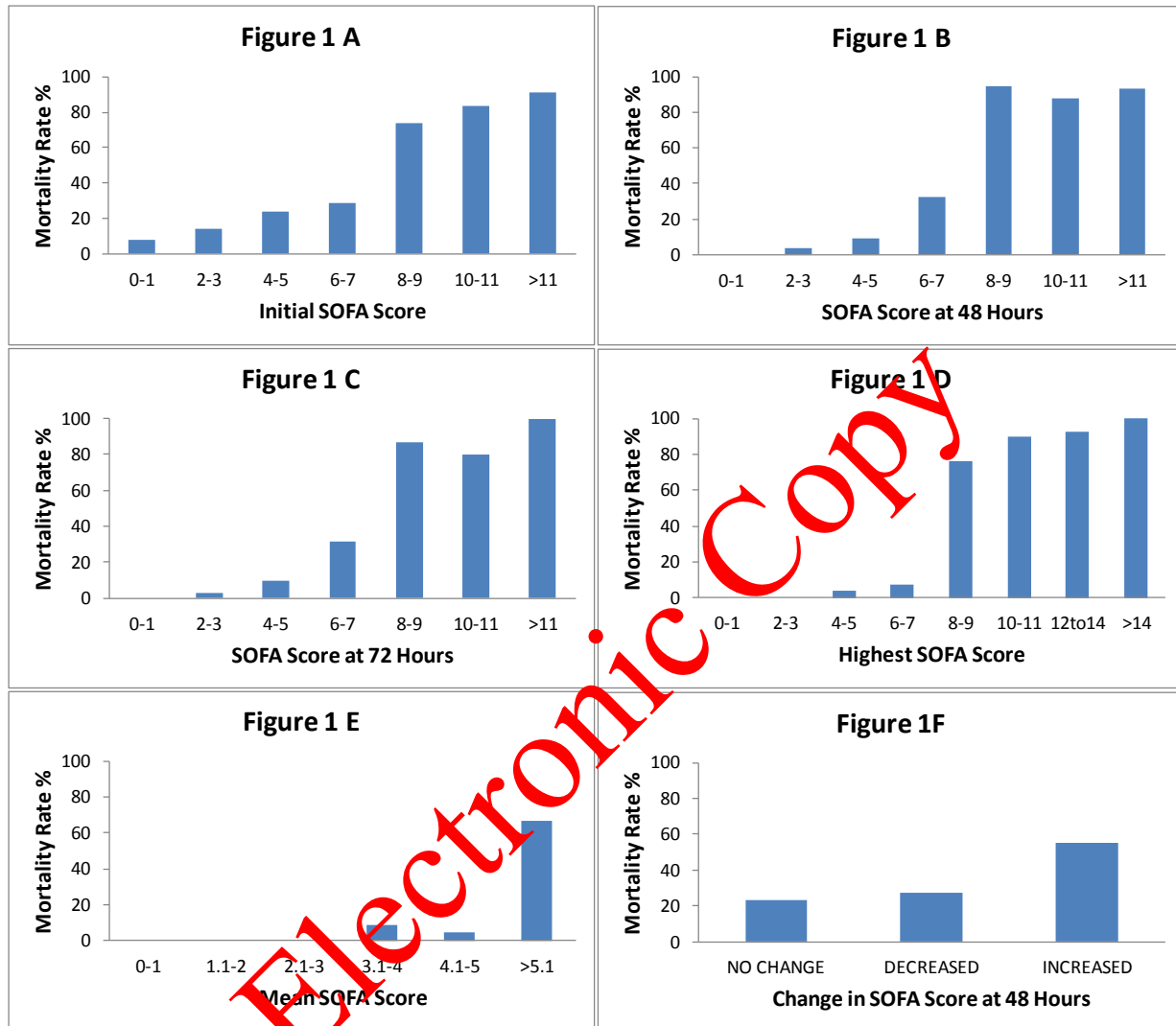


Figure No.1. Correlation between the Mortality Rate and the various SOFA scores

Table No.2. Demographics of the study population

Characteristics	Values
Total No. of patients	152
Gender	
Males	86 (56.6%)
Females	66 (43.4%)
Age (years)	
Mean(SD)	38 (16.36)
Range	18-75
Length of stay in ICU (days)	
Mean	10.57
Median	7.00
Range	1-97
No. of Deaths	54 (35.5%)

The discriminative power of the various SOFA derivatives was further analyzed by the area under receiver operating characteristic curve (AUROCC) (Figure 2). The AUROCC was largest for the Highest SOFA score (0.960, SE 0.016) followed by SOFA at 72 hours (0.950, SE 0.019), Mean SOFA score (0.946, SE 0.018) and SOFA at 48hours (0.927, SE 0.023). Finally a comparison of initial SOFA score and SOFA score at 48 and 72 hours among the survivors and non survivors was done using student t-test (Table 4). Non-survivors had significantly higher SOFA scores both initially and at 48 and 72 hours of admission when compared to survivors ( $p < 0.05$ ).

Finally a comparison of initial SOFA score and SOFA score at 48 and 72 hours among the survivors and non survivors was done using student t-test. Non-survivors

had significantly higher SOFA scores both initially and at 48 and 72 hours of admission when compared to survivors ( $p < 0.05$ , Table 4).

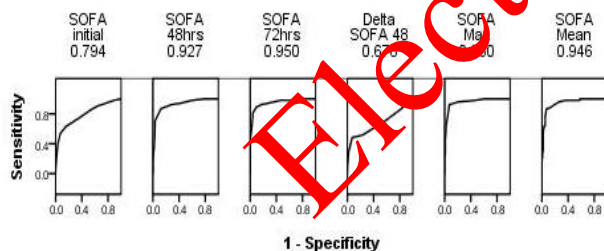
**Table No.3: Univariate Logistic Regression Analysis**

Variables	Coefficient Mean (SE)	Odds Ratio	95% CI	P Value
Highest SOFA Score	0.961 (0.173)	2.615	1.864-3.669	<0.001
Mean SOFA Score	0.924 (0.154)	2.519	1.864-3.405	<0.001
SOFA Score at 48 hrs	0.842 (0.144)	2.322	1.751-3.079	<0.001
SOFA Score at 72 hrs	0.782 (0.126)	2.185	1.707-2.798	<0.001
Delta SOFA 48	0.453 (0.106)	1.572	1.277-1.935	<0.001
Initial SOFA Score	0.411 (0.079)	1.509	1.292-1.762	<0.001
Length of Stay in ICU	0.003 (0.011)	1.003	0.982-1.025	0.776

**Table No.4: Comparison of Initial SOFA score, SOFA score at 48 hours and SOFA score at 72 hours among survivors and non-survivors**

Characteristics	Survivors	Non-survivors
Initial SOFA score, Mean (SD)	4.49 (2.37)	8.13 (3.74)*
SOFA Score at 48 hrs, Mean (SD)	4.12 (2.25)	9.37 (3.18)*
SOFA Score at 72 hrs, Mean (SD)	3.52 (2.18)	10.67 (3.60)*

\* $p < 0.05$  compared to survivors (Student t-test)



**Figure No.2. AUROCC for various SOFA scores**

## DISCUSSION

The findings of this study confirm that worsening organ dysfunction, as assessed by the serial evaluation of SOFA score, is closely related to ICU mortality. The SOFA score on admission provides an initial guide towards the prognosis while serial evaluation of SOFA score on daily basis can be used to assess patient's progress and response to treatment and help the physician to decide further management.

In our study the initial SOFA score as well as the scores at 48 and 72 hours of admission, and the trend of SOFA score in the first 48 hours correlated significantly with

mortality. Similar findings were reported by Moreno et al<sup>15</sup> in their prospective multicenter study. Other researchers have reported that mortality prediction of the initial SOFA score quantified by the AUROCC, ranged between 0.67 and 0.82.<sup>9, 16, 17</sup> Our study showed a similar predictive value of the initial SOFA score with an AUROCC of 0.794 (SE 0.040).

In a prospective study of 352 patients, Ferreira FL et al<sup>9</sup> reported that when the SOFA score increased during the first 48 hours of admission the mortality rate was at least 50%, while decreasing score predicted a mortality rate of only 27%. Another study by Russell JA et al<sup>18</sup> showed similar results. Our study also depicted a higher mortality in patients whose SOFA score increased during the initial 48 hours. Researchers have shown that organ failure can occur quite early in the ICU patients.<sup>19</sup> Hence a worsening SOFA score in the initial 48 hours can help to detect organ failure early and aid in crucial decision making.<sup>20</sup>

For patients who survive the initial phase of ICU stay the highest and mean SOFA scores can provide further insight into the possible outcome. In a prospective analysis of 1,449 patients Vincent JL and colleagues<sup>7</sup> reported a mortality rate of 90% in patients with a maximum SOFA scores greater than 15. Similarly in our study the highest SOFA score during the ICU stay correlated most closely with mortality and presented the largest AUROCC. In another study Cabrè and colleagues<sup>8</sup> reported that in patients above 60 years of age a maximum SOFA score more than 13 and a rising or unchanged SOFA score during the first 5 days of admission was associated with 100% mortality.

The performance of SOFA scoring system has also been compared with various other organ failure scores.<sup>21, 22, 23, 24</sup> In a retrospective study of 110 patients Su-Jung Chen et al<sup>21</sup> concluded that SOFA and APACHE II scores have comparable efficacy as predictors of mortality. In another study Halim DA et al<sup>22</sup> reported that SOFA and Modified SOFA scoring system performed better than APACHE II to predict ICU mortality.

The results of our study confirm that SOFA scoring system is an effective and reliable tool to predict outcome of ICU patients. Since ICU is a dynamic medical environment where patients' condition can change rapidly in either direction, SOFA scoring system may be a better prognostic tool as compared to other commonly used scoring systems such as APACHE II, SAPSII and MPM which utilize the parameters recorded within the first 24 hours of ICU admission to predict outcome. As critical care is a costly business, the implementation of such scoring system in the resource constrained ICUs of the developing countries may help to allocate their limited resources to those patients who have a better predicted outcome.<sup>25</sup>

## CONCLUSION

Serial evaluation of the SOFA score is a convenient and effective indicator of the prognosis of critically ill

patients as depicted by internationally published data. The current study aptly proves its efficacy in our population as well but larger multicenter studies are recommended locally to further emphasize its effectiveness and its implementation.

**Conflict of Interest:** The study has no conflict of interest to declare by any author.

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