

## Utility of SOFA (Sequential Organ Function Assessment) score to predict outcome in critically ill patients at a tertiary care hospital, Nagpur

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### Abstract

Prognostication is an important part of management of any critically ill patients. It helps in predicting the reliable outcome of a patients' current standing. SOFA (Sequential Organ Function Assessment) score is a prognostic scoring system used to track a person's status during the stay in an intensive care unit. It is based on functions of 6 organ systems-respiratory system, cardiovascular system, Hepatic system, coagulation system, excretory system and nervous system. Although it contains many parameters which are difficult to remember, one can use the readymade calculators present on internet. This study was undertaken with the objective to study the utility of SOFA scores in predicting outcome in critically ill patients. Outcome measures being ICU mortality and length of ICU stay. This prospective observational hospital based longitudinal study was carried out over a period of 2 months in a tertiary care hospital catering more of rural population. Adult critically ill patient irrespective of underlying cause were included in study after taking written consent from patient or his akin. Patient's demographic profile, the main diagnosis leading to hospitalization in the ICU, previous interventions, complications and hospital outcomes were recorded for each patient. Appropriate investigations were done. SOFA score was calculated in period 0-24 hrs (SOFA 1), 24-48 hrs (SOFA 2) and 48-96 hrs (SOFA 3) from admission to ICU. SOFA scores were correlated with outcome measures ICU mortality and length of ICU stay. The non survivors had high initial, mean and highest SOFA scores as compared to survivors. Initial and highest scores of more than 15 corresponded to mortality of more than 75%. The predictive value of the mean score had negligible relation and therefore was independent of the length of ICU stay. Length of stay is not significant and independent of mortality. Increasing SOFA score in first 48 hrs gives a mortality rate of >50%. The SOFA scoring system is useful in predicting outcomes in ICU. High SOFA scores, and increasing trend in SOFA scores were found to be significantly associated with mortality and length of ICU stay.

**Keywords:** ICU stay, SOFA score, Tertiary care hospital.

### Introduction

Prognostication is an important part of management of any critically ill patients. It helps in predicting the reliable outcome of a patients' current standing. Prognostication of patient's survival, are important to both physician and patient in all phases of a patient's life because they are helpful in making both clinical and personal decisions. Despite its importance, a physician prognostication on advanced illness can be largely inaccurate. Their prognosis may fail to be specific and has a chance of being mis-communicated between fellow medical professionals and the patient. The need to better prognoses a patient has led to development of many prognostic scoring system. These prognostic estimators when applied to large statistical population can be very accurate. Among the many scores that are being extensively studied, SOFA score has been a major researched topic. But despite studies, a sufficient data is still not available on the subject. SOFA (Sequential Organ Function Assessment) score is a prognostic scoring system used to track a person's status during the stay in an intensive care unit. It is based on functions of 6 organ systems-respiratory system, cardiovascular system, Hepatic system, coagulation system, excretory system and nervous system. This technique is suitable for prognosis of the mortality rate during a patient's stay at an operative

ICU.<sup>(1)</sup> Various studies across the globe proved that regular, repeated SOFA scoring helps to monitor patients' condition and disease development. The SOFA score enables comparison between patients that would benefit from clinical therapies and procedures. Vincent et al<sup>(2)</sup> many decades back in a multicentric study revealed the importance of SOFA scores in septicemic patients while Acharya et al<sup>(3)</sup> also stressed the utility of SOFA scores amongst critically ill patients. Fröhlich M et al proved importance of SOFA scores in post-traumatic patients with MODS patients.<sup>(4)</sup> Naqvi IH et al studied and compared different scores like APACHEE 2 or SAP score found SOFA score to be equally predictive of mortality.<sup>(5)</sup> Although it's not very difficult to calculate and in spite of widespread availability of SOFA calculators on internet, it is not very commonly used in majority of ICUs. This study is undertaken basically to assess utility of SOFA score in predicting outcome in critically ill patient admitted in a medical ICU in a tertiary academic hospital.

### Aim and Objective

To study the utility of SOFA scores in predicting outcome in critically ill patients. Outcome measures are ICU mortality and length of ICU stay.

## Materials and Methods

This prospective observational hospital based longitudinal study was carried out over a period of 2 months in a tertiary care hospital catering more of rural population. Study was conducted during August to October 2016. Adult critically ill patient irrespective of underlying cause admitted in MICU and who gave consent for the study were included in study. A patient who gets discharge or leaves hospital without medical advice within 24 hours were excluded from the study. After taking approval from Institute's Ethics Committee, the Project was initiated. The subjects fulfilling inclusion criteria were enrolled in the study and written consent from patient or accompanying person was taken. Demographic profile, the main diagnosis leading to hospitalization in the ICU, previous interventions, complications and hospital outcomes were recorded for each patient. Cause for admission in ICU was noted. Thorough clinical examination had been done. Subjects were evaluated for Glasgow coma scale. Partial pressure of oxygen, fraction of inspired oxygen, serum creatinine, total bilirubin, platelet count, itemized Glasgow Coma Scale score, mean arterial pressure and use of vasopressors such as dopamine, dobutamine, adrenaline and noradrenaline were noted. The worst values for each parameter in 0-24 hrs, 24-48 hrs and 48-96hrs period since admission to ICU are used. For a single missing value, a replacement was calculated from the mean of the sum of the results for the immediate preceding day and the following day. Based on these parameters SOFA score was calculated in first 24 hours and then every 48 hours. SOFA (Sequential Organ Function Assessment) score is a prognostic scoring system used to track a person's status during the stay in an intensive care unit. It is based on functions of 6 organ systems- respiratory system, cardiovascular system, Hepatic system, coagulation system, excretory system and nervous system. The SOFA score is an integer ranging from 0 to 24, where a greater value corresponds to worse organ function derangement. Its value is the sum

of 6 individual organ system scores, each ranging from 0 to 4. Two Outcome measures death and length of ICU stay are evaluated in all subjects at the end of the study. These outcome measures are compared in respect to SOFA score.

**Statistical test:** Pair-T statistical test is applied. Scatter diagrams and co efficient are calculated. Co-relations between SOFA score and outcome measures (death and length of ICU stay) are calculated, analysed and organised to establish the results. Statistical data on the following was collected:

- i. Co-relation of SOFA score in 0-24 hrs (i.e. 'SOFA 1') with mortality.
- ii. Co-relation of SOFA score in 24-48 hrs (i.e. 'SOFA 2') with mortality.
- iii. Co-relation of SOFA score in 48-96hrs (i.e. 'SOFA 3') with mortality.
- iv. Co-relation of Length of stay in ICU (i.e. 'L') with mortality.
- v. Co-relation of SOFA 1 with Length of stay (L)
- vi. Co-relation of SOFA 2 with Length of stay (L)
- vii. Co-relation of SOFA 3 with Length of stay (L)
- viii. Co-relation of mean of all SOFA scores (SOFA 1, SOFA 2, SOFA 3) with Length of stay (L)
- ix. Co-relation of mean of all SOFA scores (SOFA 1, s SOFA 2, SOFA 3) with mortality.
- x. Co-relation of change in SOFA score in first 48hrs (i.e. change from SOFA 1 to SOFA 2; increasing, decreasing and unchanged) with Mortality.

## Results

During the study period 67 patients were screened. 28 patients were excluded from the study as they did not give consent for all required investigations. 5 patients were shifted out of ICU within 24 hours while 4 patients went against medical advice within 48 hours. The results are cumulated SOFA score from each patient over different periods. It is presented as SOFA score with respect to outcome measures that are length of stay and mortality. (Table 1)

**Table 1: Data collected from patients at various time period**

S. No.	SOFA score between 0 to 24 hrs after admission to ICU (SOFA 1)	SOFA score between 24 to 48 hrs after admission to ICU (SOFA 2)	SOFA score between 48 to 96 hrs after admission to ICU (SOFA 3)	Length of ICU stay in days (L)	Current Status of patient (S: survivor) (NS: non- survivor)
1	13	9	9	19	S
2	7	7	8	4	S
3	11	15	16	24	NS
4	6	4	2	12	S
5	15	15	15	8	S
6	15	18	19	4	NS
7	14	15	17	4	NS
8	15	15	15	5	NS
9	10	7	9	5	S

10	9	7	6	7	S
11	8	7	6	5	S
12	10	11	9	8	S
13	9	9	7	3	S
14	8	14	15	10	NS
15	13	13	14	10	NS
16	9	12	7	7	S
17	14	10	7	12	S
18	15	16	16	5	NS
19	10	11	15	4	NS
20	11	9	12	19	S
21	8	8	6	4	S
22	12	13	13	19	S
23	11	7	6	9	S
24	12	12	13	10	S
25	15	16	16	3	NS
26	15	17	20	6	NS
27	11	9	9	3	S
28	8	7	6	8	S
29	9	7	7	7	S
30	12	11	7	7	S

- The SOFA score ranged from 2 to 20 in all the three periods. The highest SOFA score found among non-survivors is 20.
  - The number of non-survivors (NS) were 10 out of the 30 patients..
  - The length of stay was varying, independent of mortality.
- The relation of SOFA 1, SOFA 2, SOFA 3 and length of stay (L) with Mortality is depicted in form of Pair-T statistics in Table 2.
- The highest mean SOFA score in all periods among survivors is 10.2.
  - The highest mean SOFA in all periods among non- survivors is 16.3.
  - The mean length of stay of critically ill patient in ICU is about 8 days.
  - T-statistic of length of stay is negative, indicating Length of stay is NOT significant and independent of mortality.
  - P values of SOFA 1, SOFA 2, SOFA 3 are 0.0084, <0.001 and <0.001 respectively suggesting they are highly significant and dependent on mortality.

**Table 2: The relation of SOFA 1, SOFA 2, SOFA 3 and length of stay (L) with Mortality**

	<b>L</b>	<b>SOFA1</b>	<b>SOFA2</b>	<b>SOFA3</b>
<b>Mean among all patients</b>	8.37 days	11.17	11.03	10.9
<b>Standard deviation among all patients</b>	8.37±5.44 days	11.17±2.7 days	11.03±3.7 days	10.9±4.73 days
<b>Mean among all survivors</b>	8.80 days	10.2 days	9.05 days	8.2 days
<b>Standard deviation among all survivors</b>	8.80±5.08 days	10.2±2.35 days	9.05±2.65 days	8.2±3.07 days
<b>Mean among all non-survivors</b>	7.5 days	13.1 days	15 days	16.3 days
<b>Standard deviation among all non-survivors</b>	7.5±6.29 days	13.1±2.56 days	15±2.00 days	16.3±1.89 days
<b>T statistics</b>	-0.567	3.0051	6.871	8.9
<b>Degree of Freedom</b>	15	16.8	23.2	26.5
<b>P value</b>	0.579	0.0084	<0.001	<0.001
<b>Significance</b>	Mean length of stay between S and NS is NOT significant	Mean SOFA 1 score between S and NS is highly significant	Mean SOFA 2 score between S and NS is highly significant	Mean SOFA 3 score between S and NS is highly significant

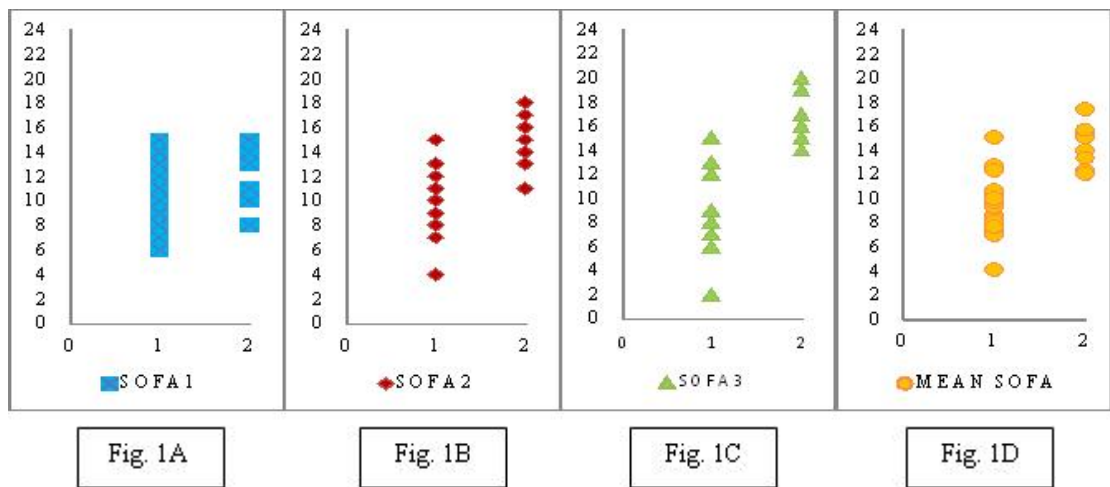
Fig. 1A shows the correlation of SOFA 1 (SOFA score between 0 to 24 hrs) with mortality. Co-relation coefficient of SOFA 1 with mortality: 0.504. Co-relation coefficient measures the degree to which the two variables are related. It lies between +1 to -1. A value of exactly 1.0 means there is a perfect positive relationship between the two variables. For a positive increase in one variable, there is also a positive increase in the second variable. A value of exactly -1.0 means there is a perfect negative relationship between the two variables. Co-relation coefficient of SOFA 1 with mortality is 0.504. It depicts a strong positive relatability between them.

Fig. 1B shows the correlations of SOFA 2 (SOFA score between 24 hrs to 48hrs) with mortality. Correlation co-efficient of SOFA 2 with mortality: 0.763. The relation between SOFA 2 and mortality is

positive. The value of 0.763 signifies a strong relatability.

Fig. 1C shows the correlation of SOFA 3 (SOFA score between 48hrs to 96hrs) with mortality. Co-relation co-efficient of SOFA 3 with mortality is 0.821 which shows a strong positive relatability. The value co-relation co-efficient of SOFA with time is increasing considerably i.e. Co-relation co-efficient of (SOFA 1 < SOFA 2 < SOFA 3). This signifies that with passage of time the SOFA score values are more relatable to mortality.

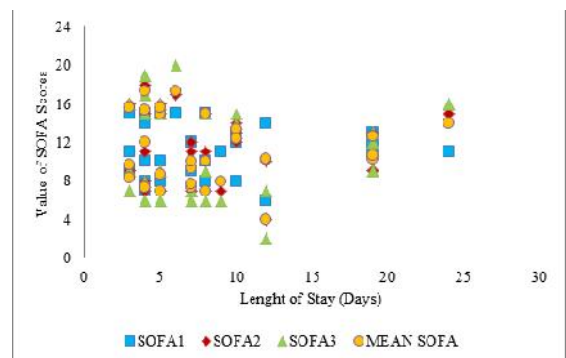
Fig. 1D shows the correlation of mean of all SOFA scores with mortality. Correlation co efficient of mean of all SOFA scores with mortality: 0.7711. Mean of SOFA scores shows strong positive relatability with mortality. Mean of SOFA score values are more relatable to mortality than values of SOFA 1.



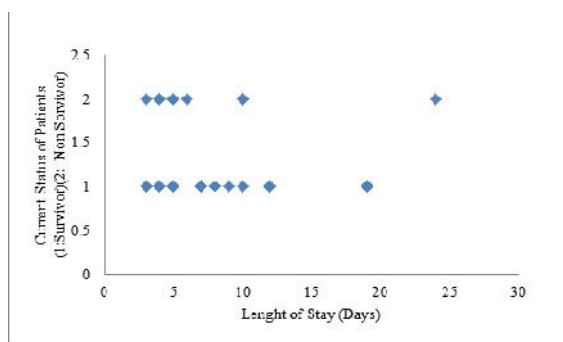
**Fig. 1 Scatter diagrams showing Co-relation between Sofa score in different time period with Mortality.**

**X axis = Current status of Patient (1: Survivor) (2: Non Survivor); Y axis = Value of SOFA scores.**

1. Co-relation co-efficient SOFA 1 with length of stay is 0.004982. The co-relation between SOFA 1 with length of stay is positive but very insignificant to derive relatability.
2. Co-relation co-efficient of SOFA 2 with length of stay is -0.01927, which is a insignificant negative value.
3. Co-relation co efficient of SOFA 3 with length of stay is 0.01487. Co-relation between length of stay and SOFA 3 has mild positive but negligible significance.
4. Corelation co efficient of mean SOFA score with length of stay is 0.001142. The correlation is positive but negligible to derive relation. (Fig. 2)



**Fig. 2: Co-relation between SOFA score in different time period with Length of stay (L)**



**Fig. 3: Co-relation of Length of stay in ICU(L) with mortality.**

Co-relation co-efficient of Length of stay in ICU with mortality: -0.114. Negative co relation co-efficient less than -1 indicates length of stay between S and NS is NOT relatable. (Fig. 3)

**Table 3: Distribution of SOFA score with mortality**

Maximum SOFA score	Mortality
0 to 6	<2%
7 to 9	0-10%
10 to 12	10-30%
13 to 14	40-60%
15	75-90%
16 to 24	>90%

Table 3 describes the mortality that may exist due occurrence of the maximum SOFA score of that specific range.

1. The presence of max. SOFA score of 15 gives a mortality of 78.5%. (i.e. 75-90%)
2. Any SOFA score in the range 13 to 14, gives a mortality of 50%. (40-60%)
3. Any SOFA score in the range 16 to 24, gives a mortality of >90%.

**Table 4: Score trend within first 48 hrs with mortality**

Score Trend (first 48 hrs)	Mortality
Increasing	> 50%
Unchanged	27 -35%
Decreasing	< 13%

The change of mortality in first 48hrs (from SOFA1 to SOFA 2) is associated with mortality. It is observed that increasing SOFA score in first 48hrs gives a mortality rate of >50% (Table 4). It is conclusive from the results that the non survivors had high initial, mean and highest SOFA scores as compared to survivors.

## Discussion

Intensive care is a dynamic medical environment. A patients health status is vulnerable to change rapidly.

It may either improve or worsen. Interpreting such dynamics can provide better insight in patients' health status over time. The most eminent and earliest research carried out on SOFA score was in 1995 by Vincent JL et al.<sup>(2)</sup> The study involved 1,449 subjects from 40 intensive care units (ICUs) in 16 countries. The study emphasised the relation of SOFA score with incidence and severity of organ dysfunction (sepsis-related problems) in critically ill patients. The result of the research showed the survivors and non survivors followed a different course of SOFA score. In our study the initial, highest, and mean SOFA scores correlated well with mortality. Our results are consistent with study done by Acharya SP et al.<sup>(3)</sup> They gave the same conclusive results of co-relations SOFA score with mortality that the non survivors had high initial, mean and highest SOFA scores as compared to survivors.<sup>(3)</sup>

In our study Initial and highest scores of more than 15 corresponded to mortality in more than 75% patients. Vincent JL et al.<sup>(2)</sup> found that initial SOFA score > 11 predicted a mortality of 80% while Archarya SP et al.<sup>(3)</sup> concluded the initial SOFA score > 11 predicted a mortality of 90%. The predictive value of the mean score had negligible relation to the length of ICU stay. Length of stay is not significant and independent of mortality. Mean and highest SOFA scores had the strongest correlation with mortality, followed by change in SOFA and initial SOFA scores. When analysing trends in SOFA score during the first 48 hours, regardless of the initial score, the mortality rate was at least 50% when the score increased, 27% to 35% when it remained unchanged, and less than 27% when it decreased. Differences in mortality were better predicted in the first 48 hours than in the subsequent 48 hours.

A number of studies had been conducted so far on different scoring systems to predict mortality. However, the comparison between the scoring system show differences in sensitivity and specificity. In a comparative study conducted by Fröhlich M et al.<sup>(4)</sup> in post-traumatic patients with multiorgan dysfunction MODS and SOFA score were comparably sensitive and the Denver score more specific. The MODS outperformed Denver- and SOFA score in predicting mortality, but was inferior predicting the length of stay. The SOFA score showed the most balanced relation of sensitivity and specificity. Naqvi IH et al.<sup>(5)</sup> in a comparative study of scoring systems however concluded that models based on SOFA scores at admission had only slightly worse performance than APACHE II/III and were competitive with SAPS II models in predicting mortality in patients in the general medical and/or surgical ICU. APACHE II has showed better calibration and discrimination power than SAP II and SOFA. Minne L et al.<sup>(6)</sup> in their systematic review found that, models with sequential SOFA scores seem to have a comparable performance with other organ failure scores. Qiao Q et al.<sup>(7)</sup> in their study concluded

that, APACHE II and SOFA scores can accurately predict mortality outcome in critically ill elderly patients, especially the maximum SOFA score and the difference between the maximum and initial SOFA scores. In our study also we found that mean and highest SOFA scores had the strongest correlation with mortality, followed by change in SOFA and initial SOFA scores.

Jacobson S et al<sup>(8)</sup> studied if SOFA scores differ between genders in a sepsis and found to have no gender-related differences in mortality or length of stay. In our study we however did not study gender difference. Many researcher did some disease specific or other modifications in SOFA score and found them to be extremely useful. In Mexican sequential organ failure assessment (MEXSOFA) score has two modifications: the PaO<sub>2</sub>/FiO<sub>2</sub> ratio was replaced with the SpO<sub>2</sub>/FiO<sub>2</sub> ratio, and the evaluation of neurologic dysfunction was excluded.<sup>(9)</sup> Chronic liver failure-sequential organ failure assessment score (CLIF-SOFA) is used to assess mortality in cirrhotic patients.<sup>(10)</sup> SOFA Score for In-Hospital Mortality Among Adults With Suspected Infection Admitted to ICU.<sup>(11)</sup>

Baradari AG et al<sup>(12)</sup> concluded that mean SOFA score rather than highest SOFA score had the highest sensitivity and specificity in prediction of ICU mortality. Anami EH et al in a study conducted in Brazil concluded that higher SOFA scores had a positive association with mortality.<sup>(13)</sup> Our results were also consistent with research on SOFA and mortality endpoints in randomized controlled trials done by de Grooth HJ et al.<sup>(14)</sup> Ferreira FL et al<sup>(15)</sup> also concluded that SOFA-based prognostic models provide insight into the dynamics of organ failures and their relation to mortality. Predicting the survival status of Intensive Care patients at the end of their hospital stay is useful for various clinical and organizational tasks.

Various studies have proved the importance SOFA score in predicting prognosis and mortality critically ill patients suffering from multitude of conditions like sepsis,<sup>(16-18)</sup> AKI,<sup>(19)</sup> Cirrhosis,<sup>(20)</sup> cancer<sup>(21)</sup> and also assessing prognosis in post cardiac arrest patients.<sup>(22)</sup> SOFA and changes in the SOFA score over time are potentially useful tools for risk stratification when applied to critically ill patients admitted to ICUs from the ED.<sup>(23)</sup>

**Limitations:** The study is based on small sample size contradictory to the earlier studies. A study with small sample size promises accurate and integral statistical data but fails on including variety and incidence of rarer cases. The study is not based on specific diseases or a single mortality cause. The study is conducted in a single tertiary care hospital therefore could not include patients from different geographical locations. The study focused on SOFA scores collected only from three periods 0-24 hrs, 24-48 hrs, and 48-96hrs since admission to ICU.

## Conclusion

The SOFA scoring system is useful in predicting outcomes in ICU. It is definitive to the fact that the non survivors had high initial, mean and highest SOFA scores as compared to survivors. It is a simple, but effective method to describe organ dysfunction/failure in critically ill patient and thus help in proper utilization of ICU resources. Regular, repeated scoring enables patient condition and disease development to be monitored and better understood. The SOFA score may enable comparison between patients that would benefit clinical trials.

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