DOI: 103126/JNPS.V4113

Original Article

Utility of Sequential Organ Failure Assessment Score in Prognosticating sick Children in Paediatric Intensive care Unit

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Article History
Received On : Dec 02, 2021
Accepted On : May 17, 2022

Funding sources: None

Conflict of Interest: None

Keywords:
Sequential organ failure assessment (SOFA) score, Mortality, Paediatric Intensive care unit (PICU)

Online Access

DOI: https://doi.org/10.3126/jnps.v42i1.41178

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Abstract

Introduction: There are number of scoring systems to assess the morbidity and mortality of sick children in intensive care unit. Out of these scoring systems our study was designed to look for the utility of Sequential Organ Failure Assessment (SOFA) score which is less time consuming and simple to apply as a predictor of mortality in sick children admitted in Paediatric Intensive Care Unit (PICU).

Methods: This was a prospective observational study done in PICU of Universal College of Medical Sciences, Bhairahawa, Nepal. Recruited patients were all critically sick children above one year who stayed in hospital above 72 hours and underwent all necessary evaluation, and were followed up until they were discharged or deceased. Initial SOFA score was calculated within 24 hours of admission (SOFA T0) and again calculated after 72 hours (SOFA T72). Delta SOFA score was calculated as the change in SOFA scores over 72 hours (SOFA T0 - SOFA T72). The primary outcome was in-hospital mortality.

Results: When compared to outcome, the non survivors had high mean initial SOFA (T0) 11.51 ± ences ec ing 3.001 (P < 0.001), mean SOFA after 72 hours (T72) was 15.51 ± 4.026 (P < 0.001) and mean delta SOFA (T0-T72) was 4.58 ± 2.59 (P = 0.166) as compared to survivors. Delta SOFA was not significantly associated with outcome (P = 0.166). The initial SOFA score T0 > / = 11 predicted a mortality of 70.90% and SOFA T72 score of >/=15 predicted a mortality of 81.60% but delta sofa >/= 4 predicts a mortality of only 43.60%. Area under receiver operating characteristic (ROC) curve for SOFA TO was 0.769, for SOFA T72 was 0.890 and for delta SOFA was 0.604 and thus, showing excellent discriminative power for SOFA 72 for predicting mortality.

Conclusions: The SOFA score demonstrated fair to good accuracy for predicting mortality when applied to sick children > 1 year admitted in PICU. Our study showed both initial SOFA T0 and SOFA at 72 hours predict mortality with good accuracy but SOFA at 72 hours is a better predictor of mortality as compared to initial and delta SOFA scores.

Introduction

Critical care predictive scoring systems derive a numerical value or severity score, from a variety of measurable clinical variables and serve as a helpful tool at admission in predicting the course of the patient in the ICU. Though their main

goal is prognostication of patient's status, they also help in the assessment of various interventions and quality of care. Multiple organ dysfunction syndromes (MODS) have been a consistent observation in Paediatric Intensive Care Unit (PICU) children. Number of failing organ system and degree of dysfunction within any given organ system directly correlates with mortality in PICU. Among the children who gets admitted to PICU about 25% of the children will suffer from MODS and the mortality associated with it is up to 50%. Also 97% to 100% of the deaths in PICUs have been related to MODS.[1,2]

The development of the Sepsis - related Organ Failure Assessment (SOFA) score was an attempt to objectively and quantitatively describe the degree of organ dysfunction over time and to evaluate morbidity in intensive care unit (ICU) septic patients.[3] Later, when it was realized that it could be applied equally well in non-septic patients, the acronym 'SOFA' was taken to refer to Sequential Organ Failure Assessment.[3,4] SOFA system was created in a consensus meeting of European Society of Intensive Care Medicine in 1994 and revised in 1996.[2,5] The SOFA score is a simple and objective score that allows for calculation of both the number and the severity of organ dysfunction in six organ systems (Respiratory, hematology, liver, cardiovascular, renal, and neurologic (Table 1),[4] with minimum score for each failing organ zero to maximum score of "4" with total score of '24'. The score increases as the organ system functioning worsens, thus assessment of individual organ dysfunction or failure can be done along with evaluation of patient as a whole.[6]

Prior studies attempted to adapt the SOFA score to paediatric patients with fair to good accuracy. However, various studies show its limitation to use in paediatric population. Age related variability are not considered in adult version of SOFA score and hence, there is emphasis use of pSOFA with age adjusted variables for cardiovascular and renal component with other variables remaining the same as adult SOFA score.[7] Outcome models currently available for children such as PELOD, APACHE, SAPS, PRISM etc. calculate a prediction on values taken in first 24 hours of PICU stay. However, these are cumbersome and many parameters are not always practical to evaluate in resource limited country like ours. In contrary, SOFA scoring system is simplified and can be used with ease in centers like ours. Moreover, there is paucity of study found in utility of SOFA score and its validation in paediatric population.

Various studies have shown inconsistent results in reliability and association of initial SOFA, SOFA at 72 hours and Delta SOFA scores for prediction of mortality. This study has been planned to find whether SOFA score is useful in predicting mortality in paediatric population or not and if yes, then which SOFA score is strongly associated with predicting mortality in pediatric population.

Table 1. SOFA score according to European Society of Intensive Care Medicine.[4]

SOFA score	0	1	2	3	4
Respiration					
PaO_2 / FIO_2 (mm Hg)	> 400	< 400	< 300	< 200	< 100
SaO_2 / FIO_2		221 - 301	142 - 220	67 - 141	< 67
Coagulation					
Platelets (10^3 / mm^3)	> 150	< 150	< 100	< 50	< 20
Liver					
Bilirubin (mg / dl)	< 1.2	1.2 - 1.9	2.0 - 5.9	6.0 - 11.9	> 12.0
Cardiovascular					
Hypotension	No hypotension	MAP < 70	Dopamine ≤ 5 or dobutamine (any)	Dopamine > 5 or norepinephrine ≤ 0.1	Dopamine > 15 or norepinephrine > 0.1
CNS					
Glasgow coma score	15	13 - 14	10 - 12	6 - 9	< 6
Renal					
Creatinine (mg / dl) or urine output (mg / dl)	< 1.2	1.2 - 1.9	2.0 - 3.4	3.5 - 4.9 or < 500	> 5.0 or < 200

Methods

This was a prospective observational study being conducted at Universal College of Medical Sciences and Teaching Hospital, Bhairahawa, Nepal for one year from July 2019 to July 2020. The study was approved by the institutional research committee (IRC) of UCMS, [UCMS/IRC/226/18]. Written consent was taken from parents of all children. All children above one year admitted at PICU for treatment were included for study and children who stayed in PICU for less than 72 hours, didn't undergo sufficient diagnostic laboratory tests in accordance with SOFA score, denial of consent were excluded from study. The criteria for admission in PICU to our center was children with altered sensorium (GCS ≤ 12), physician judgment, referred case for PICU admission from other center and referred case from other department of our center for PICU care. The mean initial SOFA was taken as 10.48[2] from previous study, with SD of 2.5. Sample size was calculated to be 100, considering allowable error L = + / - 0.5. Total 344 patients were admitted in PICU during the study period. Of which 230 patients above one year were included in the study by consecutive sampling. Total 130 patients were excluded from the study. Finally, 100 patients meeting both inclusion and exclusion criteria were enrolled in study and analyzed.

Demographic and clinical data were collected at beginning. Detailed physical examination and history was taken. Manual BP was taken with age-appropriate cuff size in supine position

in all subjects. Laboratory tests including a complete blood count (CBC), C-reactive protein (CRP), blood glucose and electrolytes, blood gas level, coagulation profile, liver and kidney function tests were done as indicated. Cultures of body fluids, including blood, urine, cerebrospinal fluid (CSF) or pleural fluid, were performed as required. Other laboratory and radiological investigations were performed where indicated based on the clinical condition. The requirement of mechanical ventilation was based on unit PICU protocol. PaO_2 / FIO_2 was derived from ABG or SaO_2 / FIO_2 was taken with significant reliability and considered in SOFA score (8 –10) noninvasive surrogate markers for lung disease severity are needed to stratify pediatric risk. We sought to validate prospectively the comparability of SpO_2/FiO_2 to PaO_2/FiO_2 and oxygen saturation index to oxygenation index in children. We also sought to derive a noninvasive lung injury score. For those patients who were on noninvasive or other modes of oxygen therapy, FIO_2 was taken as per standard guidelines.[11] Patients were followed until they were discharged from PICU or deceased. Initial SOFA score was calculated within 24 hours of admission and then was calculated after 72 hours. Delta SOFA score was calculated as the change in SOFA score over 72 hours (T0 SOFA - T72 SOFA). In each organ system, the highest score in any variable accounted was taken as the score for the organ system.

The sum total of the six scores for each organ system gives SOFA score (Ranging from 0 to 24) which was used to predict risk of mortality in PICU. Categorical data were expressed as absolute frequencies and percentages. Parametric or continuous data were expressed as mean ± standard deviation (SD) and compared them by means of the t test. Chi-square test was used to assess the association between categorical variables. Receiver operating characteristic (ROC) curve analysis was used to assess the power of the SOFA score to discriminate between survivors and non-survivors.

Results

Hundred patients were analyzed for study. There were 60% males. Children aged five to 10 years comprised maximum cases (32%). 58% of children required invasive mechanical ventilation. The mortality was 41%. We found that age group between one to two years had highest mortality rate of 65.4% and children between five to 10 years had lowest mortality rate of 31.3%. Binary logistic regression showed that the odds of mortality were about 24.7 times for those who needed invasive mechanical ventilation as compared to those who did not (OR= 24.7, 95% CI, 6.78-90.11) (Table 2).

Table 2. Comparison of demographic and clinical characteristics among survivor and non-survivor (chi square test)

Characteristics Clinical Variables	Non-survivor (n = 41) (%)	Survivor (n = 59) (%)	P value
Age years 1- 2 yrs 2- 5 yrs 5-10 yrs >10 yrs	 17 (65.4%) 7 (35%) 10 (31.3%) 7 (31.8%)	 9 (34.6%) 13 (65.0%) 20 (68.8%) 15 (68.8%)	0.0333*
Gender, No (%)			
Male	24 (40.4%)	36 (60.0%)	0.482
Female	17 (42.5%)	23 (57.5%)	
Modes of admission, No (%) Other Hospital Emergency (ED) Inpatient	 16 (38%) 20 (51.3%) 5 (26.3%)	 26 (61.9%) 19 (48.7%) 14 (73.7%)	0.170
Admission type, No (%) Sepsis / Infective Neurologic Compromise Respiratory Failure Poisoning / Metabolic Cardiovascular compromise Postoperative / Trauma Others	 13 (41.9%) 2 (16.7%) 8 (38.1%) 2 (22.2%) 2 (28.6%) 10 (76.9%) 4 (57.1%)	 18 (58.1%) 10 (83.3%) 13 (61.9%) 7 (77.8%) 5 (71.4%) 3 (23.1%) 3 (42.9%)	0.048*
Required invasive Mechanical Ventilation, No (%)	38 (65.8%)	20 (34.5%)	< 0.001*

Table 3 shows comparison of mean SOFA score at different time intervals among survivor and non-survivor using paired T-test. The mean SOFA scores among 41 non-survivors were 11.51, 15.51 and 4.58 for SOFA T0, SOFA T72 and delta SOFA respectively which were significantly higher compared to survivor group and was highly significant for SOFA T0 and SOFA T72 with p value < 0.001 while it was not significant for Delta SOFA.

Table 3. Comparison of mean SOFA scores among survivor and non-survivor (Independent t-test)

	OUTCOME	N	Mean	Std. Deviation	P value
SOFA T0 TOTAL	Non-survivor	41	11.51	3.001	< 0.001*
	Survivor	59	8.25	3.646	
SOFAT72 TOTAL	Non-survivor	41	15.51	4.026	
	Survivor	59	7.00	5.398	< 0.001*
DELTA SOFA	Non-survivor	41	4.5854	2.59784	0.166
	Survivor	59	3.8305	2.74272	

The comparison of SOFA T0, T72 and delta SOFA in terms of mortality are given in Figures 1, 2 and 3. Cutoff for SOFA scores 11, 15, and 4 for initial SOFA (T0), T72, and delta SOFA respectively was taken,[5] as mean of these different time frame SOFA was significantly associated with mortality except for mean delta SOFA. Figure 1 shows that mortality was 27.5% when SOFA T0 score was < 11 while it was as high up to 70.9% when score was greater than 11. Figure 2 shows mortality was 16.2% when SOFA T72 score was < 15 while it was as high up to 81.6% when score was greater than 15. Figure 3 shows mortality was 39.3% when DELTA SOFA score was < 4 while it was as high up to 43.6% when score was greater than 4.

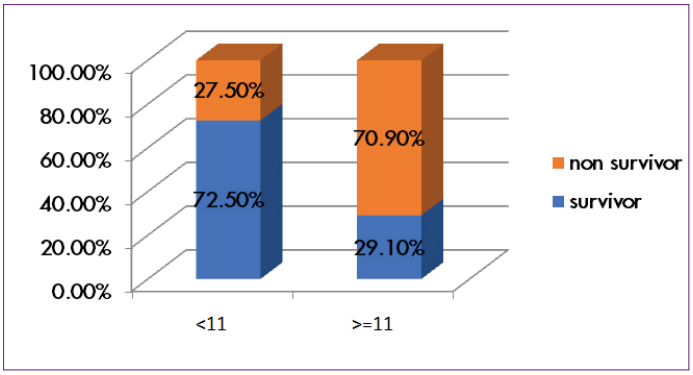

Figure 1. SOFA T0 and mortality

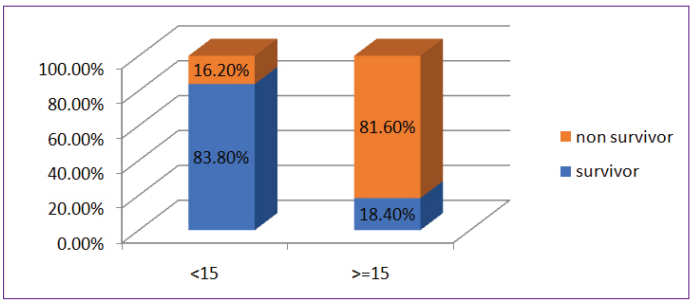

Figure 2. SOFA 72 and mortality

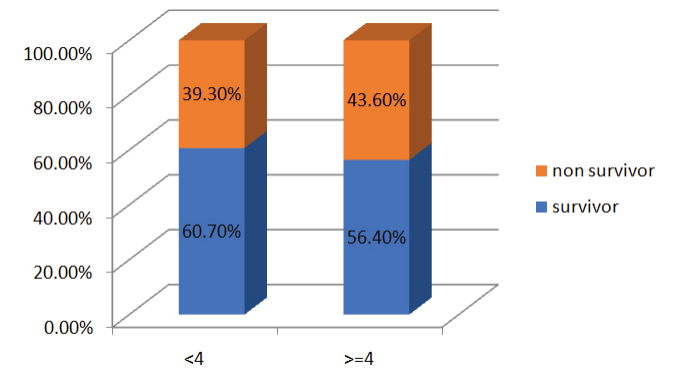

Figure 3. Delta SOFA and mortality

Comparison of discrimination power through area under curve of receiver operating characteristic (AUROC) curve was carried out and results are present in Table 4. Area under ROC curve was higher for SOFA at 72 hours, since the area under the curve was 0.890, thus we can say SOFA at 72 hours was having excellent discrimination power for predicting mortality. Furthermore, the system wise comparison of SOFA score was done and the results are given in Table 5 where the P-value was significant in all the systems in SOFA at 72 hours.

Table 4. Comparison of discrimination power through ROC curve

Scoring System	AUROC	Discrimination Power
Initial SOFA	0.769	Good
SOFA at 72 hrs	0.890	Excellent
Delta SOFA	0.604	Poor

Table 5. Role of different component of sofa score at different time frame SOFA score (Paired t-test)

System	Initial SOFA P value	72 Hours SOFA P value	Delta SOFA P value
Respiratory	0.001	< 0.001	0.894
Hematological	0.016	< 0.001	0.146
CVS	0.002	< 0.001	0.19
Hepatic	0.012	< 0.001	0.010
CNS	0.324	< 0.001	0.004
Renal	0.001	< 0.001	0.032

Discussion

Predicting systems are typically developed to predict mortality in sick patient and such measurements are helpful for standardizing research and comparing the quality of patient care. Both initial SOFA score (T0) taken within 24 hours of admission and SOFA score after 72 hours (T72) were found to be reliable predictor for both mortality prediction. But among the two, SOFA T72 was found to be better predictor of mortality. However, delta SOFA score (T0 - T72) was not correlated well with outcome and mortality prediction. Comparing mean of SOFA scores at different time intervals among survivor and non-survivors, higher mean SOFA scores were seen among non-survivors with mean SOFA TO 11.51, mean SOFA T72 15.51 and mean delta SOFA 4.58 which were statistically significant for both initial mean SOFA T0 and mean SOFA T72 and correlated well with mortality. However mean Delta SOFA score was not correlated well with the outcome. Also, contribution of each component of SOFA score at different time frames concluded that T72 was significant for all system compared (P < 0.001) that correlates well with the study done by Gogiya et al (P < 0.001).[5] Ferreira et al analyzed the SOFA scores

and found that all SOFA scores viz. initial SOFA, mean SOFA and delta SOFA values were high in non survivors as compared to survivors (P < 0.001) in all scores.[6]

Our study also revealed that both initial SOFA T0 and SOFA T72 hours scores are statistically strong enough to prognosticate risk of mortality in PICU. It correlated well to mortality as shown by discriminative power by AUROC of 0.769 and 0.890 respectively but poor discriminative power for Delta SOFA with AUROC of 0.604 only. This shows SOFA T72 to be having better correlation for prediction of mortality than SOFA T0 (Table 4). Thus, SOFA score (T72) can be used as a reliable prognostic predictor of mortality among PICU patients which was comparable with the study by Gogiya et al,[5] However, in contrast to present study, a study by Ferreira et al emphasized delta SOFA as better predictor of mortality.[6] This may be because of the different way of calculating the Delta SOFA scores. Ferreira et al, calculated the difference between SOFA at 48 hours and SOFA at 0 hour and mentioned this value as Delta SOFA 48– 0. Similarly, they calculated the difference in SOFA at 96 hours and 0 hour. They calculated the change in SOFA score with reference to the initial SOFA score (at 0 hour) with maximum SOFA score during ICU stay. Many studies have assigned delta SOFA as the variation of SOFA score day 1 and day 3, as we did in this study.[5,12]

Thus, the present study emphasizes the use of SOFA score as a prognostic indicator in critically ill children as variables measured are easily available and routinely measured in PICU and recommends use of SOFA T72 as better predictor of mortality. There are several limitations to our study. First, our results were generated using data from a single center. Validating SOFA in a larger, multicenter sample of critically ill children is necessary to assess the generalizability of the score. Second, we tried to validate adult version of SOFA score which is easier to calculate owing to less variables and excluding children < one year. An age-adjusted version of the SOFA score for paediatric patients (pSOFA) would be more appropriate as age- based variation of its measures can have many benefits, including better design of clinical trials, improved accuracy of reported outcomes, and better translation of the research and clinical strategies in the management of sick children in PICU. Third, we used small sample size of 100 to draw conclusions. Higher sample size might have used, which was not available during study period to minimize the error and better generalizability of conclusion. Fourth, we didn't calculate SOFA score at different time interval except within 24 hours of admission and after 72 hours of admission for calculation of SOFA score and overall outcome. Serial evaluation of SOFA score at a different time interval for a longer duration or till patient is discharged would have drawn better conclusion as done by another investigator.

Conclusions

Our study showed that SOFA score at 72 hours (T72) is a better predictor of mortality as compared to initial and delta SOFA scores. SOFA score demonstrated fair to good accuracy for predicting in-hospital mortality when applied to patients admitted to PICU. Use of SOFA score is an acceptable method for risk stratification, monitoring the clinical course, assessment of organ dysfunction, predicting mortality of critically ill patients in PICU and in resource limited countries like ours.

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