To Evaluate and Compare Ability of Two Prognostic Scoring Systems in Predicting the Mortality of Critically Ill Patients in Adult Intensive Care Unit

Abhay Ganar[1], Sachin Potey[2]

ABSTRACT

Introduction: Clinical assessment of severity of illness is an essential component of medical practice. Several severity-of-illness based mortality prediction models are available. Therefore, this study was undertaken to individually evaluate and compare the ability of APACHE-II and SOFA scoring systems to predict mortality of critically ill patients in adult intensive care unit.

Material and Methods: This prospective, observational cohort study was carried out on 50 patients aged more than 18 years, of either gender, admitted to Intensive Care Units (medical and surgical) of the hospital, with hospital stay more than 24 hours. Their clinical parameters and laboratory data were collected on admission and every 24 hours till discharge from ICU or death. The APACHE II and SOFA scoring were computed every day and compared.

Results: Overall mortality rate was 50%. The power of prediction of SOFA system was higher than APACHE II system score in terms of the MEAN and HIGHEST scores (reflecting patient's clinical status more accurately).

Conclusion: Though initial scores had poor predictive value but SOFA scoring system was better than APACHE II scoring system.

Keywords: Mortality Prediction, APACHE II Scoring System, SOFA Scoring System, Critically Ill, Intensive Care Unit.

INTRODUCTION

Clinical assessment of severity of illness is an essential component of medical practice to determine the need for therapeutic interventions, degree of urgency, outcome prediction and may also indicate the prognosis. Outcome prediction is important in both clinical and administrative intensive care unit management.[1]

Several severity-of-illness based mortality prediction models were developed for use in multidiagnostic patient groups. The information derived from these models can be used to evaluate ICU performance and to improve medical decision-making and resource allocation[2,3], and perhaps it can also provide patients and their relatives with better information about the ICU stay and its possible outcomes.[2,4] Unfortunately, if treatment is withdrawn in patients with a high risk for dying based on these scores, then all high-risk patients indeed will die.[2]

The earliest attempt to quantify severity of illness in general critically ill population was by Cullen by the Therapeutic Intervention Score (TIS).[5] The one most frequently used in many countries is the APACHE (Acute Physiology and Chronic Health Evaluation), originally developed by Knaus, in 1981[6], and modified in 1985, into APACHE II.[7] Another system available is the SAPS (Simplified Acute Physiology Score)[8], which differs from APACHE II in that it contains other clinical variables, such as diuresis, serum bicarbonate and bilirubin, and also for not including admission diagnosis. Other systems are also available, with application for specific subgroups, such as trauma[9], hemodynamic instability[10], myocardial ischemia[11], post heart surgery[12] and SOFA[13] (Sepsis-related Organ Failure Assessment).

These scoring systems rely mainly on data obtained early in the course of the illness. Thus, the strength of initial predictions may be influenced by numerous factors during the course of hospitalization, which may not be accounted for in the initial assessment, thus, underestimating hospital mortality. Other potential limitations include the influence of organizational factors on patient outcomes[14,15], differences in performance of models among various countries[16] and mistakes in data collection.[17] There are also several advantages of having an internationally valid mortality prediction system for patients, particularly in international comparisons and research studies.

APACHE II (Acute Physiology and Chronic Health Evaluation II)

It is the sum of three units: an Acute Physiology Score, a Chronic Health Evaluation, and a score based on patients Age.

Scoring is based on the most abnormal measurements during 24-hour stay in Intensive Care Unit (ICU). The maximum score is 71 points, although more than 80% of patients have score of 29 or less. Relationship between APACHE II scores and hospital mortality differs for surgical and non-surgical patients, since the prognostic impact of altered physiology is less severe in post-operative patients.[7]

[1]Assistant Professor, Department of Anaesthesiology, Government Medical College and Superspeciality Hospital, Nagpur, Maharashtra, [2]Consultant Anesthetist, Nagpur, Maharashtra, India

Corresponding author: Dr. Sachin Potey (MBBS, DNB Anaesthesiology), 69, Mangaldeep Nagar 1, Manewada, Nagpur 440027, Maharashtra, India

How to cite this article: Abhay Ganar, Sachin Potey. To evaluate and compare ability of two prognostic scoring systems in predicting the mortality of critically ill patients in adult intensive care unit. International Journal of Contemporary Medical Research 2019;6(3):C30-C34.

DOI: http://dx.doi.org/10.21276/ijcmr.2019.6.3.47

SOFA (Sequential Organ Failure Assessment)
It quantifies dysfunction of six organ systems[13] ranging from zero (normal) to 4 (extremely abnormal), as follows:

1. Respiratory System: PaO_2/ FiO_2 mmHg.
2. Coagulation System: Platelets × 10^3 / µl
3. Hepatic System: Bilirubin (mg/dl).
4. Cardiovascular System: Hypotension.
5. Central Nervous System: Glasgow Coma Scale Score.
6. Renal System: Creatinine mg/dl, urine output ml/day.

It has also been demonstrated to predict mortality as well in several studies.[18,19,20,21]
Therefore, this study was undertaken to individually evaluate and compare the ability of APACHE-II and SOFA scoring systems to predict mortality of critically ill patients in adult intensive care unit.

MATERIAL AND METHODS

This was a prospective, observational cohort study conducted in Kamineni Hospitals, Hyderabad, after approval from the Institution Ethics Committee.
This study was conducted on 50 patients aged more than 18 years, of either gender, admitted to Intensive Care Units (medical and surgical) of the hospital, with hospital stay more than 24 hours. The patients having post coronary artery bypass surgery and those who left treatment against medical advice were excluded from the study.
Their demographics were recorded. The clinical parameters having worst score were noted for calculation of score in the 24 hours. The laboratory data were collected on admission and every 24 hours till discharge from Intensive Care Unit or death. The APACHE II and SOFA scoring were computed everyday from the collected clinical parameters and laboratory data. For a single missing value, a replacement was calculated from the mean of the sum of the results immediately preceding and following the missing value.
The Initial Score was defined as the score at the time of admission to Intensive Care Unit. MEAN SCORE was defined as the ratio of total score to the length of stay in the ICU. The maximum score recorded during the ICU stay was taken as HIGHEST SCORE. Mortality was considered as the study outcome.

Sex	Mean Age (In years)	Survivors (In years)	Non-survivors (In years)
Male	54.71 (48.65-60.77)	53.07 (45.01-61.13)	56.35 (46.24-66.47)
Female	51.22 (43.27-59.17)	46.36 (32.85-59.87)	56.09 (46.16-66.02)
Total	53.18 (48.46-57.89)	50.12 (43.14-57.09)	56.24 (49.61-62.86)

Table-1: Gender and age distribution

Category	Total	Non-Survivors	Survivors
Non-Surgical	28	15 (53.5%)	13 (46.4%)
Elective Surgery	6	5 (83.3%)	1 (16.6%)
Emergency Surgery	16	5 (31.25%)	11 (68.75%)

Table-2: Surgical category wise distribution

STATISTICAL ANALYSIS

Chi Square (χ^2) test was used to evaluate the statistical significance of categorical variables. The results were presented as mean (SD). All statistical tests were 2-tailed and a $P\ value < 0.05$ was considered significant. These two scores were further compared by Receiver Operating Characteristics (ROC) curve[13] analysis (1- specificity plotted on X-axis and sensitivity on Y-axis). The Area Under Curve (AUC) indicates diagnostic performance and was interpreted as[29,31]

- Non-predictive AUC = 0.49
- Less predictive AUC = 0.5 – 0.69
- Moderately predictive AUC = 0.7 – 0.89
- Highly predictive AUC = 0.9 – 0.99
- Perfectly predictive AUC = 1.

RESULTS

Out of the 50 patients who participated in the study 25 (50%) expired during ICU stay (Males: 46%, Females: 54%). Mortality increased with increasing age (25% in less than 30 years vs 56% in 50-69 years).The gender and age distribution is as per Table 1 and surgical category wise distribution is as per Table 2. Mean ICU stay of study population was 5.88 ± 0.5 days. Difference between the mean ICU stay of non-survivors (6.08 ± 0.7) and survivors (5.68 ± 0.6) was not significant and ICU stay had no significant influence on outcome of patients.
The APACHE II and SOFA scoring were done as Tables 3 and 4. Statistically significant differences were seen in between the MEAN ($P<0.0001$) and HIGHEST ($P<0.0001$) APACHE II scores of non-survivors and survivors, and in between the MEAN ($P<0.0001$) and HIGHEST ($P<0.0001$) SOFA scores of non-survivors and survivors.
The comparison by AUROC curve is as per Table 5. Thus, the power of prediction of SOFA was found to be greater than APACHE II scoring system for the INITIAL, MEAN and HIGHEST scores.
The ROC curve analysis determined cut off limits for each

APACHE II	Outcome	Mean	Std. Deviation	Std. Error Mean
Inital	Non-survivors	26.48	5.86	1.17
	Survivors	25.56	4.80	0.96
Mean	Non-survivors	27.10	4.61	0.92
	Survivors	19.69	3.53	0.70
Highest	Non-survivors	33.80	5.31	1.06
	Survivors	26.12	4.87	0.97

Table-3: APACHE II scores

Sofa	Outcome	Mean	Std. Deviation	Std. Error Mean
Inital	Non-survivors	8.92	2.17	0.43
	Survivors	7.8	1.95	0.39
Mean	Non-survivors	10.11	1.83	0.36
	Survivors	6.4	1.76	0.35
Highest	Non-survivors	13.56	1.7	0.34
	Survivors	9	2.53	0.50

Table-4: SOFA scores

	Score	AUROC	95% CI	P value	Significance
Inital	Sofa	0.642	0.489-0.785	0.086	Not significant
	Apache II	0.559	0392-0.726	0.473	Not significant
Mean	Sofa	0.931	0.867-0.995	<0.0001	Significant
	Apache II	0.891	0.804-0.978	<0.0001	Significant
Highest	Sofa	0.934	0.868-1	<0.0001	Significant
	Apache II	0.851	0.743-0.960	<0.0001	Significant

Table-5: Comparison by AUROC

Apache II	Cut-off value	Total (n)	Nonsurvivors	Mortality (%)	Sensitivity (%)	Specificity (%)
Initial	≥ 26	25	15	60	56	68
Mean	≥ 20.84	29	22	75	88	76
Highest	≥ 26	35	23	65	92	64

Table-6: Cut off limit for APACHE II score: mortality, sensitivity and specificity.

Sofa	Cut off value	Total (n)	Nonsurvivors	Mortality (%)	Sensitivity (%)	Specificity (%)
Initial	≥ 10	15	9	60	32	92
Mean	≥ 6.89	34	25	73.5	100	68
Highest	≥ 10	37	25	67.5	100	72

Table-7: Cut off limit for SOFA score: mortality, sensitivity and specificity

score, which had maximum sensitivity and specificity and mortality percentage (as per Tables 6 and 7). Clearly, the SOFA scoring system was superior to the APACHE II scoring system in terms of sensitivity and specificity.

DISCUSSION

Many severity-of-illness scores have been developed and used to predict outcome in critically ill patients. During the past few years, a series of studies dealing with the application of outcome prediction models in critically ill patients demonstrated variety of results. These results have been observed in different centers with different treatment strategies. Information regarding the usefulness of these scores in critically ill patients requiring ICU care is still restricted and most reports are limited by relatively small sample sizes and/or the statistical analyses used in the assessment of models' performance. In order to assess such mortality prediction models this present study was conducted.

Berger MM, Marazzi A et al [22] studied APACHE II in Surgical Intensive Care Unit. In their observation, mean APACHE II score was 10.5 ± 7.0. Their study also showed significantly (P < 0.001) lower mean APACHE II score in the survivors (9.0 ± 5.2) than in the nonsurvivors (21.5 ± 8.5). But the cut off score they observed was lower than the present study. Sensitivity and specificity of the scores were highest in the emergency surgery group (87% and 78%), and lowest in the elective surgery group (76% and 73%).

In a study to predict prognosis of patients with ventilator-associated pneumonia (VAP), Gursel G, Demirtas S et al[23] found mortality rate of 54% and the mean APACHE II (21 ± 6, 14 ± 5; P = 0.001), and SOFA (7 ± 3, 4 ± 2; P = 0.002) scores determined at the time of VAP diagnosis were significantly higher in nonsurvivors than in survivors. Discrimination was excellent for APACHE II (ROC AUC: 0.81; P = 0.001) and acceptable for SOFA (ROC AUC: 0.71; P=0.005) scores. Of these scores only APACHE II >16 was an independent predictor of the mortality. These results suggest that APACHE II determined at the time of VAP diagnosis may be useful in predicting mortality in the pulmonary ICU patient population.

To predict survival in patients with septic shock, Fadi Alsous, Mohammad Khamiees et al[24] applied APACHEII and SOFA scores on 36 patients admitted to ICU with septic shock. Their results also reflected same picture as in the present study. Patients ranged in age from 16 to 85 years with a mean age of 67.4 ± 3.3 years. The mean admission APACHE II score was 25.4 ± 1.4, and the day 1 SOFA score was 9.0 ± 0.8. Their results are comparable to the present study where nonsurvivors had higher mean APACHE II scores (29.8) than survivors (20.4) and higher first day SOFA scores than

survivors (10.8 vs 6.9, respectively).

In a prospective study, Ture M, Memis D, Kurt I et al[25] analyzed adult respiratory distress syndrome and compared prognostic accuracy of thyroid hormones, along with APACHE II and SOFA in predicting ICU mortality. There were 47.6% survivors and 52.4% non-survivors. The survivors had a lower APACHE II score (11.50 vs. 15.82, P < 0.0005), a lower SOFA score (6.06 vs. 9.42, P < 0.0005), a younger age (57 vs. 70 years, P = 0.008), and higher fT3 level (2.18 vs. 1.72 pg/ml, P = 0.002) than non-survivors.

Ferreira FL, Bota DP, Bross A, Melot C, Vincent JL et al[26] serially evaluated the SOFA score to predict outcome in critically ill patients. Their result showed that initial and highest scores of more than 11 or mean scores of more than 5 corresponded to mortality of more than 80%. In present study, initial and highest scores of more than 11 corresponded to mortality of 84% and 78% respectively, but mean score of more than 8 corresponded to mortality of 75% which is higher than that found in their study. In both the studies, the mean and highest SOFA scores had the strongest correlation with mortality, followed by initial SOFA scores. The AUROC curve was largest for highest scores (0.90; SE, 0.02; P<0.001 vs. initial score). Both the mean and highest SOFA scores are particularly useful predictors of outcome.

Meisner M, Tschaikowsky K et al[27] compared procalcitonin (PCT) and C-reactive protein (CRP) plasma concentrations at different SOFA scores during the course of sepsis and MODS. Higher SOFA score levels were associated with significantly higher PCT plasma concentrations and higher mortality. But their cutoff limits are significantly higher than the present study.

Janssens U, Graf C et al[28] evaluated the SOFA score in patients with predominantly cardiovascular disorders with mean age 62 ± 12.6 years. Nonsurvivors had a higher total SOFA score on day 1 (5.9 ± 3.7) than survivors (1.9 ± 2.3, P < 0.001) High SOFA scores for any organ system and increasing number of organ failures (SOFA score > or = 3) were associated with increased mortality. They concluded that the SOFA, Total Maximum SOFA (TMS) and delta SOFA scores provide the clinician with important information on degree and progression of organ dysfunction in medical, cardiovascular patients. On day 1 both SOFA score and TMS score had a better prognostic value. The model is closely related to outcome and identifies patients who are at increased risk for prolonged ICU stay.

In the prospective study conducted by Ratanarat R, Thanakittiwirun et al[29], for the prediction of mortality by using the standard scoring systems in a medical intensive care unit in Thailand, the findings were similar to the present study. APACHE II scores of nonsurvivors (26.97 ± 8.27) were significantly higher than those of survivors (17.77 ± 8.22) (P < 0. 001). The AUROC curves for APACHE II was 0.788. The predictive ability to discriminate between survivors and non-survivors of APACHE II by AUROC was significantly higher.

Peres Bota D, Melot Christian, Lopes Ferreira F et al[30] studied the multiple organ dysfunction scores versus the Sequential Organ Failure Assessment (SOFA) score in outcome prediction. Outcome prediction of the APACHE II score was similar to the initial SOFA score in all patients, and slightly worse in patients with shock. Using the scores' cardiovascular component (CV), outcome prediction was better for the SOFA score at all the time intervals. They concluded that SOFA is a reliable outcome predictor.

Markus Wehler, Judith Kokoska et al[31] studied short-term prognosis in critically ill patients with cirrhosis assessed by prognostic scoring system. The short-term prognosis of acutely ill patients with cirrhosis is influenced by the degree of hepatic insufficiency and by dysfunction of extra hepatic organ systems. The SOFA showed an excellent discriminative power (AUROC 0.94), which was clearly superior to the APACHE II (AUROC 0.79). Hospital mortality rates below and above a cutoff of 8 SOFA points were 4% and 88% (P< 0.0005). They concluded that SOFA is an excellent tool to predict the hospital mortality in critically ill cirrhotic patients. The SOFA score also reflected resource use during the ICU treatment as measured by daily workload and length of stay. The SOFA is an easily applied tool with excellent prognostic abilities and can be used to enhance clinical judgment of prognosis.

Oh TE, Hutchinson R et al[32] conducted prospective cohort study to verify the Acute Physiology and Chronic Health Evaluation scoring system in a Hong Kong intensive care unit. The hospital mortality rate for study patients was 36%. Survivors were younger, had shorter ICU stays, lower APACHE scores, and lower risk of death values than nonsurvivors (P < .001). Areas under the receiver operating characteristic curves were 0.89 (all patients), 0.85 (operative) and 0.88 (non-operative). The APACHE II score was not sufficiently accurate to predict outcome of individual patients. There was close concordance between observed and predicted mortality of patient groups.

Limitations

This study was limited by the ICU admissions of the patients. Therefore, the results of this study may not be generalized.

CONCLUSION

From this study, it can be effectively concluded that:

The initial scores of both APACHE II and SOFA scoring systems had poor predictive value (AUROC 0.559 and 0.642 respectively). Thus prognostication based on initial score interpretation should be done cautiously. Also, SOFA scoring system had high predictive value for the MEAN and HIGHEST scores (reflecting patient's clinical status more accurately). Thus, it is suggested to make it mandatory to document these scores in the case records of the ICU patients on a regular basis for prognostication.

REFERENCES

1. Shortell SM, Zimmerman JE, Rousseau DM et al. the performance of intensive care unit: does good management make a difference? Med Care. 1994; 32: 508-525.
2. Sage W, Rosenthal M, Silverman J. Is Intensive Care

worth it? An assessment of input and outcome for the critically ill. Cri Care Med 1986; 14: 777-782.

3. Sophia E de Rooij, Ameen Abu-Hanna et al Factors that predict outcome of intensive care treatment in very elderly patients. Critical Care 2005, 9:307-314
4. Cullen DJ, Chernow B. Predicting outcome in critically ill patient. Cri Care Med 1994; 22: 1345-1348.
5. Cullen DJ, Civetta JM, and Ferrara LC et al. therapeutic intervention scoring system: a method for quantitative comparison of patient care. Crit Care Med 1974; 2:57-60.
6. Knaus WA, Zimmerman JE, Wanger DP et al. APACHE – Acute Physiology And Chronic Health Evaluation: a physiologically based classification system. Crit Care Med 1981; 9:591-597.
7. Knaus WA, Zimmerman JE, Wanger DP et al. APACHE II – A severity of disease classification system. Crit Care Med 1985; 13:818-829.
8. Le Gall JR, Loirat P, Alperovitch A, Glaser P, Granthil C, Mathieu D, Mercier P, Thomas R, Villers D: A simplified acute physiology score for ICU patients. Crit Care Med 1984, 12:975-977.
9. Stewart TC, Lane PL, Stefanits T. An evaluation of patients outcomes before and after Trauma Center designation using Trauma and injury Severity Score analysis. J Trauma 1995; 39: 1036-401.
10. Yeung C, Ming-Weilu, Martinez EG, Puri VK. Critical Care Scoring System-New concept based on hemodynamic data. Crit Care Med 1990; 18: 1347-52.
11. Norris RM, Brant PWT, Caughey DE, Lee AJ, Scott PJ. A new coronary prognostic index. Lancet 1969: 1: 274-8.
12. Tuman KJ, McCarthy RJ, March RJ, Najafi H, Ivankovich AD. Morbidity and duration of ICU stay after cardiac surgery. Chest 1992; 102: 36-44.
13. Vincent JL, Moreno R, Takala J et al. The SOFA (sepsis-related organ failure assessment) score to describe organ dysfunction / failure. On behalf of the Working Group on sepsis-related problems of the European Society of intensive care Medicine. Intensive Care Med 1996; 22: 707-710.
14. Rosenberg AL, Hofer TP, Strachan C, Watts CM, Hayward RA: Accepting critically ill transfer patients: adverse effect on a referral center's outcome and benchmark measures. Ann Intern Med 2003, 138:882-890.
15. Morales IJ, Peters SG, Afessa B: Hospital mortality rate and length of stay in patients admitted at night to the intensive care unit. Crit Care Med 2003, 31:858-863.
16. Livingston BM, MacKirdy FN, Howie JC, Jones R, Norrie JD: Assessment of the performance of five intensive care scoring models within a large Scottish database. Crit Care Med 2000, 28:1820-1827.
17. Polderman KH, Thijs LG, Girbes AR: Interobserver variability in the use of APACHE II scores. Lancet 1999, 353:380.
18. Vincent JL, de Mendonca A et al. Use of SOFA score to assess the incidence of organ dysfunction / failure in Intensive Care Unit: result of a multicenter, prospective study. Working group on "Sepsis Related problems" of the European Society of Intensive Care Medicine. Cri Care Med 1998; 26:1793-1800.
19. Regel G, Grotz M, Weltner T et al. Pattern of organ failure following severe trauma. World J Surg 1996; 20:422-429.
20. Antonelli M, Moreno R, and Vincent JL et al. Application of SOFA scores to trauma patients: sequential organ failure assessment. Intensive Care Med 1999; 25:389-394.
21. Moreno R, Vincent JL, Matos A et al. The use of maximum SOFA score to quantify organ dysfunction / failure in Intensive Care: results of a prospective, multicenter study. Intensive Care Med 1999; 25:686-696.
22. Berger MN, Marazzi A et al Evaluation of the consistency of Acute Physiology and Chronic Health Evaluation (APACHE II) scoring in a surgical intensive care unit. Crit Care Med. 1992;20:1681-7.
23. Gursel G, Demirtas S et al Value of APACHE II, SOFA and CPIS scores in predicting prognosis in patients with ventilator-associated pneumonia. Respiration. 2006;73: 503-8.
24. Fadi Alsous, Mohammad Khamiees et al studied Negative Fluid Balance Predicts Survival in Patients With Septic Shock. CHEST, June, 2000CHEST 2000; 117:1749-1754.
25. Ture M, Memis D, Kurt I et al. Predictive value of thyroid hormones on the first day in adult respiratory distress syndrome patients admitted to ICU: comparison with SOFA and APACHE II scores. Ann Saudi Med. 2005;25: 466-72.
26. Ferreira FL, Bota DP, Bross A, Melot C, Vincent JL: Serial evaluation of the SOFA score to predict outcome in critically ill patients. JAMA 2001, 286:1754-1758.
27. Meisner M, Tschaikowsky K, Palmaers T. Comparison of procalcitonin (PCT) and C-reactive protein (CRP) plasma concentrations at different SOFA scores during the course of sepsis and MODS. Crit Care. 1999; 3:45-50.
28. Janssens U, Graf C and Graf J et al. Evaluation of SOFA scores: a single center experience of a medical intensive care unit in 303 consecutive patients with predominantly cardiovascular disorders. Sequential Organ Failure Assessment. Intensive Care Med 2000;26:1037-45.
29. Ratanarath R, Thanakittiwirun et al. Prediction of mortality by using the standard scoring systems in medical intensive care unit in Thailand. J Med Assoc Thai. 2005;88: 949-55.
30. Peres Bota D, Melot Christian, Lopes Ferreira F et al. The multiple organ dysfunction scores versus the Sequential Organ Failure Assessment (SOFA) score in outcome prediction. Intensive Care Med 2002; 28: 1619-24.
31. Markus Wehler, Judith Kokoska, Udo Reulbatch, Eckhart George Hahn, Richard Strauss et al. Short-term prognosis in critically ill patients with cirrhosis assessed by prognostic scoring systems. Hepatology 2003;34:255-261.
32. Oh TE, Hutchinson R, Short S et al. Verification of the Acute Physiology and Chronic Health Evaluation scoring system in a Hong Kong intensive care unit. Crit Care Med. 1993;21: 647-9.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 14-02-2019; **Accepted:** 16-03-2019; **Published:** 28-03-2019