ORIGINAL ARTICLE

Comparison of Sequential Organ Failure Assessment Score and Sequential Organ Failure Assessment Score with pH in Outcome Prediction among ICU Patients: A Prospective Observational Study

Atiharsh M Agarwal[1], Amrita Gupta[2], Avanish K Saxena[3], Radhika Sahni[4], Aviral Pandey[5]

Abstract

Aim and objective: To examine if sequential organ failure assessment (SOFA) alone or SOFA in combination with pH is a better prognosis and mortality indicator.

Materials and methods: We conducted a prospective observational study in a total of sixty patients. The mortality of patients was predicted on the basis of a SOFA score alone or SOFA score in combination with pH, and the prediction by both was compared to the actual outcome. The comparison was based on the "standardized mortality ratio" and the "area under the receiver operating characteristic curve (AUROC)."

Result: At the time of admission, both the scores (SOFA and SOFA with pH) were equally effective in predicting mortality. At 48 hours, SOFA with pH proves to be slightly better in mortality prediction than SOFA score alone.

The discriminative power of both the scores was assessed by calculating AUROC. AUROC of the SOFA score was better than that of SOFA with pH at admission and at 48 hours, but statistically, both had the same level of discrimination, i.e., excellent.

Accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were the same for both the scores at admission, but all parameters except specificity were better for SOFA with pH at 48 hours. Specificity was the same for both even at 48 hours.

Conclusion: At the time of admission, SOFA score and SOFA with pH were equally effective in outcome prediction, but after 48 hours, SOFA with pH proves to be better than the SOFA score alone.

The power of discrimination is the same for both the scores at admission and at 48 hours.

Keywords: pH, Respiratory acidosis, Scoring system, SOFA score.

Indian Journal of Critical Care Medicine (2022): 10.5005/jp-journals-10071-24165

Introduction

Various organ dysfunction along with the number of failing organs is correlated with ICU mortality. So, quantification of organ dysfunction is done to facilitate the description of severity in different groups of patients enabling comparison over time or among groups to classify patients for enrollment and to compare treatment groups.[1] Various ICU scoring systems have been developed to estimate the severity of critical illness on an objective basis.[2] A scoring system usually comprises two parts—a score in which higher the number more severe is the condition and a probability model (equation giving the probability of hospital deaths of patients).[3] Old scoring systems like Acute Physiology and Chronic Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS), and Mortality Prediction Model (MPM) ignore many factors that may influence patient outcome beyond the first 24 hours.[3] SOFA score collects data every day throughout the ICU stay and has demonstrated the relationship between organ failure and mortality.[4,5] The SOFA score also requires a review data over a 24-hour period to identify the most abnormal value.

Our body functions in a relatively narrow alkaline environment (pH: 7.35–7.45). Maintenance of normal physiologic function is closely related to the maintenance of pH within this range. The two main mechanisms for this balance are respiratory and metabolic.[6,7] The respiratory response is fast and activated within minutes, while compensation is slow and takes hours to days to get activated.[8]

pH is also a major component of the APACHE-II scoring system. Rajawat et al.[9] have shown that the blood pH (both acidemia and alkalemia, irrespective of the type, i.e., respiratory and metabolic) are an important factor influencing mortality and

[1]Department of Anaesthesia and CCM, Rani Durgawati Medical College, Banda, Uttar Pradesh, India

[2,5]Department of Anesthesia, SN Medical College, Agra, Uttar Pradesh, India

[3,4]Department of General Surgery, FH Medical College and Hospital, Agra, Uttar Pradesh, India

Corresponding Author: Amrita Gupta, Department of Anesthesia, SN Medical College, Agra, Uttar Pradesh, India, Phone: +91 9837077784, e-mail: amritagupta78@gmail.com

How to cite this article: Agarwal AM, Gupta A, Saxena AK, Sahni R, Pandey A. Comparison of Sequential Organ Failure Assessment Score and Sequential Organ Failure Assessment Score with pH in Outcome Prediction among ICU Patients: A Prospective Observational Study. Indian J Crit Care Med 2022;26(4):479–483.

Source of support: Nil

Conflict of interest: None

morbidity in ICU patients. Also, the rate of improvement of pH is an important contributing factor.

Since pH is seen to be an important predictor of outcome prediction, this study was taken to include pH as an additional measure in the SOFA score to see if this improves the prediction better than the SOFA score alone.

Aims and Objectives

Aims

To examine if SOFA alone or SOFA in combination with pH is a better prognosis and mortality indicator.

Objectives

- To examine SOFA vs SOFA and pH to estimate the risk of hospital death.
- To assess the prognosis of patients using defined scores like SOFA vs SOFA and pH.
- To determine the sociodemographic profile, diagnosis, and characteristics of patients admitted to ICU.

Materials and Methods

It is a prospective observational study done in the north Indian population after the approval by the institutional ethical committee (IEC/2021/64). The study was done in the ICU of SN Medical College, Agra, from November 1, 2018, to December 31, 2019, after taking the informed written consent from patients' attendants. A total of sixty patients with age more than or equal to 18 years admitted into the ICU for more than 48 hours were included in this study, at 95% power and 5% level of significance.

Patients excluded were postoperative patients for elective ventilation, patients with acute coronary syndrome, burn patients, and patients with terminal cancer.

The SOFA score and pH score were calculated from the laboratory and patient characteristics mentioned in the ICU scoring data sheet, at 0 hours (at admission) and 48 hours.

The highest SOFA score of the day was recorded. The pre-sedation Glasgow coma score was used to evaluate the neurological status of patients under sedation.

The outcome based on the score used at 0 and 48 hours was calculated and correlated with the actual outcome, as survivors or nonsurvivors. The results were presented as mean ± standard deviation.

Statistical tests were applied as follows:

- Quantitative variables were compared using Mann–Whitney test (as the data sets were not normally distributed) between the two groups, and Wilcoxon signed-rank test was used for comparison between the SOFA score alone and the SOFA score with pH.
- Receiver operating characteristic (ROC) curve was used to find out the cutoff point of scores for predicting mortality.

A p-value of <0.05 was considered statistically significant.

Assessment of Scoring Systems

Two main properties are used to assess and validate the scoring system—model calibration and model discrimination.

Model Calibration

Calibration can be assessed by standardized mortality ratio (SMR) values. SMR = observed mortality rate/predicted mortality rate.

Calibration is considered to be good if the predicted mortality is close to the observed mortality.

Model Discrimination

This is done by calculating the area under the receiver operating characteristic (AUROC) curve which represents the number of patients who died.

Discrimination levels based on the AUROC.

AUROC	*Level of discrimination*
Perfect	1.00
Excellent	0.90–0.99
Very good	0.80–0.89
Good	0.70–0.79
Moderate	0.60–0.69
Poor	0.60

Method of Scoring and Observation

The SOFA scoring system and daily pH for each patient will be calculated using Table 1.

Table 1: SOFA scoring system and daily pH for each patient

SOFA score	*0*	*1*	*2*	*3*	*4*
Respiration PaO_2/FiO_2 mm Hg	>400	≤400	≤300	≤200	≤100
Coagulation, platelets, $\times 10^3/\mu L$	>150	101–150	51–100	21–50	0–20
Hepatic bilirubin, mg/dL	<1.2	1.2–1.9	2.0–5.9	6.0–11.9	>12.0
CNS Glasgow Coma Score	15	13–14	10–12	6–9	<6
Cardiovascular MAP, mm Hg	>70	0–70	Dopamine ≤5.0 or dobutamine (any dose)	Dopamine 5–14.9 Epinephrine ≤0.1 Norepinephrine ≤0.1	Dopamine ≥15 Epinephrine >0.1 Norepinephrine >0.1
Renal S. creatinine, mg/dL or urine output, mL	<1.2	1.2–1.9	2.0–3.4	3.5–4.9 or <500	>5.0 or <200

pH

Physiologic variables	+4	+3	+2	+1	0	+1	+2	+3	+4
Arterial pH	≥7.7	7.6–7.69		7.5–7.59	7.33–7.49		7.25–7.32	7.15–7.24	<7.15

The following parameters were observed:

- Age of patients.
- Mean length of stay in ICU and hospital.
- SOFA and SOFA with pH scores by measuring the following parameters at 0 and 48 hours:
  - PaO_2/FiO_2 (%).
  - Platelet count ($10^3/mm^3$).
  - Serum bilirubin (mg/dL).
  - Mean arterial pressure (mm Hg).
  - Presedation Glasgow coma scale.
  - Serum creatinine (mg/dL).
- Standardized mortality ratio (observed mortality rate/predicted mortality rate).
- Sensitivity, Specificity, negative predictive value (NPV), positive predictive value (PPV), and accuracy of SOFA and SOFA with pH.
- AUROC.

Results

Table 2 shows the mean age of survivors was 44.30 ± 15.85 years.

The mean age of nonsurvivors was 48.85 ± 11.83 years.

The difference between them is not statistically significant (*p*-value <0.20). Of the sixty patients included in the study, 27 recovered and 33 succumbed to the disease.

The mean length of stay in ICU in survivors was 5.96 with an SD of 1.65 and in nonsurvivors was 6.12 with an SD of 3.01. The difference between them is not statistically significant (*p*-value = 0.80).

The mean length of stay in the hospital of survivors was 14.34 (SD 3.21) and of nonsurvivors was 9.55 (SD 3.57). The difference between them is statistically significant.

Table 3 shows the mean SOFA score and SOFA with pH score at the time of admission and 48 hours after admission was significantly higher in nonsurvivors than in survivors. The difference is statistically significant (*p*-value <0.0001). The mean SOFA score and SOFA with pH score showed a decreasing trend in survivors, and in nonsurvivors, it showed a slightly increasing trend.

Table 4 shows that at 0 hours, SMR of both SOFA score and SOFA score with pH was 1.14, i.e., both the scores underpredicted the mortality. While after 48 hours, the SMR of SOFA score alone was 0.96 and that of SOFA score with pH was 1, this means that SOFA score with pH was better for prediction at 48 hours.

Table 5 shows that different statistical parameters show similar results between SOFA and SOFA with pH at the time of admission of patients.

At 48 hours, SOFA with pH had a significantly higher sensitivity (96.30%) than SOFA score alone (92.59%). The specificity of both the scores was similar (96.97%).

PPV is slightly better in SOFA with pH (96.30%) than SOFA score alone (96.15%). NPV is better in SOFA with pH (96.97%) than SOFA score alone (94.12%). SOFA score with pH had a better diagnostic accuracy (96.67%) than SOFA score alone (95%).

Table 6 shows the area under ROC curve for SOFA at 0 hour is 0.953 (Fig. 1) and SOFA score at 48 hours is 0.994 (Fig. 2). The area under ROC curve for SOFA score with pH at 0 hour is 0.927 (Fig. 3) and SOFA score with pH at 48 hours is 0.985 (Fig. 4). Both scores

Table 2: Comparison between survivors and nonsurvivors (mean SOFA score vs mean SOFA score with pH)

	Survivors	*Nonsurvivors*	*p value*
Mean age	44.30 ± 15.85 years	48.85 ± 11.83 year	0.20
Mean ICU stay	5.96 ± 1.65	6.12 ± 3.01	0.80
Mean hospital stay	14.34 ± 3.21	9.55 ± 3.57	<0.01

Table 3: Standardized mortality ratio

	Survivors (N = 27)	*Nonsurvivors (N = 33)*	*p value*	*t value*
Mean SOFA 0 hour	9.74 ± 1.46	12.36 ± 0.99	<0.0001	8.254
SOFA 48 hours (mean)	8.67 ± 1.44	12.42 ± 0.97	<0.0001	12.006
SOFA + pH 0 hour (mean)	16.99 ± 1.44	19.51 ± 0.99	<0.0001	8.009
SOFA + pH 48 hours (mean)	16.01 ± 1.42	19.60 ± 0.97	<0.0001	11.597

Table 4: SMR of SOFA score and SOFA score with pH

		0 hour	*48 hours*
SOFA score	OMR	0.55	0.55
	PMR	0.48	0.57
	SMR	1.14	0.96
SOFA score with pH	OMR	0.55	0.55
	PMR	0.48	0.55
	SMR	1.14	1

SMR, OMR/PMR; <1—overprediction; >1, underprediction; OMR, observed mortality rate; PMR, predicted mortality rate; SMR, standardized mortality ratio

Table 5: Comparison of statistical parameters at 0 and 48 hours

	Sensitivity (%)	*Specificity (%)*	*PPV (%)*	*NPV (%)*	*Accuracy (%)*
SOFA 0 hour	85.19	75.76	74.19	86.21	80
SOFA + pH 0 hour	85.19	75.76	74.19	86.21	80
SOFA 48 hours	92.59	96.97	96.15	94.12	95
SOFA + pH 48 hours	96.30	96.97	96.30	96.97	96.67

Table 6: AUROC for SOFA and SOFA with pH

	AUROC
SOFA 0 hour	0.953
SOFA + pH 0 hour	0.927
SOFA 48 hours	0.994
SOFA + pH 48 hours	0.985

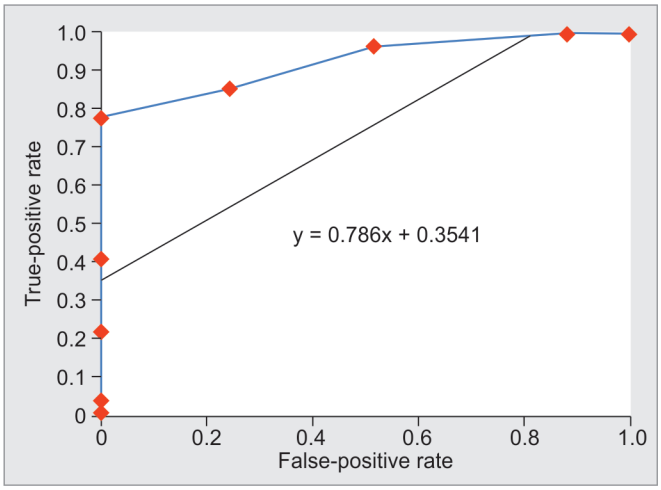

Fig. 1: ROC of SOFA score at 0 hour

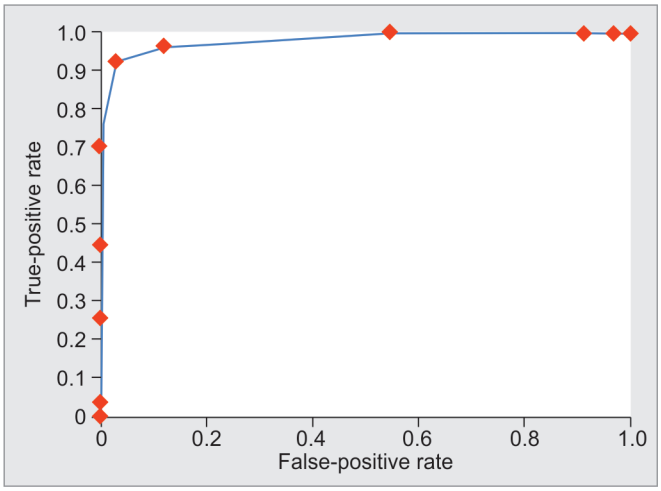

Fig. 2: ROC of SOFA score at 48 hours

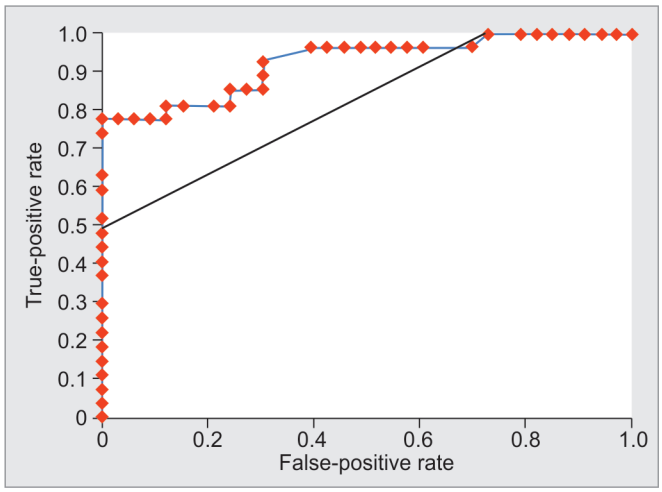

Fig. 3: ROC of SOFA with pH at 0 hour

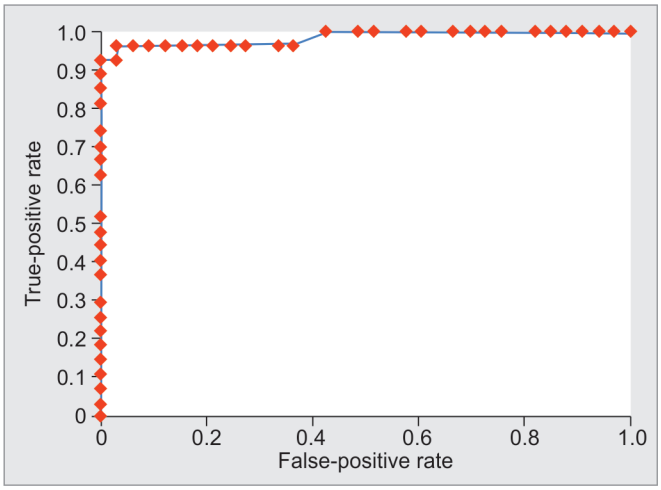

Fig. 4: ROC of SOFA with pH at 48 hours

at 0 hour and 48 hours show excellent discrimination. Although SOFA score at 0 hour as compared to SOFA with pH at 0 hour offers slight advantage in terms of power of discrimination.

Discussion

This study showed that at the time of admission both SOFA and SOFA with pH scores had equal SMR and both the scores underpredicted the mortality, but at 48 hours, the SOFA score with pH predicted mortality slightly better than the SOFA score.

SOFA score and SOFA with pH had similar statistics at the time of admission. Both had the same sensitivity, specificity, NPV, and PPV.

At 48 hours, SOFA with pH had a significantly higher sensitivity, PPV, and NPV) than SOFA score alone. The specificity of both the scores was similar.

None of the earlier studies has mentioned the sensitivity, specificity, NPV, and PPV of SOFA or SOFA scores with pH at variable time intervals.

Although AUROC for SOFA (0.953) was better than SOFA with pH (0.927) at 0 hour and marginally better at 48 hours, the power of discrimination of both the scores was statistically comparable and excellent.

Previous studies by Bale et al.[10] like our study showed that the SOFA score was significantly higher in nonsurvivors than in survivors. Franz[11] like our study mentioned that changes in pH had a better correlation with a magnitude of multiorgan failure.

The main drawback of our study was that the sample size was small.

Conclusion

Hence, SOFA score with pH seems to be superior to SOFA score alone in outcome prediction among ICU patients. But since this study was based on a single ICU and had a limited number of patients and limited resources, we propose that this study be done on a larger scale in order to achieve more accurate results.

Orcid

Atiharsh M Agarwal https://orcid.org/0000-0002-2459-3870
Amrita Gupta https://orcid.org/0000-0002-4668-2604
Avanish K Saxena https://orcid.org/0000-0001-9499-332X
Radhika Sahni https://orcid.org/0000-0001-5318-1229
Aviral Pandey https://orcid.org/0000-0002-4101-2855

References

1. Vincent JL, Gustot T. Sepsis and cirrhosis: many similarities. Acta Gastroenteral Belg 2010;73(4):472–478. PMID: 21299157.
2. Sinuff T, Adhikari NK, Cook DJ, Schünemann HJ, Griffith LE, Rocker G, et al. Mortality predictions in the intensive care unit: comparing physicians with scoring systems. Crit Care Med 2006;34(3):878–885. DOI: 10.1097/01.CCM.0000201881.58644.41.
3. Le Gall JR. The use of severity scores in the intensive care unit. Intensive Care Med 2005;31(12):1618–1623. DOI: 10.1007/s00134-005-2825-8.
4. Moreno R, Vincent JL, Matos R, Mendonca A, Cantraine F, Thijs L, et al. The use of maximum SOFA score to quantify organ dysfunction/failure in intensive care. Results of a prospective, multicentre study. Intensive Care Med 1999;25(7):686–696. DOI: 10.1007/s001340050931.
5. Ferreira FL, Bota DP, Bross A, Mélot C, Vincent JL. Serial evaluation of the SOFA score to predict outcome in critically ill patients. Journal of the American Medical Association 2001;286(14):1754–1758. DOI: 10.1001/jama.286.14.1754.
6. Watson ML. Back to basics: acid-base disorders. Can J CME 2002;14(6):57.
7. Singh V, Khatana S, Gupta P. Blood gas analysis for bedside diagnosis. Natl J Maxillofac Surg 2013;4(2). DOI: 10.4103/0975-5950.127641.
8. Khwannimit B. Serial evaluation of the MODS, SOFA and LOD scores to predict ICU mortality in mixed critically ill patients. J Med Assoc Thai 2008;91(9):1336–1342. PMID: 18843861.
9. Rajawat MS, Rathore SS, Choudhary M. pH disorders and mortality in surgical intensive care unit patients. Int Surg J 2016;3(2):905–907. DOI: 10.18203/2349-2902.ISJ20161165.
10. Bale C, Kakrani AL, Dabadghao VS, Sharma ZD. Sequential organ failure assessment score as prognostic marker in critically ill patients in a tertiary care intensive care unit. Int J Med Public Health 2013;3(3):155. DOI: 10.4103/2230-8598.118956.
11. Frantz TL, Gaski GE, Terry C, Steenburg SD, Zarzaur BL, McKinley TO. The effect of pH versus base deficit on organ failure in trauma patients. J Surg Res 2016;200(1):260–265. DOI: 10.1016/j.jss.2015.07.003.