Original Article

Comparison of Performance of APACHE II and SOFA Scoring Systems in Critically Ill Patients Admitted to Intensive Care Unit

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Abstract

Background. Several disease scoring systems have evolved for predicting the mortality in intensive care unit (ICU) patients. We evaluated the performance of Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) scoring systems in providing mortality risk estimates in critically ill patients.

Methods. During March 2015 to March 2016, 160 critically ill patients requiring mechanical ventilation (MV) at our tertiary care teaching hospital in south India were prospectively studied.

Results. Compared to survivors, non-survivors were significantly older (median [interquartile range, IQR] age [years] 42.5 (28-54.3) *versus* 33 [22–49.3] [p=0.025]); had higher median (IQR) APACHE II score (23 [18-29] *versus* 15 [11.8-19]); and SOFA score (9 [6-12] *versus* 5 [4-7] [p<0.001]); required MV for a longer duration (9 [6–13] *versus* 6 [4–9] days [p=0.048]) and had lesser duration of ICU stay (7 [4–12] *versus* 13.5 [8-21.3] days [p<0.001]) and hospital stay (9 [7–17.3] *versus* 16 [11.8-28] days [p<0.001]). APACHE II score (cut-off >17, sensitivity 67.8%, specificity 80%) and SOFA score (cut-off >7, sensitivity 78.9% and specificity 67.1%) performed similarly in predicting mortality (difference between areas under the curve 0.0180; standard error 0.0316; 95% confidence interval, -0.0440 to 0.0800; z statistic 0.569; p=0.569).

Conclusion. Both APACHE II and SOFA scores appear to be useful tools in predicting mortality in critically ill patients requiring MV in the setting of an ICU in south India. **[Indian J Chest Dis Allied Sci 2019;61:69-74]**

Key words: APACHE II, ICU, Mortality, SOFA, Mechanical ventilation, South India.

Introduction

Critical care medicine has come a long way in India since the early 1970s. Presently, intensive care units (ICUs) and critical care facilities are becoming available not only in large metros but also in smaller cities and even in towns, especially in the setting of medical college hospitals.[1,2] The goal of intensive care is to provide the highest quality of treatment in order to achieve the best outcomes for critically ill patients. Several disease scoring systems have evolved for predicting the mortality in an intensive care unit patients, Acute Physiology and Chronic Health Evaluation (APACHE) II and Sequential Organ Failure Assessment score (SOFA) are some of the scoring systems that are commonly used for objectively assessing the clinical status and severity of the disease in critically ill patients.[3,4] However, these scoring systems are poor at predicting outcome in critically ill patients admitted to ICU in India.[5] Nevertheless, the difference in efficacy was not statistically significant and the choice of scoring systems may depend on the ease of use and local preferences.[6] The performance of APACHE II and SOFA scoring systems in predicting mortality in Indian scenario has been found to be variable in some published studies.[5,7-12] With this background, the present study was undertaken to evaluate the performance of APACHE II and SOFA scoring systems in providing mortality risk estimates in critically ill patients admitted to respiratory intensive care unit (RICU) in a tertiary care teaching hospital in South India.

Material and Methods

All patients admitted to the RICU at our tertiary care teaching hospital during the period March 2015 to March 2016 were screened for inclusion into the study. Adult patients aged between 18-60 years, who were admitted to RICU and required mechanical ventilation (MV) were included. Patients aged less than 18 years and older than 60 years; those who survived less than 24 hours after admission; human immunodeficiency virus seropositive individuals and patients unwilling to participate in study were excluded. The study was approved by the Institutional Ethics Committee. A written informed consent was obtained from all the participants. In case the patient was unconscious, consent was obtained from the next responsible attendant.

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In all the patients, a complete history was obtained and a thorough physical examination was conducted. Laboratory investigations carried out at the time of initial admission were: complete haemogram, serum biochemistry, urinalysis, chest radiograph, 12-lead electrocardiogram (ECG), arterial blood gas (ABG) analysis, blood culture (BacT/ALERT®, BioMérieux Inc, Durham, USA), urine culture (Himedia Laboratories Pvt Ltd, Mumbai) and serological testing for immunoglobulin M (IgM) antibodies against scrub typhus (InBios International, Inc., Seattle, WA, USA), leptospira (Scimedx Leptospira IgM Microwell ELISA, Dover, NJ, USA) and non-structural protein 1 (NS1) antigen for dengue (Panbio ® Dengue Early ELISA, Brisbane, Australia). Malaria was diagnosed by thick and thin peripheral blood smear examination (Leishman stain) and quantitative buffy coat technique (QBC Diagnostics and The Drucker Company, Port Matilda, USA). Critical illness severity scores, namely, APACHE II[3] and SOFA[4] were computed at the time of initial presentation. Parameters monitored around the clock during course of illness included heart rate, non-invasive blood pressure, oxygen saturation, respiratory rate, Glasgow coma scale (GCS) score, urine output and blood sugar. Laboratory investigations were repeated as per clinical condition of the patient.

Organ system failure and occurrence of multiple organ dysfunction syndrome (MODS) was defined using standard definitions[4]: arterial hypoxaemia (ratio of arterial oxygen tension [PaO_2] to fraction of inspired oxygen [FiO_2] <300), acute kidney injury (AKI) (urine output <0.5 mL/kg/hour for at least two hours despite adequate fluid resuscitation and increase in creatinine by >0.5 mg/ dL), ileus, hypotension (systolic blood pressure <90 mmHg, mean arterial pressure <70 mmHg); hepatic dysfunction (plasma total bilirubin >4 mg/dL), haematological and coagulation abnormalities (international normalised ratio [INR] >1.5) or activated partial thromboplastin time [aPTT] >60s and platelet count <100,000/mm^3, and encephalopathy (presence of altered mental status).

Specific management of particular illnesses or disease was treated as per the standard care of management. Supportive treatment, such as, nutritional management, mechanical ventilatory support, glycemic control, renal replacement therapy, stress ulcer prophylaxis and deep venous thrombosis (DVT) prophylaxis were initiated wherever appropriate to all patients as per the standard institute ICU protocols.

Statistical Analysis

Data were recorded on a pre-designed proforma and managed using Microsoft Excel 2010 (Microsoft Corp, Redmond, USA). Patients were followed-up until discharge from the hospital or death. In-hospital death was used as the primary end-point. For the purposes of statistical analysis, patients who were "discharged against medical advice" (DAMA) were considered to have worst outcome, *i.e.* "death". Receiver-Operator characteristic curves (ROC-curve) for APACHE II and SOFA scores were plotted using different cut-off levels of APACHE II and SOFA scores to arrive at the choice of most appropriate cut-off level to predict death. The statistical software IBM SPSS Statistics Version 20 (IBM Corp Somers NY, USA); Stata/IC 12 for Windows (StataCorp LP, Texas, USA); and MedCalc Version 11.3.0 for Windows 2000/XP/Vista/7 (MedCalc Software bvba, Belgium) were used for all mathematical computations and statistical calculations.

Results

During the study period, a total of 12,636 patients required admission in the emergency room at our institute. Of these, 648 patients were admitted in the RICU; and 350 required assisted MV. One hundred and ninety patients were excluded (76 died within 24 hours of admission, 90 patients were of age >60 years, 20 patients were of age <18 years and four patients tested seropositive for HIV); and 160 patients were included in the study (Figure 1).

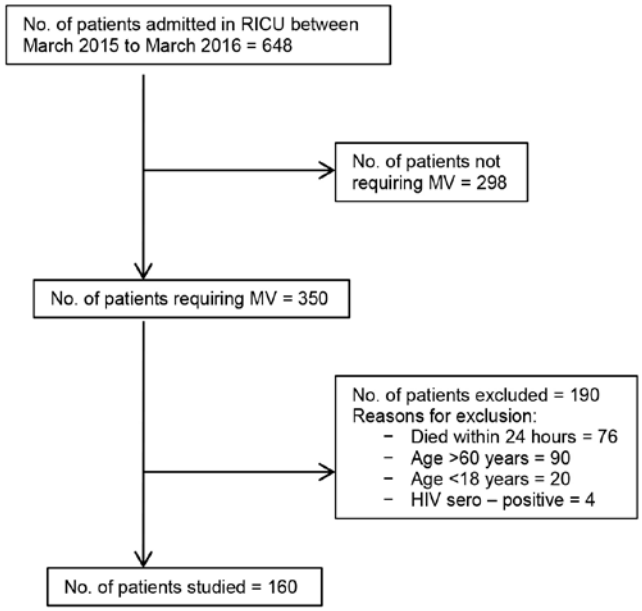

Figure 1. Study plan.

Definition of abbreviations: RICU=Respiratory intensive care; MV=Mechnical ventilation; HIV=Human immunodeficiency virus

Their mean age was 38.3±14.2 years; 88 (55%) patients were males. Common admitting indications were organophosphorous compound (OPC) poisoning (n=27, 16.9%); acute inflammatory demyelinating polyneuropathy (AIDP) (n=18, 11.3%); road traffic accident (RTA) (n=15, 9.4%), snake bite and AKI [n=11, 6.9% each] and postpartum sepsis (n=10, 6.3%) (Table 1). Univariate analysis comparing clinical and laboratory variables between survivors (alive) and non-survivors (dead) are shown in table 2. Compared to survivors, non-survivors were significantly older (p=0.025); had higher median (IQR) APACHE II score (p<0.001); and SOFA score (p<0.001);

required MV for a longer duration (p=0.048) and had lesser duration of RICU stay (p<0.001) and hospital stay (p<0.001). During the course of hospital stay, there was no statistically significant difference in the interventions required between survivors and non-survivors (p=0.778) (Table 3).

During hospital stay, 62 patients developed complications. Complications occurred more frequently in non-survivors compared with survivors: MODS [22/70 *versus* 0/90]; AKI [15/70 *versus* 5/90]; ventilator associated pneumonia (VAP) [7/70 *versus* 3/90]; complications rate among alive and dead group was statistically significant (p=0.001).

Table 1. Clinical diagnosis

Diagnosis	Number of Patients (%)
OPC poisoning	27 (16.9)
AIDP	18 (11.3)
RTA	15 (9.4)
Acute on CKD	12 (7.5)
Snake bite	11 (6.9)
AKI	11 (6.9)
Postpartum sepsis	10 (6.3)
Supervasmol (hair dye) poisoning	7 (4.9)
Meningoencephalitis	6 (3.8)
ARDS	5 (3.1)
Hanging	4 (2.5)
CVA with respiratory failure	4 (2.5)
Dengue shock syndrome	4 (2.5)
Coronary artery disease	3 (1.9)
COPD	3 (1.9)
Hypokalemic periodic paralysis	3 (1.9)
Lupus nephritis	2 (1.3)
Nephrotic syndrome	2 (1.3)
Diabetic ketoacidosis	1 (0.6)
Drowning	1 (0.6)
IgA nephropathy	1 (0.6)
Myasthenia gravis	1 (0.6)
Obstructive sleep apnoea	1 (0.6)
POP decompressivecraniectomy	1 (0.6)
Sepsis with AKI	1 (0.6)
Post-hysterectomy with uropathy	1 (0.6)
Pre-ecclampsia with sepsis	1 (0.6)
Pul. Kochs with respiratory failure	1 (0.6)
Rhabdomyolysis with AKI	1 (0.6)
Scorpion sting	1 (0.6)
Scrub typhus	1 (0.6)

Definition of abbreviations: OPC=Organo phosphorous compound; AIDP=Acute inflammatory demyelinating polyneuropathy; RTA=Road traffic accident; CKD=Chronic kidney disease; AKI=Acute kidney injury; ARDS=Acute respiratory distress syndrome; CVA=Cerebrovascular accident; COPD=Chronic obstructive pulmonary disease; IgA=Immunoglobulin A; POP=Post-operative; Pul.=Pulmonary.

Table 2. Comparison of age, APACHE II, SOFA, duration of RICU stay, mechanical ventilation in days, duration of hospital stay among survivors and non-survivors

Variables	Survivors (n=90)	Non-survivors (n=70)	p-value
Age (years)	33 (22-49.3)	42.5 (28-54.3)	0.025
APACHE II	15 (11.8-19)	23 (18-29)	<0.001
SOFA	5 (4-7)	9 (6-12)	<0.001
Duration of MV	6 (4-9)	9 (6-13)	0.048
Duration of RICU stay (days)	13.5 (8-21.3)	7 (4-12)	<0.001
Duration of hospital stay (days)	16 (11.8-28)	9 (7-17.3)	<0.001

Data are presented as median (interquartile range)

Definition of abbreviations: n=Number of patients; APACHE II=Acute Physiology and Chronic Health Evaluation; SOFA=Sequential Organ Failure Assessment; MV=Mechanical ventilation; RICU=Respiratory intensive care unit

Table 3. Interventions among survivors and non-survivors

Intervention	Outcome		Significance
	Survivors (n=90)	Non-survivors (n=70)	
No intervention	57	45	
HD	18	17	$\chi 2$=1.768
Tracheostomy	13	07	(p=0.778)
Bilateral ICD	01	01	
Fiberoptic bronchoscopy	01	00	

Definition of abbreviations: HD=Haemodialysis; ICD=Intercostal drain.

Respiratory failure (n=78), and poor GCS (n=68) were the most common causes for initiating MV. Out of 160 patients, 70 (44%) had a poor outcome; 59 died in the RICU; 11 were discharged against medical advice (DAMA). For the purposes of statistical analysis, patients who were "discharged against medical advice" were considered to have worst outcome, *i.e.* "death".

The ROC-curve for calculating the optimal cut-off value of APACHE II score and SOFA score for predicting mortality is shown in figures 2A and 2B. At a cut-off value of APACHE II score >17, the sensitivity and specificity were 67.8 and 80.0, respectively for predicting mortality (area under the curve [AUC] 0.792; standard error [SE], 0.0359; 95% confidence interval [CI], 0.721 to 0.852; Z-statistic 8.143; p=0.0001). SOFA score at a cut-off value of >7 had a sensitivity and specificity of 78.9 and 67.1, respectively for predicting mortality (AUC 0.774; SE 0.0374; 95% CI: 0.702 to 0.836; Z-statistic 7.336; p=0.0001). On comparing the performance of APACHE II and SOFA score (Figure 2C) both performed similarly in predicting mortality (difference between AUC 0.0180; SE0.0316; 95% CI 0.0440 to 0.0800; z-statistic 0.569; p=0.569).

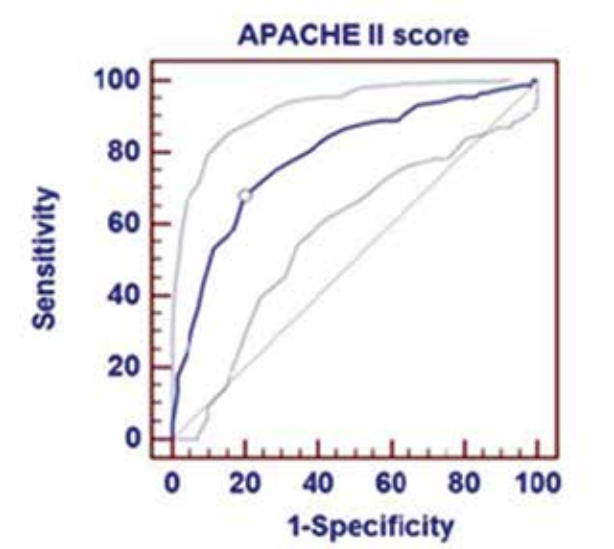

Figure 2A. ROC curve along with 95% confidence bound for calculating the cut-off value for APCHE II score to predict mortality.

The area under the curve [AUC] = 0.792; standard error = 0.0359; 95% confidence interval = 0.721 to 0.852; Z-statistic = 8.143; p = 0.0001.

Definition of abbreviations: ROC=Receiver operating characteristic curve; APACHE II=Acute Physiology and Chronic Health Evaluation II.

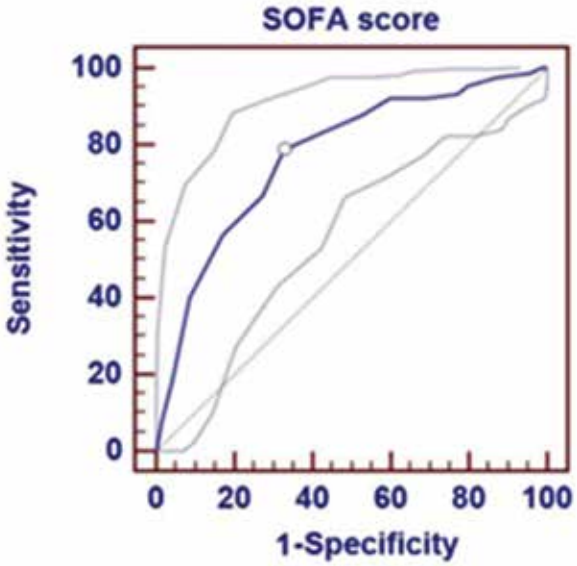

Figure 2B. ROC curve along with 95% confidence bound for calculating the cut-off value for SOFA score to predict mortality.

The area under the curve [AUC] = 0.774; standard error = 0.0374; 95% confidence interval = 0.702 to 0.836; Z-statistic = 7.336; p = 0.0001.

Definition of abbreviations: ROC=Receiver operating characteristic curve; SOFA=Sequential Organ Failure Assessment.

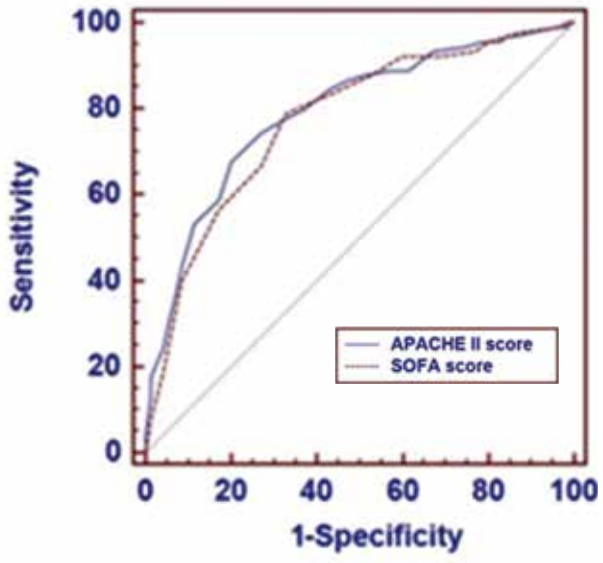

Figure 2C: Comparison of performance of ROC curves of APACHE II and SOFA scores in predicting mortality.

For APACHE II: AUC = 0.792; SE = 0.0359; 95% CI = 0.721 to 0.852; For SOFA: AUC = 0.774; SE = 0.0374; 95% CI = 0.702 to 0.836

Definition of abbreviations: APACHE II=Acute Physiology and Chronic Health Evaluation II; SOFA=Sequential Organ Failure Assessment; AUC=Area under the curve; SE=Standard error; CI=Confidence interval.

Discussion

Prediction of patient prognosis admitted in ICU always remains an area of great concern for the physicians as well as for patients' families. The impact of this prediction bears on different aspects of patient care, like selection of medical therapy, triaging, end of life care and many more. The APACHE-II scoring system has been widely accepted as a measure of illness severity. When APACHE II was originally validated, it included ICUs mainly from North America. It was not validated for the Indian ICUs. It has been shown to accurately stratify risk of death in a wide range of disease states, and in different clinical settings.[13] Among other scoring systems for predicting outcomes in ICU, SOFA score is easy as the variables measured are easily available and routinely measured in various cohorts of patients. There has been a very limited use of these scoring systems in South India. So it is very important to check its validity in the local population. The present study was, therefore, designed to prospectively evaluate the performance of APACHE II and SOFA scoring systems in critically ill patients in a tertiary care teaching hospital in south India.

The mean age of the patients in the present study was 38.3±14.2 years, which is comparable with the studies[14-16] from Jaipur, Turkey and Mumbai. Men outnumbered the women in the present study which is similar to the study[17] from Nepal. This observation should be interpreted keeping in mind the fact that, in the developing countries, like India and Nepal, men access health-care more readily than women who often seek medical aid only when they fall very sick. Also, social taboos among Indian women, particularly from the rural community play a role in fewer women seeking health care.

In the present study, OPC poisoning constituted the majority of cases requiring admission to RICU because of easy availability and accessibility. Acute inflammatory

demyelinating polyneuropathy requiring mechanical ventilatory support constituted second major aetiological cause for admission to RICU. These results were contrary to the previous study from Mexico[18] in which, majority of the cases were with severe sepsis. In the present study, the median (IQR) duration of MV was longer in non-survivors compared with survivors. Similar observations were noted in studies[17,18] from Nepal and Mexico. In another study[19] from Hyderabad conducted in obstetric patients requiring ICU admission, duration of MV was also longer in non-survivors. In our study, the median (IQR) duration of hospital stay and ICU stay (days) was longer in survivors, compared to non-survivors which is comparable to that documented in studies from Nepal, Mexico and Netherlands.[17,18,20] While in other study from Japan,[21] non-survivors were found to have a longer duration of hospital as well as ICU stay. These differences could be due to the age-groups studied, aetiologial causes of admission to ICU, duration of MV, among others. Our results were similar to a study from Mumbai[16] in which the mean duration of hospital stay in survivors was 25 days and in non-survivors was 16 days.

In our study, various complications occurred more frequently among non-survivors compared to survivors; MODS (n=22) was the most frequently encountered complication in non-survivors. Sepsis and MODS were the complications encountered in a study from Turkey[15] on outcome in patients with acute liver failure using APACHE II and GCS score. The mortality depends upon many factors, like aetiological cause, availability of nearby first-aid services, time lapse between onset of symptoms and presentation to hospital, availability of technical expertise in handling these emergencies.

A mortality of 54% in a study from Mumbai[16] in which they evaluated value of SOFA scores in predicting prognosis in patients with VAP was reported. In a study from Poland[22] overall in-hospital mortality was between 15% to 40%. The mortality rate observed in our study may be due to referral bias as the sickest patients being referred to us. Factors associated with mortality included higher age (42.5 years), higher APACHE II and SOFA score of 23 and 9, respectively, were found in non-survivors compared with survivors ($p<0.05$).

In the present study, care was taken to assess critical illness with scoring systems, like APACHE II and SOFA. Further cut-off values for APACHE II and SOFA scores for predicting mortality were defined by ROC-curve method. The median (IQR) APACHE II score in the present study in survivors was 15 (11.8-19) and in non-survivors was 23 (18-29). The results were comparable with a study from Karachi[23] done to predict mortality in chest ICU using APACHE II score in which it was 18.9±7.2 in survivors and in non-survivors the score was 22.3±7.8. A study from Iran[24] reported a mean APACHE II score of 13.2±3.5 in survivors, and 17.2±2.5 in non-survivors, which is comparable to our study. In our study at a cut-off value of APACHE II score>17, the sensitivity and specificity were 67.8% and 80%, respectively (AUC 0.792 and SE 0.0359) which is similar to a study from Japan.[21] In the derivation cohort of APACHE II, an APACHE II score of 16-19 was associated with a mortality of 20% to 30%. In the present study, we observed that 50/160 (31%) patients with an APACHE II score of >17 had poor outcome, suggesting that APACHE II score of >17 was a useful predictor of mortality. In a study from New Jersey[25], the AUC along with 95% CI for SOFA score at the time of initial presentation to predict mortality was 0.75 (95% CI 0.68-0.836). In our study, we noted a similar AUC [0.77 (95% CI 0.702-0.836)] for SOFA score to predict mortality suggesting that SOFA score is also a useful mortality predictor tool.

A study from Brazil[26] evaluated outcome in obstetric intensive care, the cut-off SOFA score was >6 with a sensitivity and specificity of 88.9% and 91.1%, respectively (AUC 0.958; 95% CI: 0.914–1.0). The present study, therefore, provides valuable data in assessing the clinical manifestations, complications, and outcome in the patients presenting with critical illness admitted to ICU. Both APACHE II and SOFA score performed similarly in predicting mortality (difference between areas under ROC-curve 0.0180; SE 0.0316; 95% CI, −0.0440 to 0.0800; z-statistic 0.569; p=0.569). They both provided prognostic information which may be useful for the clinicians.

The limitations of the present study were: (i) we did not include all patients admitted to RICU; only the patients requiring MV in RICU were included; (ii) APACHE II and SOFA score calculated at the time of initial admission only was considered for analysis. The change in trends in critical illness scoring systems over a period of time was not evaluated in the present study; and (iii) the present study is a single centre study and these observations merit validation in several centres in different parts of the country.

Conclusions

The present study provides valuable epidemiological data regarding aetiology, complications and outcome in patients presenting with critical illness requiring mechanical ventilation and admission to intensive care unit at a single tertiary care teaching hospital. Both APACHE II and SOFA score performed similarly in predicting mortality. Both provided prognostic information which may be useful for the clinicians to assess the outcome of patients admitted to intensive care unit with critical illness.

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