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# A COMPARATIVE STUDY OF SEQUENTIAL ORGAN FAILURE ASSESSMENT (SOFA) AND ACUTE PHYSIOLOGY AND CHRONIC HEALTH EVALUATION II (APACHE II) SCORES IN PREDICTING MORTALITY IN PATIENTS WITH SEPSIS-ASSOCIATED MULTI-ORGAN DYSFUNCTION SYNDROME

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## ABSTRACT

**Background:** Sepsis with multi-organ dysfunction syndrome (MODS) is a major contributor to intensive care unit (ICU) mortality. The Sequential Organ Failure Assessment (SOFA) and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores are widely used severity-of-illness tools, but their comparative prognostic accuracy in sepsis-associated MODS remains debated.
**Aim:** To assess SOFA and APACHE II scores in patients with sepsis and to compare their ability to predict mortality in patients with sepsis-associated multi-organ dysfunction syndrome.
**Materials and Methods:** This prospective observational study was conducted in the ICU of PES Institute of Medical Sciences and Research, Kuppam, over 18 months. Eighty-six adult patients with sepsis-associated MODS were enrolled by purposive sampling. SOFA score was calculated daily until ICU discharge or death, and APACHE II score was calculated within the first 24 hours of admission. Patients were categorised into survivors and non-survivors. Continuous variables were compared using Student's t-test and categorical variables using the chi-square test; receiver operating characteristic (ROC) curve analysis was used to compare discriminative performance. $p<0.05$ was considered significant.
**Results:** Of 86 patients (60 male, 69.77%; 26 female, 30.23%), 48 survived and 38 died (mortality 44.19%). Non-survivors were older (58.92±15.66 vs 52.7±12.9 years) and had a higher prevalence of comorbidities (71.05% vs 43.75%). Mean maximum SOFA score was significantly higher in non-survivors (12.28±1.29) than survivors (5.85±1.22, $p<0.001$), and mean APACHE II score was also higher in non-survivors (18.92±6.91 vs 12.58±5.54, $p<0.001$). Mortality rose sharply with maximum SOFA score >10 (97.37% of non-survivors) and with APACHE II score ≥20 (42.11% of non-survivors). ROC analysis showed the maximum SOFA score had a higher area under the curve (AUC 0.879) than APACHE II (AUC 0.765) for predicting mortality.
**Conclusion:** Both SOFA and APACHE II scores were significantly associated with mortality in sepsis-associated MODS, but the maximum SOFA score showed superior discriminative ability. Serial SOFA scoring, particularly from Day 3 onward, provides an early, dynamic marker of prognosis and may complement APACHE II in guiding risk stratification in the ICU.
**Keywords:** Sepsis; multi-organ dysfunction syndrome; SOFA score; APACHE II score; mortality prediction; intensive care unit.

## INTRODUCTION

Sepsis is a life-threatening condition arising from a dysregulated host response to infection, resulting in widespread inflammation, endothelial dysfunction, microcirculatory failure, and cellular injury, and remains a leading cause of morbidity and mortality among critically ill patients.[1] When sepsis progresses to involve dysfunction of two or more organ systems, it culminates in multi-organ dysfunction syndrome (MODS), the most severe end of the sepsis spectrum, reflecting the cumulative burden of physiological derangement across the lungs, kidneys, liver, cardiovascular system, central nervous system, and coagulation pathway.[2] The presence, number, and severity of organ failures correlate closely with mortality, making early identification of high-risk patients essential for timely escalation of care, optimal allocation of intensive care resources, and informed clinical decision-making.

Given the heterogeneous presentation and dynamic course of sepsis-associated MODS, objective severity-of-illness scoring systems have been developed to quantify organ dysfunction and predict outcome.[3] The SOFA score assesses the degree of dysfunction across six organ systems and permits serial assessment, making it useful for tracking the progression or resolution of organ failure over time.[4] The APACHE II score, in contrast, is a composite severity index based on acute physiological derangement, age, and chronic health status, traditionally calculated within the first 24 hours of ICU admission.5 Both systems have demonstrated prognostic value in septic patients but differ in complexity, timing of assessment, and emphasis on acute physiology versus evolving organ dysfunction.

Despite widespread use, there remains ongoing debate regarding the comparative accuracy and clinical utility of SOFA and APACHE II scores in predicting mortality specifically in patients with sepsis-induced MODS, with variation in patient populations, timing of score calculation, and resource availability across healthcare settings underscoring the need for context-specific evaluation. This study was therefore designed to compare the predictive performance of the SOFA and APACHE II scores in estimating mortality among patients with sepsis-associated MODS, in order to identify the more reliable and practical tool for risk stratification in the intensive care setting.

### Aims and Objectives

**Aim:** To compare SOFA and APACHE II scores in predicting mortality in patients with sepsis-associated multi-organ dysfunction syndrome.

### Objectives

1. To assess SOFA score in patients with sepsis.
2. To assess APACHE II score in patients with sepsis.
3. To compare SOFA and APACHE II scores in predicting mortality in patients with multi-organ dysfunction syndrome in sepsis.

## MATERIALS AND METHODS

### Study Design, Setting, and Duration

This prospective observational study was conducted in the Intensive Care Unit (ICU) of PES Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, over a period of 18 months.

### Study Population and Sampling

All adult patients admitted to the ICU with sepsis-associated multi-organ dysfunction syndrome (MODS) during the study period were eligible. A total of 86 patients fulfilling the inclusion criteria were enrolled using purposive sampling.

### Inclusion and Exclusion Criteria

Inclusion criteria were: patients of either gender aged ≥18 years; patients or legally acceptable attendants willing to provide informed consent; and patients with clinical and laboratory evidence of sepsis with MODS at admission. Patients receiving immunosuppressive therapy, those with retroviral infection, and pregnant patients were excluded.

### Data Collection

Ethical clearance was obtained from the Institutional Review Board prior to commencement of the study, and written informed consent was obtained from patients or their legally acceptable representatives. Detailed clinical history, including comorbidities, and physical examination were recorded on a predesigned proforma. Relevant investigations, including complete blood picture, urine routine examination, serum electrolytes, chest X-ray, pulse oximetry, blood pressure, and arterial blood gas analysis ($PaO_2$ , pH, bicarbonate), along with blood culture, were performed for all patients. Sepsis and MODS were defined according to standard clinical guidelines. All patients were prognosticated using APACHE II and SOFA scores and categorised into survivor and non-survivor groups for comparison of the predictive ability of both scoring systems.

### SOFA Score Assessment

The SOFA score was calculated daily until ICU discharge or death. It assesses dysfunction in six organ systems, each graded 0–4 (maximum score 24): respiratory system ($PaO_2$ /$FiO_2$ ratio), coagulation (platelet count), liver (serum bilirubin), cardiovascular system (mean arterial pressure and vasopressor requirement), central nervous system (Glasgow Coma Scale), and renal system (serum creatinine and urine output). Use of vasopressors, mechanical ventilation, and renal replacement therapy was documented, as these influence SOFA scoring, and a rising SOFA score trend was considered indicative of poor prognosis.

### APACHE II Score Assessment

The APACHE II score was calculated within the first 24 hours of ICU admission (range 0–71, with higher scores indicating greater risk of hospital

mortality) using axillary temperature (corrected to approximate core temperature), heart rate, respiratory rate, mean arterial pressure, arterial blood gas parameters ($PaO_2$ , arterial pH, serum bicarbonate), haematocrit, white blood cell count, serum creatinine, urine output, and Glasgow Coma Scale.

**Statistical Analysis**

Data were entered into Microsoft Excel and analysed using SPSS software version 23.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were expressed as frequencies and percentages, and continuous variables as mean ± standard deviation. Continuous variables were compared using Student's t-test and categorical variables using the chi-square test. Receiver operating characteristic (ROC) curve analysis was used to assess and compare the discriminative ability of SOFA and APACHE II scores for mortality. A p-value <0.05 was considered statistically significant.

## RESULTS

A total of 86 patients with sepsis-associated multi-organ dysfunction syndrome were enrolled, of whom 48 (55.81%) survived and 38 (44.19%) did not survive.

**Demographic Characteristics**

The majority of patients were aged 40–49 years (23.26%) and 60–69 years (20.92%); patients aged 50–59 years and ≥70 years each constituted 19.77% of the cohort, while patients younger than 40 years accounted for 16.28%. Of the 86 patients, 60 (69.77%) were male and 26 (30.23%) were female, indicating a clear male predominance.

**Table 1: Demographic profile of the study population (N=86)**

| Characteristic | n | % |
|---|---|---|
| Age <40 years | 14 | 16.28 |
| Age 40–49 years | 20 | 23.26 |
| Age 50–59 years | 17 | 19.77 |
| Age 60–69 years | 18 | 20.92 |
| Age ≥70 years | 17 | 19.77 |
| Male | 60 | 69.77 |
| Female | 26 | 30.23 |
| Total | 86 | 100 |

**Baseline Characteristics According to Outcome**

The mean age of survivors was 52.7±12.9 years, compared with 58.92±15.66 years among non-survivors, indicating an increasing trend of mortality with advancing age. Among survivors, 32 (66.7%) were male and 16 (33.3%) were female; among non-survivors, 28 (73.7%) were male and 10 (26.3%) were female. Comorbidities were present in 21 survivors (43.75%) and 27 non-survivors (71.05%), indicating that mortality was higher among patients with comorbid conditions; renal disease (21.05%) and cardiovascular disease (13.16%) were notably more frequent among non-survivors than survivors (6.25% and 2.08% respectively), while diabetes mellitus and hypertension were similarly represented in both groups.

**Table 2: Age, gender, and comorbidity status according to outcome**

| Characteristic | Survivors (n=48) | Non-survivors (n=38) |
|---|---|---|
| Mean age ± SD (years) | 52.7±12.9 | 58.92±15.66 |
| Male, n (%) | 32 (66.7) | 28 (73.7) |
| Female, n (%) | 16 (33.3) | 10 (26.3) |
| Comorbidities present, n (%) | 21 (43.75) | 27 (71.05) |
| No comorbidities, n (%) | 28 (58.33) | 10 (26.32) |

**Table 3: Distribution of individual comorbidities according to outcome**

| Comorbidity | Survivors, n (%) | Non-survivors, n (%) |
|---|---|---|
| Diabetes mellitus | 6 (12.5) | 6 (15.79) |
| Hypertension | 7 (14.58) | 6 (15.79) |
| Respiratory disease | 3 (6.26) | 6 (15.79) |
| Cardiovascular disease | 1 (2.08) | 5 (13.16) |
| Kidney disease | 3 (6.25) | 8 (21.05) |
| Malignancy | 0 | 1 (2.6) |

**SOFA and APACHE II Scores by Outcome**

The mean SOFA score was consistently higher among non-survivors than survivors at every time point assessed. On Day 1, mean SOFA scores were 3.93±0.69 in survivors and 7.02±0.63 in non-survivors; by Day 3, scores were 4.79±0.77 versus 9.01±0.66 (p<0.001); and by Day 15, scores were 5.58±1.39 versus 12.30±1.36. The mean maximum SOFA score was significantly higher among non-survivors (12.28±1.29) than survivors (5.85±1.22, p<0.001). Similarly, the mean APACHE II score among survivors was 12.58±5.54, compared with 18.92±6.91 among non-survivors (p<0.001), indicating higher illness severity at admission among non-survivors.

**Table 4: Comparison of SOFA and APACHE II scores between survivors and non-survivors**

| Score | Survivors, mean ± SD | Non-survivors, mean ± SD | p-value |
|---|---|---|---|
| SOFA Day 1 | 3.93±0.69 | 7.02±0.63 | 0.97 |
| SOFA Day 2 | 4.47±0.50 | 8.02±0.63 | 0.68 |
| SOFA Day 3 | 4.79±0.77 | 9.01±0.66 | <0.001* |
| SOFA Day 4 | 4.29±0.61 | 10.11±0.53 | 0.97 |
| SOFA Day 5 | 4.16±0.63 | 10.92±1.24 | 0.84 |
| SOFA Day 10 | 4.85±0.96 | 11.76±0.62 | <0.001* |
| SOFA Day 15 | 5.58±1.39 | 12.30±1.36 | <0.001* |
| Maximum SOFA | 5.85±1.22 | 12.28±1.29 | <0.001* |
| APACHE II | 12.58±5.54 | 18.92±6.91 | <0.001* |

**Organ Support, Neurological Status, and Duration of Stay**

Inotropic support was required in 12 survivors (25%) and 22 non-survivors (57.89%, p=0.001), and dialytic intervention in 5 survivors (10.42%) and 14 non-survivors (36.84%, p=0.003). The mean GCS score was significantly lower among non-survivors (9.60±3.00) than survivors (13.27±1.87, p<0.001). The type of respiratory support required did not differ significantly between groups. Non-survivors also had a significantly longer duration of both ICU stay (8.47±2.63 vs 6.58±2.79 days, p=0.002) and hospital stay (14.15±3.69 vs 11.85±3.19 days, p=0.003) compared with survivors.

**Table 5: Organ support, neurological status, and duration of stay according to outcome**

| Parameter | Survivors (n=48) | Non-survivors (n=38) | p-value |
|---|---|---|---|
| Inotropic support, n (%) | 12 (25) | 22 (57.89) | 0.001* |
| Dialytic intervention, n (%) | 5 (10.42) | 14 (36.84) | 0.003* |
| GCS, mean ± SD | 13.27±1.87 | 9.60±3.00 | <0.001* |
| Invasive ventilation, n (%) | 3 (6.25) | 7 (18.42) | 0.08 |
| Non-invasive ventilation, n (%) | 38 (79.17) | 25 (65.79) | 0.16 |
| Both modalities, n (%) | 7 (14.58) | 6 (15.79) | 0.87 |
| ICU stay, days, mean ± SD | 6.58±2.79 | 8.47±2.63 | 0.002* |
| Hospital stay, days, mean ± SD | 11.85±3.19 | 14.15±3.69 | 0.003* |

**Mortality by Score Category and ROC Analysis**

No mortality was observed among patients with a maximum SOFA score of 0–7. Only 1 non-survivor (2.63%) had a maximum SOFA score of 8–10, whereas 37 non-survivors (97.37%) had a maximum SOFA score >10, demonstrating a sharp rise in mortality beyond this threshold. Similarly, among non-survivors, 3 patients (7.89%) had an APACHE II score ≤9, 6 (15.79%) had scores of 10–14, 13 (34.21%) had scores of 15–19, and 16 (42.11%) had scores ≥20, with mortality increasing progressively across categories.

**Table 6: Mortality according to maximum SOFA and APACHE II score categories**

| Score category | Non-survivors, n | Mortality (%) |
|---|---|---|
| SOFA 0–4 | 0 | 0 |
| SOFA 5–7 | 0 | 0 |
| SOFA 8–10 | 1 | 2.63 |
| SOFA >10 | 37 | 97.37 |
| APACHE II ≤9 | 3 | 7.89 |
| APACHE II 10–14 | 6 | 15.79 |
| APACHE II 15–19 | 13 | 34.21 |
| APACHE II ≥20 | 16 | 42.11 |

ROC curve analysis showed that the maximum SOFA score had an area under the curve (AUC) of 0.879, indicating very good discriminatory ability for mortality prediction, while the APACHE II score showed an AUC of 0.765, reflecting good but comparatively lower predictive accuracy.

**Table 7: ROC curve analysis for prediction of mortality**

| Scoring system | Area under curve (AUC) | 95% Confidence interval |
|---|---|---|
| Maximum SOFA score | 0.879 | 11.86–12.71 |
| APACHE II score | 0.765 | 16.65–21.19 |

## DISCUSSION

Sepsis with multi-organ dysfunction remains a major cause of ICU mortality, and prognostic scoring systems such as SOFA and APACHE II are widely used to stratify severity and predict outcome. The present study evaluated demographic variables, comorbidities, organ support requirements, neurological status, duration of ICU and hospital stay, and severity scores, and compared their prognostic utility with previously published data.

**Age and Gender**

Non-survivors in this cohort were older than survivors (58.92±15.66 vs 52.7±12.9 years), consistent with the well-established association between advancing age and poor outcome in sepsis.

Mehta and Patil8 reported a comparable mean age of 56.71±16.77 years with significantly higher mortality among older patients, and Lokesh and Latha,[11] similarly observed that most septic patients were above 60 years, with higher mortality in this age group. Tekin et al,[14] in an elderly cohort with a median age of 79 years, reported a 28-day mortality of 41%, reinforcing age as a strong determinant of adverse outcome, likely reflecting immunosenescence, reduced physiological reserve, and greater comorbidity burden.

Male predominance was observed in the present study (69.77%), with a higher proportion of males among non-survivors (73.7%), mirroring the gender distribution reported by Mehta and Patil8 (69% male) and Lokesh and Latha,[11] though gender itself was not an independent predictor of outcome in this or comparable studies.

**Comorbidities and Mortality**

Comorbidities were present in 55.81% of patients in this study, with significantly higher mortality among those with comorbid conditions (56.25%) than without (26.32%); renal (21.05%) and cardiovascular (13.16%) comorbidities were particularly common among non-survivors. These findings are in keeping with Beigmohammadi et al,[9] who found that 169 of 204 patients had at least one comorbidity, of whom 103 did not survive, and George et al,[12] who also reported poorer outcomes among patients with multiple comorbidities, underscoring the compounded risk imposed by chronic organ dysfunction on prognosis in sepsis.

**SOFA Score and Mortality Prediction**

The present study demonstrated a strong, consistent gradient between rising SOFA scores and mortality, with non-survivors having significantly higher scores at every time point. Mortality rose sharply beyond a maximum SOFA score of 10 (97.37% of non-survivors), compared with only 2.63% among those scoring 8–10 and none among those scoring ≤7. These findings agree closely with Abhinandan and Vedavathi,6 who reported 36% overall mortality and found that serial SOFA scores, particularly on Day 3, outperformed APACHE II in longitudinal mortality prediction. Swamy et al,[7] in a prospective study of 100 patients with sepsis-associated MODS, similarly found that daily SOFA scoring had better predictive accuracy than APACHE II. Mehta and Patil8 further demonstrated that patients with SOFA scores of 4–5 had 48% mortality, higher than that predicted by comparable APACHE II categories (34.6%), while Sharma et al,[13] reported consistently lower SOFA scores among survivors at admission, 48, and 72 hours, underscoring the value of dynamic monitoring over a single-point assessment. Taken together with the present findings, this evidence highlights the critical threshold value of a maximum SOFA score of 10 in identifying patients at very high risk of death.

**APACHE II Score and Outcome**

APACHE II score at admission was also significantly associated with mortality in this study, with non-survivors scoring markedly higher (18.92±6.91) than survivors (12.58±5.54, p<0.001), and a clear stepwise rise in mortality with increasing score category. Comparable findings were reported by Mehta and Patil8 (non-survivors 17.10±6.77 vs survivors 11.23±5.69) and by Sharma et al.13, who found APACHE II scores up to 17.20 among non-survivors (p<0.01). Lokesh and Latha,[11] observed similarly higher APACHE II scores among non-survivors, with improved sensitivity and specificity at 24 hours, and Tekin et al,[14] reported good discriminative ability of APACHE II (AUC 0.784) for 28-day mortality in elderly septic patients, albeit slightly inferior to SOFA (AUC 0.802). Nonetheless, the static nature of APACHE II, based largely on admission variables, limits its ability to reflect the dynamic evolution of organ dysfunction, an important limitation also noted by Abhinandan and Vedavathi.[6]

**Comparative Performance of SOFA and APACHE II**

ROC curve analysis in this study demonstrated superior discriminative ability of the maximum SOFA score (AUC 0.879) compared with APACHE II (AUC 0.765), consistent with Swamy et al,[7] and Mehta and Patil,[8] who both reported superior mortality prediction with SOFA, and with Tekin et al,[14] who found a higher AUC for SOFA (0.802) than APACHE II (0.784) in elderly septic patients. Lokesh and Latha,[11] additionally reported that SOFA had better specificity (87.10%) while APACHE II had higher sensitivity (96.77%), suggesting complementary roles for the two scores — APACHE II for early identification of high-risk patients, and SOFA for more accurately tracking disease progression. Agarwal et al,[10] further showed that incorporating arterial pH into the SOFA score modestly improved its predictive ability at 48 hours, reinforcing the value of evolving physiological parameters in outcome prediction.

**Organ Support, Neurological Status, and Duration of Stay**

Requirement for organ support was significantly higher among non-survivors in this study, with inotropic support required in 57.89% of non-survivors versus 25% of survivors, and dialysis in 36.84% versus 10.42%, consistent with Swamy et al,[7] and George et al,[12] who both linked escalating organ support needs, particularly cardiovascular and renal, to higher severity scores and mortality. Neurological status, assessed by GCS, was also strongly associated with outcome, with non-survivors scoring significantly lower (9.60±3.00) than survivors (13.27±1.87, p<0.001); as GCS is a shared component of both SOFA and APACHE II, this finding is consistent with the lower GCS values among non-survivors reported by Swamy et al,[7] Sharma et al,[13] and Mehta and Patil.8 Finally, non-survivors in this study had significantly longer ICU stay (8.47±2.63 vs 6.58±2.79 days, p=0.002) and hospital stay (14.15±3.69 vs 11.85±3.19 days, p=0.003), in keeping with Sharma et al,[13] and

George et al,[12] who reported that higher severity scores and greater organ support needs were associated with prolonged critical care and hospitalisation.

**Limitations**

1. Single-centre study, which may limit generalisability of findings to other settings.
2. Observational design precludes establishment of causal relationships.
3. Microbiological profile and source-specific sepsis analysis were not included.
4. Long-term outcomes and post-discharge mortality were not assessed.

## CONCLUSION

Increasing age, presence of comorbidities, higher illness-severity scores, and greater requirement for organ support were strongly associated with mortality in patients with sepsis-associated multi-organ dysfunction syndrome. Among the severity assessment tools studied, serial SOFA scoring showed superior prognostic accuracy compared with APACHE II, particularly when maximum SOFA scores were considered. The Day 3 SOFA score emerged as an early discriminator of outcome, with a significant difference between survivors (4.79±0.77) and non-survivors (9.01±0.66, $p<0.001$), indicating that divergence in organ-dysfunction trajectory becomes evident by the third day of ICU stay. A rising SOFA trend beyond Day 3 was a strong predictor of adverse outcome, whereas stabilisation or improvement was associated with survival, and the maximum SOFA score demonstrated excellent discriminative ability, outperforming APACHE II. Dynamic assessment using serial SOFA scoring, particularly from Day 3 onward, therefore provides valuable prognostic insight that can facilitate timely escalation of care and targeted intervention in critically ill patients with sepsis.

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