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Brief Report

# The Sequential Organ Failure Assessment Score Predicts 30-Day Mortality in a Geriatric Acute Care Setting

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***Background.*** Several tools to predict patients' survival have been proposed in medical wards, though they are often time consuming and difficult to apply. The Sequential Organ Failure Assessment (SOFA) is a promising tool that has been validated in intensive care units but never in acute medical wards. The aim of this study was to assess whether the SOFA score predicts short-term (30 days) mortality in a population of elderly patients admitted to a geriatric ward.

***Methods.*** This prospective observational cohort study was carried out in a Geriatric Clinic of an Italian teaching hospital. Among 359 patients consecutively and firstly admitted between January and April 2012, we considered eligible those ($n$ = 314) directly admitted from the emergency department. Demographic, functional, and clinical variables were collected. The SOFA score was measured on admission (SOFA-admission) and 48 hours later (SOFA-48h). The vital status of participants was assessed over the 30 days following discharge.

***Results.*** Patients who died at 1-month follow-up were prevalently men, more comorbid, disabled, and undernourished and had higher SOFA scores on admission and at 48 hours than their counterparts. Among all potential predictors of 1-month mortality, the SOFA-48h score was the best, with a score greater than 4 significantly increasing the risk to die during hospitalization or in the 30 days following discharge (odds ratio = 7.030; 95% confidence interval = 3.982–12.409).

***Conclusions.*** The SOFA score, a user-friendly tool used in intensive care units to estimate prognosis, is able to predict 1-month mortality also in patients admitted to an acute geriatric setting.

***Key Words:*** Geriatric assessment—Frailty—Hospital related—Morbidity—Multimorbidities—Outcomes.

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RECENTLY, the number of patients admitted to hospital wards with serious clinical problems has led to increasing interest in clinical tools estimating patients' survival (1–5). However, many proposed tools (6–8) are difficult to apply in clinical practice because they include variables that are often not immediate to obtain or time consuming (9). Other prognostic indices have been developed to predict the medium- and long-term but not the short-term survival (2,10–14).

The Sequential Organ Failure Assessment (SOFA) is a promising tool, generally used to track a patient's status during the stay in an intensive care unit (9,15,16), which has been shown to predict short- and long-term mortality (17,18). The SOFA score is simple to calculate based on clinical and laboratory parameters routinely assessed in medical practice. However, its usefulness has not been demonstrated outside the intensive care unit setting.

The aim of this study was to assess whether the SOFA score is able to predict short-term (at 30 days) mortality in a population of elderly patients admitted to an acute geriatric ward. A secondary aim was to identify the best cutoff value to predict the mortality risk.

## Materials and Methods

This prospective observational cohort study was conducted among patients of the Geriatric Clinic at S. Gerardo University Hospital, Northern Italy. Between January 1 and April 30, 2012, a total number of 359 patients were consecutively and firstly admitted to our ward. Patients

eligible for this study were all those directly admitted from the emergency department. Patients transferred from other hospitals' wards were excluded because of the difficulty in obtaining a complete baseline data set. Patients admitted from emergency department represent the majority (87% in the last year) of the admissions to our Geriatric Clinic.

All patients underwent a multidimensional assessment, including demographic, functional, nutritional, and global health status evaluation. The functional status was assessed with the Katz's activities of daily living (19), whereas the nutritional status with the Malnutrition Universal Screening Tool (20) and with the albumin serum levels. Health status was assessed with the Charlson comorbidity index (21), the number of drugs, and the C-reactive protein serum levels. The SOFA score (17) was assessed on admission and 48 hours later. This tool is based on six different scores, one each for the respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems (see Supplementary Appendix). For each system, a score between 0 (no organ/system impairment) and 4 (severe organ/system impairment) is assigned. The sum provides a numerical index ranging from 0 (no impairment) to 24 (maximum impairment).

Vital status of study participants over the 30 days following discharge was assessed by telephone interviews with proxies and by examining the regional administrative database.

Analyses were performed using SAS software (version 9.3, SAS Institute, Cary, NC). Statistical significance was set at the .05 level. *p* Values were two sided. The Student's *t* test and the chi-square test were used to compare clinical characteristics between dead and alive patients. We also used the Fisher exact test, the Cochran–Armitage test for trend, and the correction of Satterthwaite for the degrees of freedom of test *t*, where appropriate. Receiver operating characteristic curves were constructed, and the area under the curve (AUC) was identified to evaluate the discriminant power of SOFA score. The optimal cutoff of SOFA score in predicting 30-day mortality was identified as the value that maximized the Youden's index (22). The association between the optimal cutoff SOFA score and the risk of 1-month mortality was assessed with logistic regression models including continuous (age, activities of daily living score, albumin, and C-reactive protein serum level) and categorical variables (Malnutrition Universal Screening Tool and gender). The additive value of the SOFA score in predicting 1-month mortality with respect to other possible predictors was carried out by (i) comparing the areas under the receiver operating characteristic curves of these models and (ii) evaluating the integrated discrimination improvement, which assesses the increment in sensitivity and specificity of the model along all range of possible risk categories (23). Finally, we performed an internal validation of the predictive model using a bootstrapping method (100 bootstrap samples with replacement of the same size of the original sample) (24).

We collected and stored patients' informed consents in our archives. The study design was approved by the Ethics Committee of the University of Milano-Bicocca.

## Results

The study included 314 patients with a mean (standard deviation) age of 84.5 (6.8) years and a proportion of men of 41.4%. Twenty patients (16%) were resident in nursing homes before admission. Table 1 shows that patients who died were more likely to be men, disabled, and undernourished and had more comorbidities than survivors. Furthermore, they had higher C-reactive protein serum levels and higher SOFA scores both on admission and 48 hours later. No significant differences in age, marital status, medications, and total length of stay were observed.

Figure 1 shows the receiver operating characteristic curves and the corresponding AUC for 1-month mortality with regard to the SOFA score on admission (SOFA-admission, panel A), SOFA score at 48 hours (SOFA-48h, panel B), and mean SOFA score (SOFA-mean, panel C). The receiver operating characteristic plot for SOFA-48h showed the widest AUC (AUC = 0.7552). A score of 4 was the best cutoff to identify the patients at risk to die at 30 days, as maximized by the Youden's index.

One-month survival was significantly lower for patients with SOFA-48h score greater than 4 (71% of patients died in this group), with a sevenfold increased risk to die during hospitalization or in the 30 days following discharge (odds ratio = 7.030; 95% confidence interval = 3.982–12.409). In a multivariate regression model, adjusted for age, sex, Malnutrition Universal Screening Tool, activities of daily living, albumin, and C-reactive protein serum levels, the SOFA-48h score was an independent predictor of death (odds ratio = 5.064, 95% confidence interval = 2.668–9.613). This model showed an AUC of 0.82; the same model, without including the SOFA-48h score, yielded an AUC of 0.77. The difference in AUC between these models was 0.05 (*p* value .0255) and the integrated discrimination improvement was 0.072 (*p* value .0001).

Finally, the AUC of the predictive model including the SOFA-48h score was evaluated in 100 bootstrap samples, showing an average of 0.84 (standard deviation = 0.02), and suggesting no optimistic performance in the original analysis with regard to its predictive power.

## Discussion

This study shows that (i) the SOFA-admission and SOFA-48h score were good predictors of 1-month mortality among a population of elderly patients in an acute geriatric ward; (ii) a SOFA-48h greater than or equal to 4 was the best cutoff to predict short-term mortality risk; and (iii) in a logistic regression including a list of variables that are thought to predict short-term mortality, the inclusion of the

Table 1. Demographic and Clinical Characteristics of 314 Patients Consecutively and Firstly Admitted to the Geriatric Clinic of S. Gerardo University Hospital, According to Vital Status at 1-Month Follow-up

| Variables | Alive at 1-Month ($n$ = 239) | Dead at 1-Month ($n$ = 75) | $p$ Value |
|---|---|---|---|
| Age, y | 84.1 ± 6.8 | 85.6 ± 6.8 | .1021 |
| Gender | | | |
| Male | 90 (37.7) | 40 (53.3) | .0162 |
| Female | 149 (62.3) | 35 (46.7) | |
| Marital status | | | |
| Single | 11 (4.6) | 4 (5.3) | |
| Married | 82 (34.3) | 32 (42.7) | .4973* |
| Widowed | 143 (59.8) | 39 (52.0) | |
| Divorced | 3 (1.3) | 0 (0.0) | |
| Functional status | | | |
| ADL score | 3.5 ± 2.4 | 2.1 ± 2.4 | <.0001 |
| Charlson comorbidity index, *n* | 2.6 ± 2.1 | 3.3 ± 2.1 | .0014 |
| Medications, *n* | 5.6 ± 3.5 | 5.9 ± 3.4 | .5809 |
| Malnutrition Universal Screening Tool score | | | |
| 0 (no malnutrition) | 178 (74.8) | 35 (46.7) | |
| 1 (risk of malnutrition) | 23 (9.7) | 12 (16.0) | <.0001† |
| ≥2 (malnutrition) | 37 (15.5) | 28 (37.3) | |
| Laboratory indices, serum levels | | | |
| Albumin (g/dL) | 3.5 ± 0.4 | 3.2 ± 0.6 | <.0001‡ |
| C-reactive protein (mg/dL) | 5.7 ± 7.0 | 9.3 ± 7.4 | .0002 |
| Main diagnosis | | | |
| Pulmonary disease | 42 (30.7) | 27 (45.0) | .0008 |
| Cardiovascular disease | 37 (27.0) | 9 (15.0) | .4570 |
| Cancers | 5 (3.7) | 11 (18.3) | <.0001* |
| Acute cerebrovascular disease | 28 (20.4) | 6 (10.0) | .3663 |
| Urinary tract infections | 16 (11.7) | 7 (11.7) | .4441 |
| Diabetes | 9 (6.6) | 0 (0.0) | — |
| SOFA score | | | |
| On admission | 2.6 ± 1.8 | 3.9 ± 1.9 | <.0001 |
| At 48 h | 2.3 ± 1.6 | 4.4 ± 2.5 | <.0001‡ |
| Δ-SOFA score* | -0.2 ± 1.1 | 0.4 ± 1.9 | .0045‡ |
| Length of stay, d | 11.9 ± 6.3 | 11.7 ± 7.5 | .8247 |

*Notes:* Values are reported as mean ± *SD* or *n* (%). SOFA denotes Sequential Organ Failure Assessment. Δ-SOFA score denotes the difference between the 48-h and the admission SOFA score. ADL = activities of daily living.

*Fisher score.

†Test trend Cochran–Armitage.

‡Satterthwaite correction.

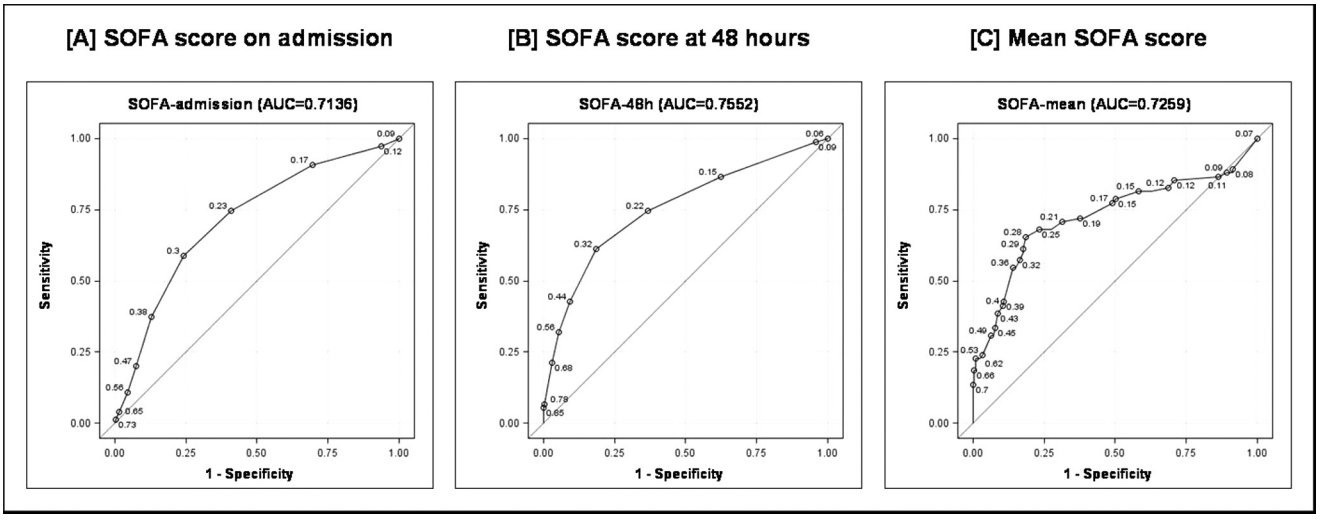


Figure 1. Receiver operating characteristic (ROC) curves for prediction of 1-month mortality.

SOFA-48h score (dichotomized as <4 or ≥4) significantly improved the predictive power of this model.

The 1-month mortality rate we found in this study (24.8%) is different from rates reported in other studies carried out in geriatric wards (12,25) and similar to those reported in medical high dependency wards (26), intermediate care units (27), and some intensive care unit settings for medical patients (28,29). This suggests that patients admitted to our clinic were on average critical and had a high level of clinical complexity. In line with this observation, we found that malnutrition, a known risk factor for poor clinical outcomes (30–33), was an independent predictor of 30-day mortality.

Our findings extend to geriatric wards the results of previous studies carried out in intensive care units and have several practical implications. As it is rapid and simple to use, the SOFA score may be appropriate for a routine use in the practice of medical units. Hence, the routine application of this score within the first 48 hours of hospitalization would improve physicians' ability to predict the patients' short-term survival, maximizing their clinical expertise. Furthermore, using this score, physicians may be allowed to early recognize critical patients, plan appropriate medical interventions, shorten the time of clinical decisions, and anticipate possible scenarios to patients' family members. From a research-driven perspective, the SOFA-48h score may be used to stratify individuals into groups with similar clinical risk profile, possibly comparing the effectiveness of different interventions.

Our study has some limitations. Firstly, this is not a multicenter study, implying that further researches including various medical centers and larger sample sizes are needed. Secondly, we recognize that our results cannot be immediately transferable to other settings, and in particular that the cutoff proposed (SOFA score >4) in this study may not perform as well as in other geriatric and medical wards. Thirdly, we have not applied the SOFA score systematically to monitor the patients' clinical course, neglecting a possible field of application of this tool (9). Finally, we have not compared the SOFA score with other predictive tools already adopted in geriatric settings.

## Supplementary Material

Supplementary material can be found at: http://biomedgerontology.oxfordjournals.org/

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## Conflict of Interest

The authors have no conflict of interests to disclose, and they did not receive any funding for this study.

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