

# Weaning Pattern Characteristics, Based on Simplified Acute Physiology Score 3, of Critically Ill Patients Requiring Ventilator Care



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## Abstract

**Background:** The Simplified Acute Physiology Score 3 (SAPS 3) scoring system was developed through a worldwide prospective study to predict hospital mortality in critically ill patients. The present study focuses on how outcomes, according to SAPS 3 score, differ in patients receiving or not receiving mechanical ventilation.

**Methods:** We retrospectively reviewed electronic medical records of patients admitted to the surgical or medical ICU from October to December 2014. The SAPS 3 model scores were evaluated for all patients, and for subgroups of patients receiving mechanical ventilation (MV group) or not (Non-MV group). The MV group was further subdivided into two groups, based on the ventilator weaning (simple [MV-SW] and others [MV-Others]), to compare patient characteristics and mortality, based on SAPS 3 scores.

**Results:** The SAPS 3 score and mortality were significantly higher, and the length of ICU stay was significantly longer in the mechanical ventilation group ( $p = 0.004$ ,  $p < 0.001$ , and  $p = 0.007$ , respectively) compared to the non-mechanical ventilation group. The MV-SW group included patients requiring significantly more postoperative care, while the MV-Others group had more patients intubated due to hypoxemia ( $p < 0.001$ ). The AUC value, indicating discrimination, was 0.871.

**Conclusion:** The present study, conducted using the SAPS 3 score, showed good discrimination. It is believed that this method will be useful in predicting weaning difficulties and mortalities of patients requiring mechanical ventilation.

**Keywords:** Intensive care unit; Mechanical ventilation; Mortality; SAPS 3; Ventilator weaning

## Introduction

Severity scoring systems are used to predict and compare outcomes, to help guide the allocation of limited resources and to evaluate the process of care in intensive care units (ICU). In critically ill patients, several scoring systems have been developed over the last three decades [1,2]. The Acute Physiology and Chronic Health Evaluation (APACHE) and the Simplified Acute Physiology Score (SAPS) are the most widely used scoring systems in ICUs. Recently, the SAPS 3 was developed through a worldwide prospective study to predict hospital mortality in critically ill patients. It is based on 20 different variables, that are easily measured at patient admission, and dissociating patient status from the quality of care in the ICU [3-7]. There has, however, been no investigation into how outcomes differ in patients receiving or not receiving mechanical ventilation.

The aim of this study was to evaluate the epidemiology and prognostic performance of the SAPS 3 in a retrospective electric chart review, and to describe the weaning pattern characteristics of patients receiving mechanical ventilation.

## Materials and Methods

The study protocol was approved by the institutional review board.

## Patient population

All patients admitted to the surgical or medical ICU from October to December 2014 were included in the present study. In addition, patients who were admitted to the ICU with serious medical or surgical postoperative complications were also included. Pediatric patients (<18 years of age), patients with

an ICU stay < 24 h, and patients who were readmitted after an initial ICU discharge were excluded.

**Data collection**

One individual retrospectively reviewed the electronic medical records. These records provided all of the data required to predict the mortality rate using the SAPS 3 model. The SAPS 3 score was obtained from the most severe laboratory findings 1 h before or after ICU admission. Predicted hospital mortality rate (PMR) was calculated using the following equation; where score means SAPS 3 admission score [6].

$$PMR (\%) = \frac{e^{-32.7+7.3 \times \log_e(\text{score}+20.6)}}{1 + e^{-32.7+7.3 \times \log_e(\text{score}+20.6)}} \times 100$$

The performance of the model was evaluated in all patients, as well as, in two subgroups of patients who had received mechanical ventilation (MV group) or not (Non-MV group). Based on the ventilator weaning pattern, the MV group was further subdivided into two groups to compare the characteristics and

mortality based on SAPS 3. The simple weaning group (MV-SW group) included patients with a successful 1st extubation after the 1st spontaneous breathing trial (SBT); the MV-Other group included patients with difficult, prolonged, or chronic mechanical ventilation weaning.

**Statistical analysis**

Statistical analyses were performed using IBM SPSS Statistics 21 for Windows. Data were reported as means ± standard deviation (SD) or medians with 25th and 75th quartiles for continuous variables, and percentages for quantitative variables. Student’s t-test, chi-squared test, or Fisher’s exact test were used depending on whether the variables were continuous or categorical. P-values less than 0.05 were used to indicate statistical significance. The area under the curve (AUC) of the receiver operating characteristic (ROC) curve was used to measure discrimination for hospital mortality.

**Results**

**Table 1:** Characteristics of patients admitted to the intensive care units.

	Total (n=141)	MV (n=45)	Non-MV (n=96)	p-value
Age (yr, mean ± SD)	67.7 ± 14.4	65.7 ± 14.3	68.7 ± 14.5	0.262
Male gender [n (%)]	76(53.9)	27(60)	49(51.0)	0.320
Route of admission [n (%)]				0.370
OR/PACU	76(53.9)	20(44.4)	56(58.3)	
ER	11 (7.8)	3(6.7)	8(8.3)	
Ward	49(34.8)	20(44.4)	29(30.2)	
Other ICU	5(3.5)	2(4.4)	3(3.1)	
Department [n (%)]				0.073
IM	52(36.9)	23(51.1)	29(30.2)	
GS	28(19.9)	8 (17.8)	20(20.8)	
NS	19(13.5)	7 (15.6)	12(12.5)	
TS	17(12.1)	5 (11.1)	12(12.5)	
OS	13 (9.2)	0(0)	13(13.5)	
PS	2(1.4)	1(2.2)	1(1)	
UR	4(2.8)	0(0)	4(4.2)	
NR	6(4.3)	1(2.2)	5(5.2)	
SAPS 3 score [mean ± SD]	46.1 ± 17.8	52.3 ± 18.0	43.2 ± 17.0	0.004
ICU length of stay (days), median (IQR)	2.0 (1.0–3.0)	3 (2.0–6.0)	2.0 (1.0–3.0)	0.007
Hospital length of stay (days), median (IQR)	23.0 (13.0–47.0)	31.0 (14.5–53.0)	22.0 (12.0–43.0)	0.343
ICU mortality [n (%)]	15(10.6)	12(26.7)	3(5.2)	0.000
Hospital mortality [n (%)]	23(16.3)	15(33.3)	8(8.3)	0.000

MV: patients who received mechanical ventilation; Non-MV: patients who did not received mechanical ventilation; OR: operating room; PACU: postanesthetic unit; eR: emergency room; ICU: intensive care unit; IM: internal medicine; GS: general surgery; NS: neurosurgery; TS: Thoracic surgery; OS: orthopedic surgery; PS: plastic surgery; UR: urosurgery; NR: neurology; SAPS: Simplified Acute Physiology Score; IQR: Inter-quartile range.

Of the 154 patients admitted to the ICU between October and December 2014, 2 pediatric patients, 4 readmissions, and 7 patients with missing data, mostly due to ICU length of stay < 24 h, were excluded. The study group, therefore, comprised 141 patients: 76 males (53.9%) and mean age 67.7 yr. The characteristics of the study group are shown in (Table 1). There

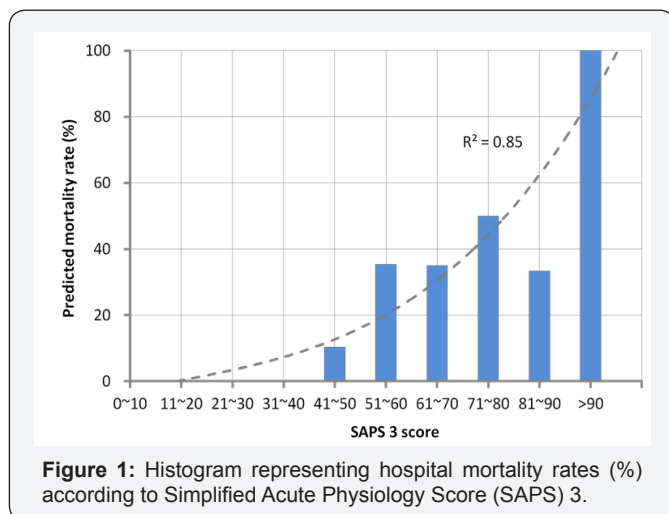
were no significant differences in demographic characteristics between patients in the MV group and the Non-MV group. The SAPS 3 score and ICU mortality were significantly higher in the MV group ( $p = 0.004$  and  $p < 0.001$ , respectively). In addition, length of ICU stay was significantly longer ( $p = 0.007$ ) for the MV group.

**Table 2:** Specific characteristics of patients who received mechanical ventilation according to weaning pattern.

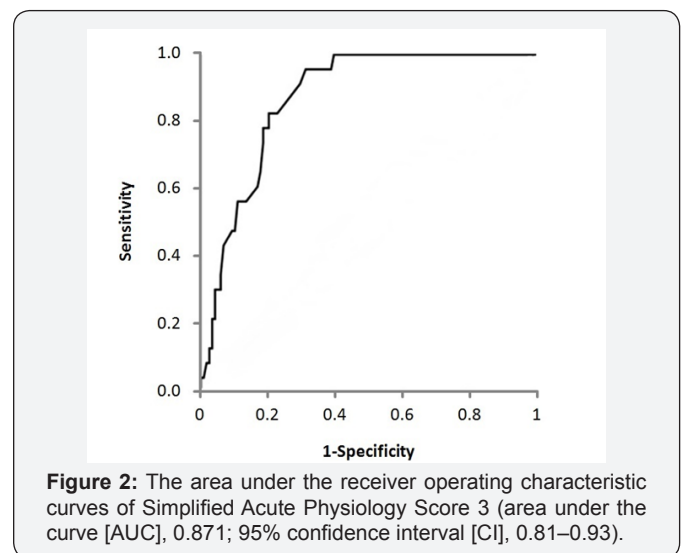
	MV-SW (n=23)	MV-Others (n=20)	p-value
Age (yr, mean ± SD)	67.5 ± 13.3	65.6 ± 14.9	0.657
Male gender [n (%)]	11 (47.8)	14 (70.0)	0.166
Reason for intubation [n (%)]			0.000
Hypoxemia	0 (0.0)	17 (85.0)	
Hypoventilation	4 (17.4)	3 (15.0)	
Postoperative care	19 (82.6)	0 (0.0)	
SAPS 3 score [mean ± SD]	42.7 ± 17.1	62.1 ± 13.2	0.000
ICU length of stay (days) [median (IQR)]	2.0 (2.0–3.0)	4.0 (2.0–10.0)	0.097
Hospital length of stay (days) [median (IQR)]	27.0 (17.0–51.0)	32.0 (8.0–53.0)	0.774
Predicted mortality (%)	15.8	39.4	0.000
Observed mortality (%)	0.000	60	0.000
median (IQR)			
Predicted mortality (%)	15.8	39.4	0.000
Observed mortality (%)	0.0	60	0.000

MV-SW: patients who received mechanical ventilation and simple weaning; MV-Others: patients who received mechanical ventilation and all other weaning groups; SAPS: Simplified Acute Physiology Score; IQR: inter-quartile range.

The MV group (n = 43; excluding 2 patients with missing weaning protocol data) was subdivided based on weaning pattern. When the reason for the intubation was compared between subgroups, the MV-SW group included patients requiring significantly more postoperative care, while the MV-Other group had significantly more intubations due to hypoxemia ( $p = 0.001$ ). Observed mortality, SAPS 3 score, and predicted mortality were significantly higher in the MV-Other group (Table 2), and observed mortality (60.0%) was higher than the predicted mortality (39.4%).



**Figure 1:** Histogram representing hospital mortality rates (%) according to Simplified Acute Physiology Score (SAPS) 3.



**Figure 2:** The area under the receiver operating characteristic curves of Simplified Acute Physiology Score 3 (area under the curve [AUC], 0.871; 95% confidence interval [CI], 0.81–0.93).

Hospital mortality was considerably greater in patients with higher SAPS 3 scores. The highest hospital mortality rate was observed in patients with a SAPS 3 score greater than 90 (Figure 1). Discrimination, as measured by the AUC, was good (AUCs = 0.871), (Figure 2).

**Discussion**

In the present study, the mean SAPS 3 score of all patients was 46.1; the score was 10 points higher for the group requiring

mechanical ventilation compared to the group without. Although there were no significant differences in gender, age, route of admission, and department between the groups, the group requiring mechanical ventilation exhibited longer ICU stays and higher mortality. Among members of the MV group, those capable of simple weaning showed lower severity scores and mortality.

Many previous studies have shown that SAPS 3 is a scoring system model with good discrimination but poor calibration [5,8-10]. In the present study, the AUC value, which indicates discrimination, was 0.871; this is similar to previous studies (0.8–0.89) and indicates favorable discrimination [5,11]. While there were no in-hospital mortalities in patients with SAPS 3 scores of  $\leq 40$  points, patients with scores of 41–90 points had a mortality rate under 50%, and the mortality rate increased rapidly for patients with scores  $>90$ .

Unlike previous SAPS 3 studies that compared discrimination or calibration to outcomes from other scoring models or investigated regional variations [10,12-14], the present study focused on how outcomes differed in patients receiving or not receiving mechanical ventilation. This is because, among various factors affecting SAPS 3, the effect of applying mechanical ventilation on the score is minimal; however, a significant number of patients in the ICU receive ventilator care and applying mechanical ventilation has a clinically significant impact on the clinical course of critically ill patients.

The patient group requiring mechanical ventilation was divided into two subgroups based on the weaning pattern. The simple weaning (MV-SW) group included patients with successful 1st extubation after the 1st SBT. The other (MV-Other) group included all other weaning groups: Difficult weaning (failed 1st SBT trial, but succeeded within the 3rd SBT trials or successful weaning within 7 days after the 1st SBT); prolonged weaning (failed weaning on the 3rd SBT trial or required more than 7 days on the 1st SBT); and chronic mechanical ventilation weaning (the same as tracheostomy) [15,16].

The majority of patients from our hospital had chronic mechanical ventilation weaning when simple weaning failed; for this reason, we consolidated the three groups into one. Since most of the patients who had simple weaning were those who underwent extubation after maintaining mechanical ventilation for postoperative care due to old age, prolonged operation time, or underlying diseases (19 subjects, 82.6%), they not only showed lower SAPS 3 scores, but also lower mortality rates compared to the MV-Other group. Conversely, most of the patients within the MV-Other group were intubated for mechanical ventilation because of hypoxemia caused by impairment of normal ventilation function (17 subjects, 85%), which may have manifested as an increase in the severity of weaning.

The mean length of hospital stay for the MV-Other group, whose conditions were more severe, was not significantly

different from the MV-SW group; this may be attributed to a shortened overall length of hospital stay due to the larger number of “do not resuscitates” (DNRs) and patients who passed away in this group. Moreover, it can be surmised that the observed mortality rate (60.0%) in this group was higher than the predicted mortality (39.4%) because of the influence limited proactive management for patients who were expected to have unfavorable prognosis and had effectuated DNRs in advance.

The limitations of this study include having a small number of participants, which resulted in a low number of patients in the ventilated group and corresponding subgroups. In addition, at the time of data collection, the hospital did not have a standard weaning protocol; weaning was carried out either by applying a T-piece or a pressure support ventilation (PSV) mode after the SBT and the protocol used was determined by the doctor in charge of the department. Consequently, the reason for a patient not having been placed into a weaning subgroup may not have been due to the patient’s condition.

Furthermore, while all charts were reviewed by a single person responsible for the ICU, the SAPS 3 scores were inputted by different doctors who were in charge of the department at the time of admission; for this reason, individual evaluator errors cannot be eliminated. We plan to perform future studies with a larger number of patients; furthermore, the hospital plans to implement a standard SBT protocol, therefore data obtained after the protocol is applied may be compared to the results presented to allow the mechanical ventilation subgroups to be more clearly defined to determine any differences.

### Conclusion

In conclusion, in the present study, conducted on patients who were hospitalized in the surgical or internal medicine ICU, SAPS 3 score assisted-evaluations showed good discrimination. It is believed that this will be a useful method for predicting weaning difficulties and mortalities in patients requiring mechanical ventilation.

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