Comparison of SOFA and APACHEII Scores in Predicting Weaning of Patients from Ventilator in the ICU Ward of Amin Hospital in Isfahan, Iran

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ABSTRACT

Today, mechanical ventilation devices play an effective role in the improvement of patients. Prolonged mechanical ventilation and inappropriate weaning of patients from ventilators have undesirable consequences. To measure the readiness of patients to be weaned from a ventilator, accurate and valid criteria are required. The present study was conducted to compare SOFA with APACHEII scores in predicting the results of weaning patients from the ventilator in the intensive care unit (ICU). This was a descriptive-analytic study of comparative type conducted in 2015 in Isfahan, Iran on patients admitted to the ICU. The study sample was all patients admitted to the ICU of Amin Hospital. Sampling was conducted using the convenience (accessible) sampling method. Overall, 85 patients comprised our sample. Of the 85 patients, 24 patients died and were excluded from the study. In this study, the standard forms of SOFA and APACHEII were used to score patients' conditions. Descriptive statistical tests and the t-test, logistic regression, correlation coefficient, and calculation of specificity, sensitivity and area under ROC curve were used. Then, the data were analyzed using SPSS18 software. In this study, of the 61 patients included in the sample, 15 patients (24.6%) were females and 46 patients (75.4%) were males. In terms of age, the highest frequency distribution was related to patients over 70 years (18%), and 60.7% of the patients had an underlying disease. This study showed that there is a significant relationship between the SOFA and APACHEII scores. However, the values of sensitivity, specificity, positive predictive value, negative predictive value, and area under the ROC curve were higher in the APACHEII scoring system than in SOFA. In addition, the APACHEII score at admission and at first weaning predicted the result of the first weaning of patients from the ventilator. On the other hand, the mortality rate was zero percent in patients who first their weaning of ventilator was successful. While there is a significant relationship between the SOFA and APACHEII scores, the APACHEII scores were a better indicator than SOFA for predicting successful weaning of the patient from ventilator. Also this study show that failure at the first weaning of the patients from ventilator accompanies an increase of mortality.

Keywords: Sequential Organ Failure Assessment; Acute Physiology and Chronic Health Evaluation; Weaning; Mechanical Ventilation

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INTRODUCTION

1.1. Background
Many patients admitted to the ICU require respiratory support using a mechanical ventilator [1]. The final goal of caring for patients using mechanical ventilation is to acquire spontaneous breathing and successful weaning from the ventilator [2].

1.2.The importance of weaning

Since, mechanical ventilation is accompanied by many adverse consequences, inappropriate weaning of the patient from the ventilator could result in dyspnea or respiratory arrest, so it is required to wean the patient from the ventilator as soon as spontaneous breathing is possible [3]. Reducing the time of patients' connection to the ventilator improves their quality of life, increases their motor function, and gives them a sense of independence. In addition, it reduces ventilator-associated pneumonia (VAP) [4]. Prolonged use of ventilation by the patient can result in several adverse consequences, including laryngeal injuries, tracheal stenosis, sinusitis, pneumothorax, decreased cardiac output, physiologic problems, reduction of oxidative enzymes in the respiratory muscles, and nervous myopathy [5]. These direct consequences can result in indirect adverse consequences, including increased length of stay (LOS), emotional distress, and increased expenditures [6]. In addition, failure to wean patients off the ventilator can increase morbidity, mortality, duration of mechanical ventilation, and length of stay (LOS) in the ICU [3,7,8].

It should be noted that reintubation accompanies an increase of 7 to 11-fold in mortality in hospitals [9]. Patients with their first unsuccessful extubation stay longer in the ICU than those with first successful extubation, and there is a 7-fold higher probability that they will die in the hospital. In addition, patients with unsuccessful extubation who survived in the hospital are 6-fold more likely to require long-term care and the assistance of a rehabilitation facility [10].

1.3.The nurse's role in the weaning process

The key factor in the ICU is an experienced nursing team that is continuously capable of immediate decision-making and performing different nursing processes in emergencies. Performing the protocol of weaning from the ventilator by nurses improves clinical outcomes, decreases the duration of mechanical ventilation and LOS in ICU, and is effective in early extubation as well [11]. According to the studies that have been conducted, nurses have been specified as having high levels of responsibility and management of mechanical ventilation and weaning of patients from the ventilator [12]. In 2007, Rose cited Thoren et al.'s conclusion that nurses help to improve the results of patients' weaning from the ventilator, since they diagnose acid-base disorders, electrolyte disturbances, hypoxia, tachypnea, and pain in patients earlier [12].

1.4.Effect of predictor criteria

Predicting prolonged mechanical ventilation is a challenging issue. Currently, there is no reliable instrument through which we are able to predict patients' requiring prolonged mechanical ventilation. In most cases, decisions are made based on clinical criteria, which are often discovered with delay and are subjective and unreliable [13]. Predictive criteria give us the ability for prognosis and affordable analyses. In addition, they prevent disabilities, reduce LOS in the ICU and in the hospital, and improve the efficiency of health care systems [14].

1.5.SOFA and APACHE II score

SOFA and APACHEII scores are two indicators commonly used in Isfahan's Amin Hospital to predict patients' weaning from the ventilator. The SOFA score evaluates six systems of the body, i.e., respiratory, nervous, cardiovascular, liver, coagulation, and renal systems. SOFA Scoring ranges is between zero and 24 which SOFA are scored on a scale of 0-4[15]. SOFA score is first calculated at admission and then on a daily basis in the ICU. A high SOFA score represents organ failure and dysfunction [16]. The APACHEII score consists of three different parts, i.e., 1) acute physiology score (APS) including 12 clinical measurements (temperature, mean arterial pressure (MAP), heart rate, respiratory rate, oxygenation, arterial pH, serum sodium, potassium and creatinine, hematocrit, white blood count, Glasgow Coma Score (GCS) and serum HCO3); 2) the role of patient's age; and 3) the evaluation of history of chronic diseases[16]. This score is between zero and 71, and each variable receives a score between 0-4 [17]. The APACHEII score is measured at admission and 24 hours after admission [3, 18].

1.6. Objectives

After a thorough review of the literature, it was apparent that studies to compare SOFA and APACHEII scores to predict patients' faster weaning from the ventilator are limited in Iran. Therefore, the present study was conducted to compare SOFA and APACHEII scores in predicting patients' weaning from the ventilator.

MATERIALS AND METHODS

2.1. Research Design and Setting

This was a cross-sectional, descriptive-analytic study of comparative type, conducted in -2015 in Isfahan, Iran, on patients admitted to the ICU. The research environment of this study was the intensive care unit of Amin Hospital in Isfahan. All of the subjects in the study were patients who were admitted to the ICU at Amin Hospital.

2.2. Sampling

To estimate the sample size, we used n= $(\frac{Z\alpha/2}{d})^2$ S^2_m. The normal standard area under curve ($Z\alpha/2$) for 95% confidence was 1.96, and the value of error committed by the examiner (d) was considered to be 5%. The variance of the primary sample (S^2_m) was obtained as 0.039 using references and the pre-sampling method. By putting the numbers in the above formula, the sample size was obtained to be 60. Due to the risk of sample loss, 85 subjects were considered as the sample. In addition, convenience sampling (accessible) was employed.

2.3. Instrument and Data Collection

Data collection tools in this study were SOFA and APACHEII standard forms. In the first section of these forms, demographic information of the subjects was collected. In previous studies, the validity and reliability of SOFA and APACHEII scores were verified [3, 19, 20]. The researcher conducted sampling with regard to inclusion and exclusion criteria. Then, demographic information was completed using medical files and by obtaining information from the relatives of the patients. SOFA and APACHEII forms were completed at the time of admission of the patients to the ICU, when weaning the patient from the ventilator, when connecting the patient to the T-Piece, and before extubation of the patient, according to the tests and arterial blood gas (ABG) sample. In this study, the patients were connected to the T-Piece according to the following indices: 1) Hemodynamic stability including lack of fever or dangerous dysrithmia, heart rate of 60-120 bpm, systolic blood pressure of 90-180 mmHg, and a respiratory rate of less than 25 breaths per minute; 2) Fraction of inspired oxygen of less than 50% with Pao_2 of higher than 60mmHg; 3) S_{aO2} over 90%; 4) parameters in ABG being normal, including pH and $Paco_2$; 5) positive end expiratory pressure (PEEP) lower than 8 cmH_2o; and 6) GCS of higher than 8[21, 22, 23]. It should be noted that nurses in the ICU received required explanations and training in terms of the project and its objectives, and, in the case of absence of the researcher in the ward, nurses were able to check the required tests for the patients. Eighty-five samples were selected as the sample. Of these 85 samples, 24 samples died before the weaning stage from the ventilator, and they were excluded from the study. Sixty-one samples reached the weaning stage from the ventilator. According to statistical study, of the 61 samples, 37 samples had successful weaning from the ventilator, i.e., they were extubated successfully in the primary weaning from the ventilator. Of the remaining 24 samples, 13 samples failed the first attempt at weaning. However, they were extubated successfully in later sessions of weaning from the ventilator, and 11 samples were re-intubated after being weaned from the ventilator, and they died. Fifty samples were weaned successfully from the ventilator and transferred to the ward.

2.4. Ethical Consideration

The Ethics Committee of the Department of Nursing and Midwifery, Isfahan University of Medical Sciences, approved the present study with the ethical ID of IR.MUI.REC.1394.4.39. To observe research ethics, the authors introduced themselves to the officials of the study's environment, presented a written letter of introduction from the Department of Nursing and Midwifery, and obtained permission to conduct the study. Then, the aim of conducting the study was explained to the relatives of the subjects, and their consent was obtained to conduct the study. Only samples were selected whose relatives were in agreement with their participation in the study. In addition, the author committed to the confidentiality of all information related to the samples in the data collection tools.

2.5. Statistical Analysis

Data were analyzed using descriptive tests, such as mean and standard deviation, and inferential analyses, such as the t-test, logistic regression, correlation coefficient, sensitivity and specificity, Receiver Operating Characteristic (ROC) curve, and SPSS software.

RESULTS

3.1: Demographic Information

Of the 61 patients in the sample, 15 were females (24.6%) and 46 were males (75.4%). The highest frequency distribution was related to patients whose ages were over 70 (18%). In terms of LOS in the ICU, the highest frequency observed (45.9%) was related to patients with 11-30 days of stay. Nearly 61% of the patients who were admitted had an underlying disease, and 62.3% of the patients were admitted for nervous system diseases (problems and disorders of the nervous system).

3.2: correlation SOFA with APACHE II Score

There was a positive and significant correlation between the SOFA and APACHE II scores on admission (p<0.05, r=0.486) and SOFA and APACHE scores at the first weaning time (p<0.05, r=0.364) (Table 1).

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Table 1: Relationship between SOFA and APACHE II scores at admission and at the first weaning from mechanical ventilation

APACHE II Score SOFA Score	Admission time		First Weaning time	
	correlation coefficient	p-value	correlation coefficient	p-value
Admission time	0.486	<0.001	----	----
First Weaning time	----	----	0.364	0.004

3.3: Comparison SOFA with APACHE II Score

The cut point for the SOFA score at admission was 5.5. About 71% of the patients with first unsuccessful weaning had SOFA scores over 5.5 at admission (sensitivity=70.8%), and about 30% of patients with first successful weaning had SOFA scores of over 5.5 at admission time (specifity=29.9%). In addition, about 40% of patients with SOFA scores less than 5.5 at admission were reintubated after their first weaning (positive predictive value= 39.5%), and about 67% of patients with SOFA scores less than 5.5 at admission were fully extubated in the first weaning (negative predictive value= 61.1%). The area under the ROC curve was 0.499 in predicting the failure of the first weaning based on the SOFA score at admission (Figure 1, Table 2).

In the prediction of the first unsuccessful weaning, the cut point for the APACHE II score was 13.5 at admission, with about 88% of patients with their first unsuccessful weaning from the ventilator had an APACHE score of over 13.5 at admission (sensitivity= 87.5%), and about 51% of patients with their first successful weaning had APACHE scores of less than 13.5 at admission (specificity= 51.4%). In addition, about 54% of patients with an APACHE score over 13.5 at admission were reintubated after their first weaning (positive predictive value= 53.8%), and about 86% of patients with an APACHE score of less than 13.5 at admission were fully extubated after their first weaning (negative predictive value= 86.4%). The area under the ROC curve was 0.683 in predicting failure of the first weaning based on the APACHE score at admission (Figure 1, Table 2).

Table 2. Comparison of SOFA and APACHE scores at admission and at the first weaning in predicting the first unsuccessful weaning of patients

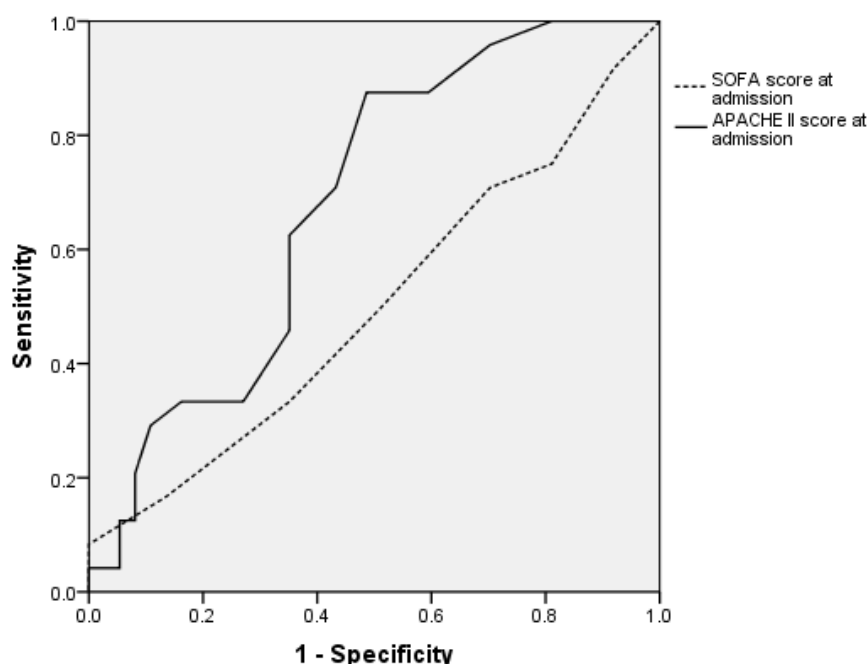| Parameters	SOFA Score		APACHE II Score	
	Admission time	First Weaning	Admission time	First Weaning
Cut-off value	5.5	5.5	13.5	11.5
Sensitivity	70.8	45.8	87.5	75.0
Specificity	29.7	62.2	51.4	70.3
Positive predictive value	39.5	44.0	53.8	62.1
Negative predictive value	61.1	63.9	86.4	81.2
p-value	.994	.712	.016	<.001

Figure 1: Receiver operating characteristic (ROC) in determining failure at the first weaning of the patients, based on SOFA and APACHE II scores at admission

Furthermore, in predicting the first unsuccessful weaning, the cut point was obtained as 5.5 for SOFA scores at the first weaning. About 46% of patients with their first unsuccessful weaning had SOFA scores over 5.5 at the first weaning (sensitivity= 45.8%). About 62% of patients with first full extubation had SOFA scores of less than 5.5 at the first weaning (specificity= 62.2%). Furthermore, about 55% of patients with SOFA scores over 5.5 at the first weaning had their first unsuccessful weaning (positive predictive value= 44%), and about 64% of patients with SOFA scores less than 5.5 at the first weaning had their first successful weaning (negative predictive value= 63.9%). The area under the ROC curve in predicting failure of the first weaning based on the SOFA score was 0.545 at the first weaning (Figure 2, Table 2).

In predicting the first unsuccessful weaning, the cut point for the APACHE score was 11.5 at the first weaning. About 75% of the patients with a first unsuccessful weaning had an APACHE score over 11.5 at the first weaning (sensitivity= 75%). About 70% of patients with their first full extubation had an APACHE score less than 11.5 at the time of their first weaning (specificity= 70.3%). Furthermore, about 62% of the patients with an APACHE score over 11.5 at the first weaning had their first unsuccessful weaning (positive predictive value= 62.1%), and about 81% of patients with an APACHE score less than 11.5 at the first weaning had their first successful weaning (negative predictive value= 81.2%). The area under the ROC curve in predicting the failure of first weaning based on the APACHE score was 0.779 at the first weaning (Figure 2, Table 2).
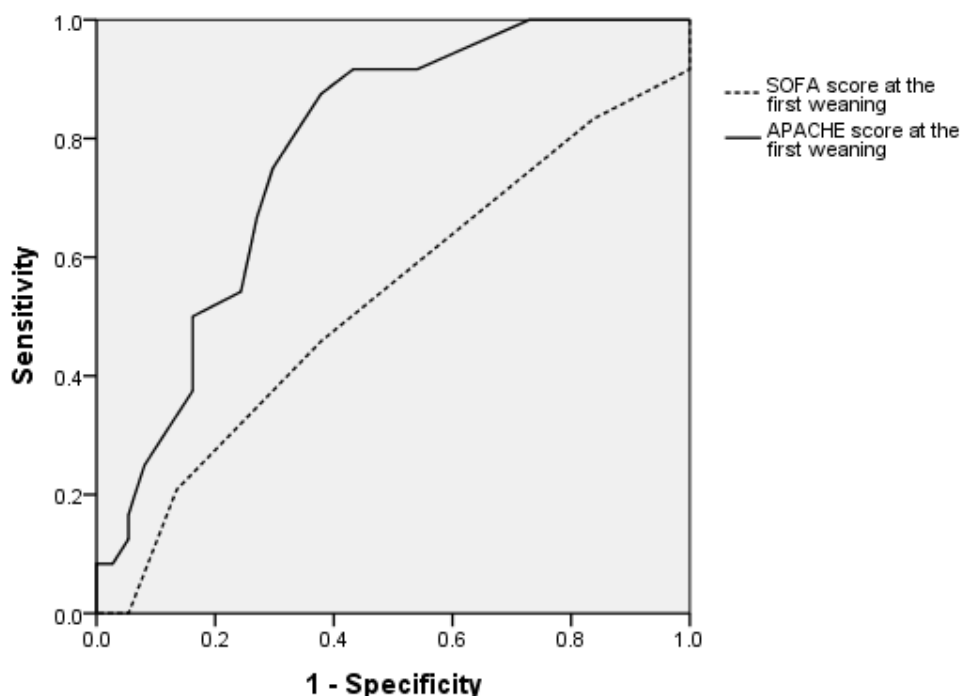

Figure 2. Receiver operating characteristic (ROC) in determining failure at the first weaning of patients based on SOFA and APACHE scores at the first weaning

In addition, based on the results of fitness of logistic regression models, odd ratio for APACHE score was 1.11 at the admission time that shows for each unit of increase in APACHE score when admission, the chance of first unsuccessful weaning of the ventilator increases for 11%, i.e., it becomes 1.11-fold.Inaddition, odd ratio for APACHE score at the first weaning was observed as 1.26 that shows for each unit of increase in APACHE score at the first weaning, the chance of first unsuccessful weaning of the patient from ventilator increases for 26%, i.e., it becomes 1.26-fold. In fact, the effect of the SOFA score on admission and at the first weaning were not significant in predicting the success of the first weaning of the patient from the ventilator ($p>0.05$). However, the effects of the APACHE scores at admission and at the first weaning from the ventilator were significant in predicting the results of the first weaning of the patient from the ventilator ($p<0.05$) (Table 3).

Table 3. Results of multiple logistic regression model in predicting first successful weaning of patients from the ventilator

Model	Variable Forecast	Parameter	Standard deviation	Parents' statistic	Degrees of freedom	*P*-value	Odd ratio
1	Constant value	0.548	0.911	0.362	1	0.547	0.58
	SOFA Score at Admission time	0.018	0.135	0.018	1	0.895	1.02
2	Constant value	0.485	1.343	0.131	1	0.718	0.62
	SOFA Score at First Weaning time	0.010	0.243	0.002	1	0.968	1.01
3	Constant value	2.161	0.890	5.894	1	0.015	0.12
	APACHE II Score at Admission time	0.105	0.051	4.207	1	0.040	1.11
4	Constant value	3.291	0.960	11.763	1	0.001	0.04
	APACHE II Score at First Weaning time	0.234	0.074	9.984	1	0.002	1.26

3.4. Correlation Weaning with Mortality Rate
Mortality rate was 8.45percentinpatients who first their weaning of the ventilator was unsuccessful and mortality rate was zero percent in patients who first their weaning of ventilator was successful (Table 4).

Table 4.frequency distribution based on the first successful weaning of patients from ventilator and mortality rete

First Weaning Mortality	Unsuccessful		Successful		Total	
	Number	Percent	Number	Percent	Number	Percent
No	13	54.2	37	100.0	50	82.0
Yes	11	45.8	0	0.0	11	18.0
Total	24	100.0	37	100.0	61	100.0

DISCUSSION

4.1: Principal Finding:
4.1.1: Correlation SOFA with APACHE II Score
According to the results of this study, it could be stated that there is a significant relationship between SOFA and APACHE scores at admission and at the first weaning (p<0.05). The results of this study were in agreement with the results of some other studies [24, 25, 26]. According to the study conducted by Qiao et al. in 2012, the mean SOFA and APACHEII scores are lower in surviving patients than in those who died, and there is a positive relationship between these two scores at the time of admission (p<0.01; r=0.541) [24]. Also in their study, they stated that the sensitivity, specificity, and area under the ROC curve were more related to APACHE II scores than SOFA scores (p<0.05); therefore, the discriminatory ability of the APACHEII score was higher than that of the SOFA score [24]. Velissaris et al., in their study in 2012,stated that the SOFA score was related to mortality results as well as to the APACHEII score [25]. Mansour et al., in their study in 2013, investigated the relationship between SOFA score, APACHEII score, and the Simplified Acute Physiology Score II (SAPS II) using linear regression analysis, and they concluded that the highest correlation was between APACHEII and (SAPS II) (r^2=0.78), while the lowest correlation was between the SOFA and APACHEII scores (r^2=0.61). In addition, similar to other studies, they concluded that the relationship between these three scores was highly significant and that combining these scores can improve the accuracy of individual scores [26].

4.1.2: Comparison SOFA with APACHE II Score
According to the results of the present study, a SOFA score of less than 5.5 demonstrated that we are 61% confident on admission and 64% confident at first weaning that this patient would not be reintubated after the first weaning. In addition, a SOFA score higher than 5.5 shows that we are 40% confident on admission and 44% confident at the first weaning that this patient would be reintubated after the first weaning (Table 2).

An APACHE score of less than 13.5 on admission shows that we are 86% confident that this patient would be fully extubated at the first weaning, and an APACHE score of less than 11.5 at the first weaning shows that we are 81% confident that this patient would not be reintubated after the first weaning. In addition, an APACHE score higher than 13.5 on admission shows that we are only 54% confident that this patient would be reintubated, and an APACHE score of higher than 11.5 at the first weaning shows that we are 62% confident that this patient would be reintubated after the first weaning (Table 2).

According to Table 2, sensitivity, specificity, positive predictive value, negative predictive value, and the area under the ROC curve were higher in APACHEII scores than SOFA scores, and the logistic regression model shows that the role of the APACHEII score is more significant in predicting the results of weaning the patient from the ventilator.

In general, results of the present study suggest that it could not possible to predict success or failure of patient's weaning off the ventilator using the SOFA score. The results of this study were in agreement with several other

studies [27, 28, 29], but they were not in agreement with other studies [30, 31]. It appears that the reason for the different results of this study relative to other studies lies in the different research methods used, i.e., in each study, the SOFA score at different times was considered as an indicator to predict weaning the patients from the ventilator. While in the study by Peipei in 2010, the SOFA score at admission and after 48 hours and the immediate cumulative SOFA score (SOFA score for a patient during stay in ICU) were measured [30]. In another study by Gnanapandithan in 2011, the first SOFA score and two other factors (duration of ventilation before weaning of patient off the ventilator and method of patients' weaning) were considered as indicators for weaning the patients from the ventilator [31]. In the present study, the SOFA score at admission and at weaning time were compared and were considered for predicting successful or unsuccessful weaning.

In addition, the results of the present study show that successful weaning of patients from the ventilator could be predicted using the APACHEII score. The results of this study were inn agreement with the results of several other studies [3, 10, 18, 31, 32, 33, 34, 35]. However, the results of this study were not in agreement with the results Sanabria et al.'s study in 2013. It appears that the reason for the difference in the results was using the APACHEII score for two different subjects. In the study by Sanabria et al. in 2013, the APACHEII score was used to predict performing early tracheostomy [13]. However, in this study, the APACHEII score was used to predict patients' weaning from the ventilator, connecting the patient to the T-Piece, and then successful extubation.

In previous studies, SOFA and APACHEII scores were compared; however, these comparisons were conducted to predict the mortality and sepsis in patients [36, 37, 38], and no comparison was conducted between SOFA and APACHEII scores to predict patients' weaning from the ventilator.

According to the study by Tseng et al. in 2012, mortality and dependence on ventilator are both related to SOFA and APACHEII scores [39]. Higher SOFA and APACHEII scores suggest that lung function is endangered, which could be related to the difficulty of weaning from the ventilator [39]. In the study by Tseng et al., sensitivity, specificity, and area under ROC curve related to SOFA score were higher than the APACHEII score. However, in the study by Tseng et al., the cut points for the SOFA and APACHEII scores were 8.5 and 23.5 respectively [39]. It appears that these differences in the two studies could be related to several factors, i.e., 1) the subjects in these studies were different; 2) in the study by Tseng et al., a special group of patients (patients with VAP) were selected for study, while, in this study, all accessible patients (respiratory system disease, nervous system disease, and others)were evaluated; 3) the difference between the number of samples and patients' ages could affect the results as well; 4) cut point, sensitivity, specificity, and area under the ROC curve were measured at the start of VAP in the study by Tseng et al.; however, in this study, the above-mentioned factors were evaluated at admission and at the first weaning from the ventilator.

4.1.3. Correlation Weaning with Mortality Rate
The results of the present study show that failure at the first weaning of the patients from ventilator accompanies an increase of mortality. The results of this study were in agreement with the results of most studies [40,10,8,3,41,42]. According to the study by Thille et al. in 2011,failure at the first weaning of the patients from ventilator is a warning message [40].In a study conducted by Epstein et al. in 2000, it is stated that patients with unsuccessful extubation stay in the ICU longer than those with successful extubation. In addition, the mortality rate among patients with unsuccessful extubation in the hospital is seven times higher [10].In several studies is stated that failure in weaning patient from the ventilator and failure in extubation increases morbidity and mortality [41,42,3,8].

4.2. Limitation:
Limitations of this study include:
1)Sample loss (patients' death);
2)Lack of cooperation of hospital staff in conducting ABG at the time of weaning from the ventilator or admission that resulted in exclusion of patients from the study;
3)In spite of training the staff and attempts to precisely record of vital signs, it is possible that the vital signs of the patients were different because they were measured by different staff members with different accuracies, thereby affecting the results.

CONCLUSION

To reduce the complications of prolonged stay of patient in the ICU, prolonged mechanical ventilation, reduction of reintubation of patient and reduced Hospitalization expenditures, an indicator is required to predict timely weaning of patients from the ventilator. The SOFA score shows the degree of organ dysfunction and failure [16]. While it is useful to predict mortality and prognosis in patients with sepsis [36,37,38] and it has been used in different studies, the results of the present study suggest that the SOFA score is not a good indicator to predict successful weaning of patients from the ventilator. However, since a lower SOFA score represents improvement in patients' conditions, in

this study, the SOFA score was lower in patients who were weaned successfully from the ventilator. Another indicator for weaning of patients from the ventilator in the present study was the APACHEII score. In previous studies, it has been verified that the APACHEII score is useful in predicting mortality [15,17,32]. In addition, in several studies, the relationship between this scoring system and weaning patients from ventilators has been stated [3,10,18,31,32,33,34,35]. The results of this study show the relationship of this scoring system with weaning of patients from ventilator as well, which implies that higher APACHEII scores on admission (higher than 18) and at the time of weaning of patients from ventilator (higher than 14) show failure in weaning patients from the ventilator. In general, the results of this study suggest that, while there is a significant relationship between SOFA and APACHEII scores, the APACHEII score is a better indicator of predicting successful weaning of patients from the ventilator than the SOFA score, and it is also a better predicting indicator at the first weaning.

Acknowledgments

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