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Predictors of Successful Weaning among Mechanically Ventilated Patients

Asmaa M Abd El-Moaty[1], Naglaa M. El Mokadem[2], Asmaa H. Abd-Elhy[3], Yasser I. Fathy[4]

[1]Assistant Lecturer of Critical Care and Emergency Nursing Department, Faculty of Nursing,

[2]Prof. of Critical Care and Emergency Nursing Department, Faculty of Nursing,

[3]Assistant Prof. of Medical Surgical Nursing Department, Faculty of Nursing -

[4]Assistant Prof. Anesthesia Department, Faculty of Medicine, Menofia University

Abstract: **Weaning patients from mechanical ventilation is a challenging and complex issue for healthcare providers in ICUs. Aim: To determine the predictors of successful weaning among mechanically ventilated patients. Design: A descriptive correlational study. Setting: the study was carried out at neurosurgical ICU of Menoufia University Hospital. Sample: A convenient sample of 60 patients who were admitted to the neurosurgical ICUs. Tools:(1)A Semi Structured Demographic Questionnaire, (2) Respiratory Neuromuscular Function Questionnaire, (3) Glasgow Coma Scale (GCS),(4)Acute Physiology and Chronic Health Evaluation II scale, (5) Charlson Comorbidity Index, and (6) Modified Nutrition Risk Assessment in Critically Ill (m-NUTRIC). Results: reveals that there was no correlation between weaning success rate and age, nutritional status, co- morbidities among mechanically ventilated patients. However, there was a significant negative correlation between weaning success rate and severity of illness (APACHE II score) (P= 0.000).**

Conclusion: There was no significant relationship between predictors of weaning as age, nutritional status, co-morbid conditions while there was a significant negative correlation between severity of illness and weaning success rate among mechanically ventilated patients. Recommendation: The findings of the current study can provide direction for predicting the factors behind successful weaning that can be used as a foundation for future research.

Keywords: **Integrative Weaning Index, Mechanical Ventilation, Nutritional Status, Severity of Illness, Weaning Predictors.**

1. INTRODUCTION

Mechanical Ventilation (MV) is an effective therapeutic and medical means in the treatment of critically ill patients in Intensive Care Units (ICUs) [1] Mechanical ventilation is the primary intervention for the patients with respiratory failure, reducing the respiratory muscles workload, and reversing or preventing muscle fatigue and provides respiratory muscle rest [2]. The ultimate goal of caring for mechanically ventilated patients is to obtain spontaneous breathing and successful weaning. Weaning a patient from MV involves gradual movement from dependence on the ventilator toward spontaneous breathing.

Weaning predictors were proposed to optimize weaning. Weaning predictors have been defined as those predictors measured before a weaning trial to predict if patients will tolerate the weaning trial [3, 4]. Predictors also have the potential for identifying specific physiological changes responsible for weaning failure [5].

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Many weaning predictors have been proposed to improve weaning outcome; however, the accuracy and precision of these predictors is still controversial. Patients' ventilation parameters were the focus of the majority of previous studies. Other non-respiratory components of the patients' clinical status may also cause weaning failure. Few studies considered patient's medical conditions and its association with successful weaning. Therefore, in the current study we incorporated nutritional status, co- morbidities and severity of diseases as predictors of weaning.

About 20% of patients with prolonged and difficult weaning attributed to a number of variables such as age, co-morbid conditions, nutritional status, muscle strength and lung mechanics [6]. Also, excessive trachobronchial secretions, inadequate cough, severity of disease and ventilator associated pneumonia contribute to difficult weaning [7].

Many mechanically ventilated patients exhibit some form of malnutrition because of preexisting chronic illnesses. It was reported that 81% of patients requiring MV for at least 6 days received inadequate protein and calories [8]. Additionally, increased caloric demand is another factor that may predispose mechanically ventilated patients to increased risk of malnutrition. Thus, the role of nutrition in weaning patients from mechanical ventilation is receiving increased attention. Malnutrition has adverse effects on lung function including decreased respiratory muscle function, decreased ventilator drive, and altered pulmonary defense mechanisms.

Adequate nutrition in mechanically ventilated patients can minimize mortality and morbidity and accelerate the weaning process. Underfeeding reduces regeneration of the respiratory epithelium and induces respiratory muscle exhaustion which fails the respiratory muscle strength and endurance restoration and ultimately prolongs mechanical ventilation. Overfeeding increase physiological stress and prolongs mechanical ventilation by increasing carbon dioxide production, which increases the amount of ventilation needed to balance or compensate arterial blood gases [9] .

Cardiac and respiratory co-morbidities are significant risk factors for weaning failure in patients requiring prolonged mechanical ventilation [10, 11]. The presence of two or more co-morbidities in mechanically ventilated patient significantly associated with prolonged weaning, longer durations of MV and ICU length of stay; in addition to higher mortality rate [12].

Severity of illness reported as one of the weaning outcome predictors. Increase severity of disease is associated with weaning failure. It was reported that patients with low severity of disease get better weaning results, less time of MV and less ICU length of stay [13,14]

Age is a significant variable associated with augmented risk of extubation failure as the lungs continue to develop with greater functions achieved throughout life but with aging, lung functions gradually decrease; about 20% to 35% of patients reintubated within Forty Eight hours of extubation. Physiological changes can occur with increased age such as thoracic cage stiffening, debilitated respiratory and diaphragmatic muscle, higher residual volume, decline sensitivity of the cough center and cardiac function, consequently the patients may encounter greater difficulty of weaning from mechanical ventilation [15].

Significance of the Study

Weaning patients from mechanical ventilation is a challenging and complex issue for healthcare providers in ICUs. Delayed and premature weaning from MV is associated with adverse effects on critically ill patient outcomes, prolonged MV and increased the ICU length of stay [16, 17]. Premature weaning cause additional load on the respiratory and cardiovascular systems, [18] while delays can lead to diaphragmatic atrophy [19] delirium, and Ventilator Associated Pneumonia (VAP); all of which are associated with increased mortality and morbidity [20-22]. Deciding what is the appropriate time for weaning patient from mechanical ventilation is very crucial to critical care nurses to avoid the complication of prolonged mechanical ventilation and untimely weaning. Currently, there is no single appropriate predictor that can assist healthcare providers to accurately predict weaning outcomes. Identifying the potential predictors of weaning may improve the initial management of mechanically ventilated patients. Knowledge generated from the present study will help critical care nurses to develop a clinical profile of patients who are successfully weaned from mechanical ventilation. Therefore, the present study examined the predictors of weaning among critically ill patients.

Aim of the Study

To determine the predictors of successful weaning among mechanically ventilated patients

Research Question

Is there a relationship between successful weaning and nutritional status, co-morbid conditions, severity of illness and age among mechanically ventilated patients?

2. METHODS

Research Design: A descriptive correlational design

Sample: A convenient sample of 60 patients who were admitted to the neurosurgical ICU of Menoufia University. Participants were approached over a year from the beginning of January 2020 to the end of December 2020. Patients who met the study inclusion criteria including: a) Adult patients age from 19 to 65 years old; b) Patients on mechanical ventilator for more than 48 hours; c) Patients being Hemodynamic stable; d) Patients have a Glasgow Coma Scale scores of ≥13. Subjects were excluded if they: a) younger than 19 years or older than 65years old because the study focus is adult population; b) hemodynamiclly instable or under sedation; c) have neuromuscular disease such as Myathenia Gravis or Guillain Barre Syndrome because these diseases affect the respiratory muscles causing weaning failure; d) have cerebral strokes that affect respiratory drive, airway reflexes or respiratory muscles.

Sample size Calculation

In the current study, sample size was calculated based on power analysis. Previous studies appreciated the predictive performance of the Integrative Weaning Index (IWI) and revealed that 81.7% of patients had successful weaning [23]**.** Using the same index to achieve 80% power with a 5% significance (a=0.05) , and effect size of 0.125 a sample size of 51patients were determined. Assuming a possible attrition rate of 15%, therefore another nine patients were added to the previously calculated sample size to compensate for the attrition rate. The final sample size was 60 patients **.**

Setting: The current study was conducted at the Neurosurgical ICU of the Menoufia University Hospital.

Data collection Tools

I) A Semi Structured Demographic Questionnaire: to collect data about age, gender, number of comorbidities , diagnosis on admission. Data were extracted from the patient's medical records by the researcher.

II) Respiratory Neuromuscular Function Questionnaire: which include Spontaneous respiratory rate (F), Spontaneous tidal volume (VT) , Plateau pressure (Pplat), Positive End Expiratory Pressure (PEEP) and respiratory mechanics which include Static Compliance (Cs**),** integrative weaning index (IWI) from equation = Cst × SaO2/ F/ VT [24]**.** The validity of the IWI was tested in the present study by using Pearson Product Moment Correlations based on the significant value obtained by the Sig (2-tailed) <0.05 and the internal consistency (r=0.785, p-value = <0.001). The reliability of the IWI was tested in the present study using Cronbach's co-efficiency Alpha (a=0.823).

III) Glasgow Coma Scale (GCS): It is a neurological scale developed by [25] to assess the conscious state of a patient for initial as well as subsequent assessment. A patient was assessed against the criteria of the scale, and the resulting points give a patient score between 3 (indicating deep unconsciousness) and 15 (indicating full consciousness).The validity of the GCS was tested in the present study by using Pearson Product Moment Correlations Based on the significant value obtained by the Sig (2-tailed) <0.05 and the internal consistency (r=0.957 p-value<0.001). The reliability of the GCS was tested in the present study using Cronbach's co-efficiency Alpha (a=.0.874).

IV) Acute Physiology and Chronic Health Evaluation II (APACHE II) Scale: developed by [26]**.** It is one of several ICU scoring system that was designed to measure the severity of disease within 24 hours of patient's admission to the ICU; an integer score from 0 to 71 is computed based on several measurements; higher scores indicate more severe disease and a higher risk of death. The validity of APACHE II scale was tested in the present study by using Pearson Product Moment Correlations Based on the significant value obtained by the Sig (2-tailed) <0.05 and the internal consistency (r=0.830 p-value<0.001). The reliability of APACHE II scale was tested in the present study using Cronbach's co-efficiency Alpha (a=.0.856).

V) The Charlson Comorbidity Index: was developed by [27] for categorizing comorbidities of patients based on the International Classification of Diseases (ICD). Each comorbidity category has an associated weight (from 1 to 6), based on the adjusted risk of mortality or resource use, and the sum of all the weights results in a single comorbidity score for a patient. Thus, it recommended that 1 point be added to the total score for each decade above the age of 40. A score of zero indicated that no comorbidities were found. The higher the score, the more comorbidities and risk to mortality. Thus people with a score > 5 have essentially a 100% risk of dying at one year [27]. Validity of Charlson Comorbidity Index has moderate to good correlation (>0.4) with other comorbidity indices and predictive validity for criterion such as mortality, readmission, disability and length of stay [28]. Reliability of Charlson Comorbidity Index has high test re-test reliability with intra class correlation coefficients of 0.92 [29]. The validity of Charlson Comorbidity Index was tested in the present study by using Pearson Product Moment Correlations Based on the significant value obtained by the Sig (2-tailed) <0.05 and the internal consistency (r=0.895 p-value<0.001). The reliability of Charlson Comorbidity Index was tested in the present study using Cronbach's co-efficiency Alpha (a=.0.902).

VI) Modified Nutrition Risk Assessment in Critically Ill (NUTRIC): was developed by [30]. It was the first tool to assess nutritional risk at admission developed specifically for Mechanically Ventilated patients in the ICU. Later [31] validated the modified NUTRIC, which allows the exclusion of the IL-6 levels, if not available. The Modified NUTRIC has the following variables: age, number of comorbidities, days from hospital to ICU admission, and Acute Physiology and Chronic Health Evaluation II (APACHEII) and Sequential Organ Failure Assessment (SOFA) scores at admission. The modified NUTRIC score ranges from zero to nine. If the Patient has a high mNUTRIC score ≥5, the patient at higher risk for malnutrition and low score of 0-4 associated with a low malnutrition risk [29]. The validity of the modified NUTRIC score was tested in the present study by using Pearson Product Moment Correlations Based on the significant value obtained by the Sig (2-tailed) <0.05 and the internal consistency (r=0.950 p-value<0.001). The reliability of the modified NUTRIC score was tested in the present study using Cronbach's co-efficiency Alpha (a=0.897).

Ethical Consideration

An official permission for conducting the study was obtained from the Research Ethics Committee at the Faculty of Nursing and the University hospital director after explaining the nature and the purpose of the study. Oral consent was obtained from the relatives of the patients who met the study inclusion criteria to participate in the study. At the initial interview, relatives were informed about the purpose, procedure, and benefits of participating in the study. Confidentiality and anonymity of patients ‘information were assured through coding all data and put all collected data sheets in a secured cabinet. Questionnaires were fulfilled by the investigator.

Data Collection Procedure

The researcher extracted the demographic data of the participants' medical records and screened all participants to assess the severity of the disease, Co-morbidities, and the patients' nutritional status at the beginning of data collection as a base line. The researcher assessed patient's respiratory function by using the respiratory neuromuscular function questionnaire to calculate the integrative weaning index (IWI) score.

If the patient has a score of ≥ 25 according to the IWI index, the patient was allowed for Spontaneous Breathing Trial (SBT) on a T-piece for 30 minutes. After 30 minutes of SBT, patient's ABG parameters and hemodynamic status were recorded again and the patient assessed for any signs and symptoms of SBT failure. If the patient experience any signs and symptoms of SBT failure which include: agitation and anxiety, altered mental status, dyspnea, cyanosis and clinical evidence of increased respiratory effort, hypoxemia and/or hypercapnia and hemodynamic instability, patient was returned back to the mechanical ventilator support.

Statistical Analysis

Data was statistically analyzed using Statistical Package for Social Science (SPSS) Version 16 for windows. The findings were collected, tabulated, and statistically analyzed by two types of statistics that were: Descriptive statistics (Frequency, Arithmetic Mean (X), Stander Deviation (SD), and Analytic Statistics (Pearson Chi-square test (χ^2) & Fisher`s Exact Test, Student t- test, Paired t- test, Pearson correlation). Student t test was used to test the association between two variables. For each test the P value of 0.05 level was used as the cut off value for statistical significance.

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3. RESULTS

Table (1): Demographic Characteristics of the Studied Sample (N=60)

Demographic Characteristics	*(N=60)*	
	No	%
Age X ± SD	42.25 ±12.17	
Gender Male Female	 31 29	 51.7% 48.3%

Table (1) illustrates that the mean age of the studied sample was 42.25 ±12.17 years old and 51.7% of the participants were male.

Table (2): The Medical history of the Studied sample (N=60)

Medical History	*(N=60)*	
	No.	%
Diagnosis		
▪ Cardiogenic shock	18	30.0%
▪ Chronic Obstructive Pulmonary Disease (COPD)	1	1.7%
▪ Respiratory Failure	1	1.7%
▪ Poisoning	7	11.7%
▪ Traumatic Brain Injury (TBI)	6	10.0%
▪ Shock	6	10.0%
▪ Eclampsia	14	23.3%
▪ post Abdominal Exploration	7	11.7%
Medical History		
Yes	48	78.3%
No	12	21.7%
Past Medical History		
▪ No	12	20.3%
▪ Diabetes Mellitus (DM)	15	25.4%
▪ Hypertension (HTN)	27	45.8%
▪ Cardiac disease	3	5.1%
▪ Chest disease	3	5.1%
Glasgow Coma Scale X ± SD	14.07 ±0.89	
Charlson Co-morbidity index score(CCI) X ± SD	0.98 ±0.83	

Table (2) shows that 30.0 % of participants were diagnosed with cardiogenic shock. Regarding past medical history, 45.8% had hypertension. The mean score of Glasgow Coma Scale (GCS) of the participants was 14.07 ±0.89. The mean score of Charlson comorbidity index was 0.98 ±0.83, which indicate that the patients have little comorbidities and lower risk to mortality.

Table (3) The Nutritional Status of the Studied sample (N=60)

Items	*(N=60)*	
	No	%
Modified NUTRIC Risk Assessment Score		
0-4 (low malnutrition risk)	57	95.1%
5-9 (high malnutrition risk)	3	5.0%

Table (3) shows that most of the participants (95.1%) had low malnutrition risk (0-4).

Table (4): The Severity of illness and Predicted Mortality Rate of the studied sample (N=60)

Items	*(N=60)*	
	No	%
Severity of illness (APACHE score) X ± SD	10.96±8.05	

Table (4) clarifies the APACHE II score and the predicted mortality rate of the studied sample. The mean APACHE II score among the studied sample was 10.96±8.05.

Table (5): The Relationship between Weaning Success Rate and Age, Nutritional Status, Co-morbid Conditions and Severity of Illness among Mechanically Ventilated Patients (N=60)

Items	Weaning Success Rate	
	R	P –value
Age	-.055-	0.675
Severity of illness (APACHEII) score	-.457-**	0.000
Charlson Comorbidity Index (CCI)	-.005-	0.967
Modified Nutric Risk Assessment score (m-Nutric)	-.196-	0.133

Table (5) reveals that there was no significant correlation between weaning success rate and age, nutritional status, comorbid conditions among mechanically ventilated patients. However, there was a significant negative correlation between weaning success rate and severity of illness (APACHE II score) (P= 0.000).

4. DISCUSSION

The current study examined the relationship between weaning success rate and age, nutritional status, co morbid conditions and severity of illness in mechanically ventilated patients. The present study findings revealed that there was no correlation between weaning success rate and nutritional status, comorbid conditions and age among mechanically ventilated patients. However, weaning success rate and severity of illness (APACHE II) score was negatively correlated.

Weaning Success Rate and Nutritional status

The findings of the current study revealed that weaning success rate and nutritional status were not correlated. Similar findings have been reported by [32] who examined the influence of obesity on weaning from mechanical ventilation and reported that there was no correlation between the weaning success rate and obesity. However, the findings are inconsistent with [33, 11, 13] who examined the weaning outcomes and revealed that malnutrition identified as significant risk factors for weaning failure.

Weaning Success Rate and Co-morbidities

The findings of the current study showed that weaning success rate and co-morbidities were not correlated. This finding is similar to [11] who examined the incidence and outcome of weaning from mechanical ventilation and revealed that there was no correlation between the weaning success rate and co-morbidities. However, the finding of the current study is different from [12,34] who examined the predictors of prolonged weaning among mechanically ventilated patients and reported that the presence of at least two co-morbidities increased duration of MV and decreased weaning success rate.

Weaning Success Rate and Age

The finding of the current study revealed that the weaning success rate and age was not correlated. This finding is similar to a study by [35,36] who revealed that there was no significant difference between the weaning success rate in different age groups. However, the finding is different from [2, 37, 38] who found that there was a negative association between the mean age and the occurrence of dysfunctional ventilatory weaning response, whereas, with each year increasing in age, the chance of weaning failure increases.

Weaning Success Rate and Severity of Illness

The APACHE II score was revealed as a predictor of weaning outcome. It was reported that APACHE II score was statistically higher in extubation failure groups than in the successful extubation groups [39]. The findings of the current study revealed that weaning success rate and severity of illness were significantly correlated. The findings of the current study are in agreement with [40] who found that low severity of disease was associated with successful weaning. However, the findings of the current study contradicted [41,42] who investigated whether APACHE II score can predict freedom from prolonged mechanical ventilation and revealed that APACHE II cannot predict weaning outcome in patients requiring prolonged mechanical ventilation.

Limitations of the Study

1. Patients participated in the current study were recruited from a single site (the neurosurgical ICU). Therefore, whether the study findings can be generalized to all critically ill patients in different settings still need future research.

2. The findings of the current study are limited in their generalizability because of the convenience sample.

5. CONCLUSION

There was no significant relationship between predictors of weaning such as age, nutritional status, co-morbid conditions while there was a significant negative correlation between severity of illness and weaning success rate among mechanically ventilated patients

6. RECOMMENDATIONS

The present study explored predictors of successful weaning taking into consideration patient's medical conditions not focusing only on patients' respiratory parameters. The findings of this study can provide direction for predicting factors behind successful weaning that can be used as a foundation for future research.

Implication for Nursing Practice

Train critical care nurses to screen mechanically ventilated patients to identify people at risk for weaning difficulty. Early prediction of factors influencing weaning process can improve the management of mechanically ventilated patients.

Implications for Future Research

Replication of the study is recommended using larger sample size and random selection technique.

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