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Comparison between burns weaning assessment program and integrative weaning index as predictors of weaning outcomes

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Abstract

Background: Prolonged mechanical ventilation is associated with negative clinical outcomes that increased risk of mortality and morbidity including weaning failure. Using of indices that combining objective and subjective endpoints predicting weaning outcomes can diminish the risk of weaning failure and complications associated with morbidity, such as re intubation.
Aim: To compare the Burns Weaning Assessment Program (BWAP) and the Integrative Weaning Index (IWI) as predictors of weaning outcomes.
Design: A comparative study design was utilized.
Setting: The study was conducted at Neurosurgical ICUs of Menoufia University Hospital, Menoufia Governorate.
Sample: A convenient sample of 120 patients who were admitted to the neurosurgical ICUs was recruited.
Tools: a) A Semi Structured Demographic Questionnaire, b) Cardiorespiratory Parameters Questionnaire, c) Respiratory Neuromuscular Function Questionnaire, d) Glasgow Coma Scale (GCS).
Results: The majority of the participants in IWI group had a successful weaning rate of 93.30%. There was a statistically significant difference between the two groups regarding weaning success rate ($P < 0.006$). Also, there was a statistically significant difference between the two groups regarding the ICU length of stay and duration of mechanical ventilation $P <$ 0.013 & < 0.011) respectively.
Conclusion: IWI is an objective index in predicting the outcomes of spontaneous breathing trials compared to the Burns Weaning Assessment Program (BWAP).
Recommendation: Critical care nurses should use IWI as a more objective index which can predict the outcomes of spontaneous breathing trials in concurrent with clinical weaning criteria during weaning process of mechanically ventilated patients.

Keywords: Burns weaning assessment program, critically ill patients, integrative weaning index, mechanical ventilation, weaning outcomes

Introduction

Mechanical Ventilation (MV) is a life-saving intervention. More than 800,000 patients need MV in the Unites States annually, moreover, the patients who need MV support for more than 3 weeks account for more than 50% of the total ICU costs [1, 2].

Increase duration on mechanical ventilation is associated with series of adverse effects as tracheal lesions, Ventilator-Associated Pneumonia (VAP), ventilator-induced diaphragmatic dysfunction [3, 4]. While early extubation expose the patient to cardiovascular stress because of spontaneous breathing which require reestablishment of ventilatory support [3]. Therefore, patients should be weaned from MV as soon as possible to avoid these complications.

The decision to wean a patient from mechanical ventilation is based on complete assessment of patients' readiness to wean as well as compliance with a list of physiological criteria [4]. A critical care nurses have crucial role for promoting overall patient safety and comfort during MV and the weaning process. Therefore, critical care nurses must participate in the planning and implementation of the weaning process, which requires both experience and competence. Critical care nurses are in a good position to determine if a patient is ready to wean from MV [5].

The clinician's assessment broadly affects the decision to attempt discontinuation from mechanical ventilation. Decision to wean a patient from MV based on certain factors including: the verification of patients' hemodynamic stability, resolution of the primary cause, ability to cough, mental and cognitive status, nutritional status and specific parameters of lung mechanics [6]. However, clinical evaluation alone is not sufficient to evaluate the prognosis of weaning from MV. Therefore, accurate indices might be useful to make the outcome of weaning from MV safer.

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The indices of weaning are commonly used in ICUs; but few of these indices have high accuracy [7]. In clinical practice various weaning predictors have been used as an attempt to objectively assist the decision-making of the weaning process considering the capacity of the respiratory muscles as the Rapid Shallow Breathing Index (RSBI), Maximal Inspiratory Pressure (PI max), The compliance/ Rate/Oxygenation/Pressure (CROP) Index, The airway pressure (P0.1) Index. But until now, studies are still controversial and there is no agreement on the optimal approach due to the multifactorial origin of weaning from mechanical ventilation [9].

Currently, the most functional strategy for weaning from mechanical ventilation and subsequent extubation is combining subjective assessment and objective indices. The use of weaning indices can minimize the risk of weaning failure and complications associated with morbidity, such as re intubation [9]. The latest indices presented for predicting weaning outcomes are the Integrative Weaning Index (IWI) and Burns Weaning Assessment Program checklist (BWAP) which are beneficial in distinguishing reversible causes of weaning failure, stand as indicator for the following attempts [10].

The IWI index was developed by [11] which evaluate respiratory mechanics, oxygenation, and respiratory pattern in an incorporated method. The Integrative Weaning Index had been examined as a predictor of weaning outcomes among mechanically ventilated patients and it was found to be more objective indicator and has proper precision and power for predicting the two hours Spontaneous Breathing Trial (SBT) results. Therefore, in addition to the reliable prediction of the final weaning outcome, it has favorable power to predict if the patient is ready to breathe spontaneously as the first step of weaning. The IWI has a sensitivity of 99% and specificity of 86% in predicting the outcome of weaning from mechanical ventilation [12, 13, 14].

Burns Weaning Assessment Program checklist (BWAP) is another indicator for successful weaning process, developed by [15] and used to assess and track the weaning progresses of the mechanically ventilated patients through general and respiratory assessment. The Burns Weaning Assessment Program is a 26-factor scoring instrument, used to decrease variability in managing patients on MV. The total score of the instrument is 26. When the patients have a score over 17, they considered ready for weaning and the process of weaning can be started [15]. Burns Weaning Assessment Program had been found to be a good predictor of weaning from MV in patients who require prolonged mechanical ventilation and lessening duration of MV and the ICU length of stay.

Significance of the Study

Although, the majority of patients are extubated pretty safely, the first weaning attempt fails in 20% of mechanically ventilated patients [16]. Premature extubation followed by reintubation is linked with increase morbidity and death. Thus, early identification of the proper time of weaning patients from mechanical ventilation is a pressing need to minimize complications. Several objective criteria have been proposed to assess whether a patient is ready to be weaned off mechanical ventilation [17, 18] Weaning decisions based on subjective assessment alone have been proved to be a wrong predictor of weaning outcomes. Since a multiple factors influence weaning time and hence integrated indices is likely to be more predictive than single criterion. Also, it is evident that using of indices that combining objective and subjective endpoints predicting weaning outcomes might provide a more precise prognosis for weaning from MV and reduce the risk of weaning failure and adverse complications such as early extubation and re-intubation. Thus, the current study was conducted to compare two weaning indices in predicting successful weaning from mechanical ventilation. The findings of the present study will enable critical care nurses to evaluate patient's readiness for weaning as the initial step of weaning from MV and will be useful in identifying patients who will not tolerate weaning from MV. Also, knowledge generated from the present study will assess critical care nurses in identifying reversible causes of weaning failure.

Aim of the Study

The aim of the present study was two folds: a) compare the Burns Weaning Assessment Program (BWAP) and the Integrative Weaning Index (IWI) in predicting successful weaning from mechanical ventilation and b) examine the relationship between Integrative Weaning Index and Burns Weaning Assessment Program scores and weaning outcomes in mechanically ventilated patients.

Research Hypotheses

- There is a difference in weaning success rate and Integrative Weaning Index (IWI) among mechanically ventilated patients.
- There is a difference in weaning success rate and Burns Weaning Assessment Program (BWAP) among mechanically ventilated patients.
- There is a relationship between integrative weaning index (IWI) score & weaning outcomes in mechanically ventilated patients.
- There is a relationship between Burns Weaning Assessment Program checklist (BWAP) score & weaning outcomes in mechanically ventilated patients.

Methods

Research Design: A descriptive comparative study design was utilized.

Sample: A convenient sample of 120 patients who were admitted to the neurosurgical ICU of the University

Hospital of Menoufia University who were studied over a year from the beginning of January 2020 to the end of December 2020. Patients who met the study inclusion criteria which include: (a) Adult patients age (19 years to 65 years old), (b) patients who stay on mechanical ventilation more than 48 hours, (c) Patients being Hemodynamic stable (no signs of myocardial ischemia, normal blood pressure with no or minimal vasoactive drugs (e.g. dopamine or dobutamine dosage ≤5μg/kg/min) and HR≤140 beats/min), (d) Glasgow Coma Scale ≥13. Patients were excluded if they have any of the following conditions: (a) Patients younger than 19 or older than 65years old will be excluded because the study focus is adult population, (b) Patients with hemodynamic instability or under sedation, (c) Patients with neuromuscular disease such as Myathenia Gravis and Guillain Barre Syndrome as it affect respiratory muscles causing weaning failure, (d) Patients with cerebral strokes that affect respiratory drive, airway reflexes or respiratory muscles.

Sample size Calculation: In the present study, it was computed based on power analysis performed in previous study which applied the predictive performance of a new IWI. Findings of the previous study showed that 81.7% of patients had successful weaning [11]. The same assessment was used in the present study to identify this variation with a significance level of 5% and to achieve 80% power which yielded a sample size of 102. A potential attrition rate of 15% was assumed [19]. The final sample size needed was determined to be 120, (60 each group).

Setting: The present study was carried out at the Neurosurgical ICU of the Menoufia University hospital, in Menoufia governorate.

Tools

I) A Semi Structured Demographic Questionnaire**:** to collect data on age, gender, ICU length of stay, number of comorbidities, diagnosis on admission. Data were extracted from the patient's medical records by the investigator at the initial data collection point.

II) Cardiorespiratory Parameters Questionnaire: the questionnaire developed by [20] to assess oxygenation and hemodynamic parameters. Arterial blood sample was drown from the patient and was analyzed via blood gas analyzer (RAPID Point® 500) which equipped with fully automated calibration mechanism. The reliability of Rapid Point 500® was reported in a sample of 165 hospitalized adult patients in ICU. The Intra-and inter- assay coefficients was higher than 0.91 [21]. The validity of Rapid Point 500® was assessed through paired-sample analysis, the correlation coefficients for the values determined by the two systems showed a significant relationship (r = 0.962 for pH, r = 0.9955 for $PaCO_2$ and r = 0.9829 for PaO_2 [22]. Hemodynamic parameters included Central Venous Pressure (CVP), heart rate, respiratory rate, Blood Pressure, and Mean Arterial Pressure. These parameters were collected from the bed side monitor (NIHON KOHDEN, life scope, BSM 3000 series, Tokyo, Japan). CVP was measured manually. The validity of the Cardiorespiratory Parameters Questionnaire 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=0.982, *P*<0.001). The reliability of the Cardiorespiratory Parameters Questionnaire was tested in the present study using Cronbach's Co-efficiency Alpha (a=0.931).

III) Respiratory Neuromuscular Function Questionnaire: which include Spontaneous respiratory rate (F), Spontaneous tidal volume (VT), Plateau pressure (P plat), Positive End Expiratory Pressure (PEEP) and respiratory mechanics which include Static Compliance (Cs**),** integrative weaning index (IWI) based on the equation = Cst × SaO_2/ F/ VT. The validity of the IWI was reported in a study of 105 critically ill adult patients, and has a high sensitivity of 95.6%, and 40% specificity, Positive and negative predictive values of 90.5% and 60%, and 86.7% accuracy [11]. In the present study, the validity of the IWI was tested 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).

IV) Glasgow Coma Scale (GCS): was developed by [23] to give a reliable, objective way of monitoring level of consciousness for initial as well as subsequent assessment for patients. It gives the patient a score between 3 (indicating deep unconsciousness) and 15 (indicating full--consciousness). The reliability of GCS scale was reported in a study of 100 critically ill adult patients who had neurologic condition. Internal consistency was evaluated using Crombach` Efficiency alpha and was 0.87 for both the first and the second rater. Spearman correlation coefficients was high (P= 0.98 for the first rater; P= 0.92 for the second rater [24] also, the validity of the GCS scale was shown to be high when used in critically ill patients (r^2=0.233, *p*<0.0001) [25]. The validity of 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 GCS was tested in the present study using Cronbach's Co-efficiency Alpha (a=.0.874).

V) Burns Weaning Assessment Program (BWAP) Checklist: was developed by [15] to assess and follow weaning progresses of the mechanically ventilated patients. The BWAP is a 26-factor scoring Checklist used to diminish variability in managing patients on MV. The checklist has three components: general assessment, respiratory assessment, and arterial blood gases results. The answer of each question of these subscales is yes, no, or not assessed [15]. The BWAP score was computed by dividing the total number of yes responses by 26 (the total number of BWAP factors). A yes answer indicated that the factor fulfill the established threshold definition. A no response means that the factor did not fulfill the established threshold definition, and the response not assessed was used when data is not sufficient. The effect of not assessed responses on the total score was negative; a response of not assessed counts as a response of no in the total calculation [26]. The checklist cut off point is 50, a score more than 50 means that the patients are more likely to be weaned successfully. This means that a score more than 50 was a predictor for successful weaning. Furthermore, if the score is less than 50 this indicates that the patient is more likely to have unsuccessful weaning. The inter-rater reliability of the BWAP checklist is 95% [27]. The validity of the Burns Weaning Assessment Program (BWAP) 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=0.794 p-value<0.001). The reliability of the BWAP was tested in the present study using Cronbach's Co-efficiency Alpha (a=0.856).

Ethical Consideration

Permission for performing the study was obtained from the Ethical Committee at the Faculty of Nursing and hospital director to carry out the study after explaining the purpose of the study. Oral consent was obtained from the relatives of the patients who met the inclusion criteria. At the first interview, the researcher explained to the relatives the purpose, procedure, 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 closed place. Questionnaires were fulfilled by the investigator.

Data Collection Procedure (Intervention)

At the initial visit, the demographic data of the participants were extracted from the patients' medical records by using the Semi structured demographic questionnaire then the researcher divided the patients into two groups randomly, one group monitored by the Integrative Weaning Index (IWI) and the other monitored by Burns Weaning Assessment Program checklist (BWAP).

The researcher started with IWI group and assessed patients who met Criteria for readiness to wean. Before the beginning of the Spontaneous Breathing Trial (SBT) the researcher assessed the patient's oxygenation and hemodynamic parameters. Then the researcher monitors patient's respiratory neuromuscular function and calculate the integrative weaning index (IWI) score.

When the patient met the weaning criteria with an IWI index score ≥ 25, the patients started SBT on a T-piece for 30 minutes. After 30 minutes of SBT; the researcher assessed and recorded patient's ABG parameters and hemodynamic status and assessed patient for 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 hyper capnia (PaO_2<60 mmHg or SaO_2<90% on $FiO_2 \geq 0.5$; $PaCO_2$ >50 mmHg, pH <7.32), hemodynamic complications (cardiac arrhythmias, tachycardia (HR>140 beats/min or ΔHR≥20%), hypertension (SBP>180 mmHg or Δ SBP≥20%) or hypotension (SBP<90 mmHg) [28]. If the patient had SBT failure, patient was connected again to the mechanical ventilator.

The second group was assessed by using Burns Weaning Assessment Program, the researcher assessed patients readiness weaning Criteria and the ABG parameters and hemodynamic status. The researcher calculate the BWAP score by answering the checklist question regarding general assessment, respiratory assessment, arterial blood gases assessment as Yes or No or Not assessed response then the number of yes responses was divided by 26 (the total score of the checklist).

When the patient met the weaning criteria with BWAP score ≥ 50, the patients started spontaneous breathing trial (SBT) on a T-piece for 30 minutes. After 30 minutes of SBT; patient's ABG parameters and hemodynamic status assessed again and the patient assessed for any signs and symptoms of SBT failure. Also, the researcher monitored ICU length of stay and duration of mechanical ventilation for all subjects in both groups.

Comparison between the two groups were done and based on the outcome of the trial they were separated into two groups: the group of patients with successful SBT and the group with SBT failure. The SBT considered as a success or failure at 30 minutes, based on both subjective indices and objective measurements. The basis for predicting success of SBT was an IWI index score ≥ 25, BWAP score ≥ 50 and absence of any signs and symptoms of SBT failure while criteria of SBT failure included: an index score <25, BWAP score <50, signs and symptoms of SBT failure and the patient was returned back to the mechanical ventilator.

Statistical Analysis

The data were statistically analyzed using descriptive statistics (Frequency, Arithmetic Mean (X), Stander Deviation (SD), and Analytic Statistics (Pearson Chi-square test ($\chi 2$) and Fisher`s Exact Test, Student t- test, Paired t-test, Pearson correlation). For each test the P value of 0.05 level was used as the cut off value for statistical significance.

Results

Table 1: Demographic Characteristics of the studied sample (N=120)

Demographic Characteristics	Burns Weaning Assessment Program Group (BWAP) (n=60)		Integrative Weaning Index Group (IWI) (n=60)	
Age X ± SD	41.88 ±12.58		42.25 ±12.17	
	No	%	No	%
Gender				
Male	28	46.7%	31	51.7%
Female	32	53.3%	29	48.3%
Education				
Educated	29	48.3%	30	50.0%
Non Educated	31	51.7%	30	50.0%
Marital Status				
Single	16	26.7%	13	21.7%
Married	44	73.3%	47	78.3%

Table (1) illustrates that, the mean age of the studied sample in BWAP group and IWI group was (41.88 ±12.58; 42.25

±12.17) respectively. Regarding gender more than one half of the participants in the BWAP group was female (53.3%), while in the IWI group (51.7%) was male.

Fig 1: Successful Weaning Rate of the Studied Sample (N=120)

Figure 1 shows that most of the participants in the IWI group had successful weaning rate of 93.30% while in the BWAP group it was 75% which indicate that the IWI is a more objective index of weaning success rate.

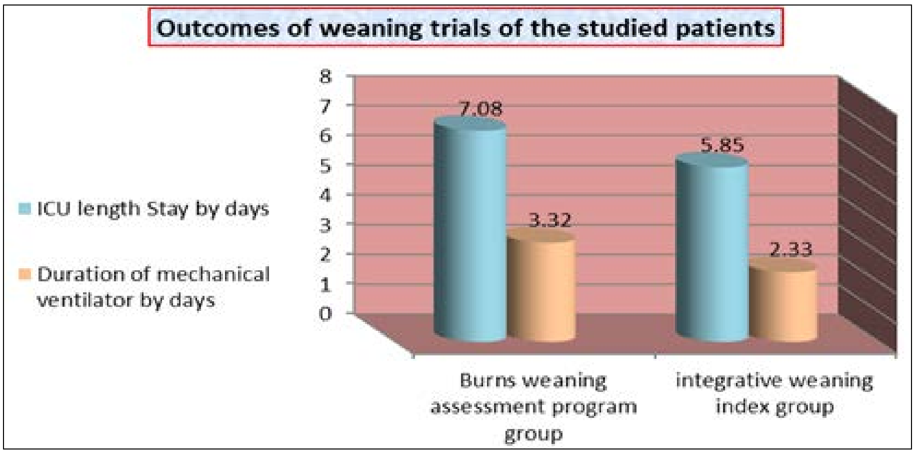

Fig 2: Outcomes of Weaning Trials among Studied Sample (N=120)

Figure (2) shows that the mean duration of mechanical ventilator by days in BWAP and IWI group was (3.32 ±2.63& 2.33 ±1.32) respectively, also the mean ICU length of Stay by days in both BWAP & IWI groups was (7.08 ±3.25&5.85 ±1.91) respectively, which indicate that the IWI is a better predictor of weaning outcomes than the BWAP.

Table 2: The Correlation between the IWI & the BWAP scores and the Weaning outcomes trials in the studied Sample (N=120)

Items	Weaning Success Rate			
	Burns Weaning Assessment Program Group (BWAP)		Integrative Weaning Index Group (IWI)	
	R	P –value	R	P –value
Duration of Mechanical Ventilator by days	.813-**-	.000	.747-**-	.000
ICU length of Stay	.783-**-	.000	.656-**-	.000

Table (2): shows that there was a negative correlation between weaning success rate and duration of mechanical ventilation, ICU length of Stay; also there was a highly statistically significant difference between weaning success rate, duration of mechanical ventilator by day and ICU length of Stay in both groups, *P* <0.000.

Discussion

Prolonged mechanical ventilation is associated with a series of adverse effects. Therefore weaning from mechanical ventilation safely and as early as possible is paramount [29].

The current study hypothesized that there is a difference between integrative weaning index (IWI) score and weaning success rate among mechanically ventilated patients. The present study findings revealed that participants in the IWI group had higher successful weaning rate which indicate that the IWI is a more objective index and can predict successful weaning of spontaneous breathing trials better than the BWAP.

These findings are concurrent with [12] who found that Integrative weaning index can be used as a predictor of spontaneous breathing trial. Also, similar findings were reported by [13] who examined the accuracy of IWI in predicting weaning among 50 mechanically ventilated patients for more than 72 hours and revealed that Integrative weaning index is a significant predictor of weaning and high IWI score was associated with successful weaning rate. Similar findings reported by [10] who examined the success rate of the Spontaneous breathing trial in mechanically ventilated patients and revealed that the IWI is a more objective indicator of SBT.

However, the findings of the current study are different from [30] findings that compared the efficiency of some predictors for successful weaning from mechanical ventilation in different weaning modes and revealed that there was no significant difference regarding IWI. A possible explanation of Mabrouk's findings may be the small sample size (25 for each group).

The present study hypothesized that there is a relationship between integrative weaning index (IWI) score and outcomes of weaning trials in mechanically ventilated patients. The findings of the current study showed that there was a statistically significant decrease in the duration of mechanical ventilation and ICU length of stay in the IWI group which indicate that the IWI is a more objective index which can predict weaning outcomes of spontaneous breathing trials.

Similar findings have been reported by [14] who compared the efficiency of some different predictors of successful weaning off mechanical ventilation in patients with type II respiratory failure and found that the IWI was associated with significant shorter duration of mechanical ventilation, ICU length of stay and hospital stay.

Also, similar findings reported by [31] who examined several weaning predictors as determinants of successful extubation after elective cardiac surgery and revealed that IWI showed better performance of weaning predictors in patients under mechanical ventilation with significant decrease period of mechanical ventilation, ICU length of stay and hospital stay.

Moreover, the results of the current study are similar to what was reported by [32] who studied the effectiveness of integrative weaning index (IWI) as a predictor of weaning success among 120 patients received mechanical ventilation for more than 24 hours and revealed that the use of the IWI shortens the total duration of mechanical ventilation and the ICU length of stay. The consistency across the previous studies can be justified by what [33] was suggested that the significant physiologic weaning parameters included in the IWI make it a better predictor than the other ones.

Limitations of the Study

The findings of the current study are limited in their generalizability because of the convenience sample and lack of randomization. The lack of random sampling may contribute to sample selection bias and limits the generalization of the findings.

Conclusion

Weaning success rate was significantly higher in the IWI group as compared with Burns Weaning Assessment Program group. Also, using the IWI shortens the duration of mechanical ventilation and the ICU length of stay.

Recommendations

Train the critical care nurse to use the integrative weaning index as weaning predictor beside the clinical data during weaning process of mechanically ventilated patient as a routine practice in the critically ill patients.

Implications for Nursing Practice

Establish regular in-service education courses for critical care nurse to educate them about the most proper timing of weaning to avoid premature weaning, which expose patients to severe respiratory, cardiovascular, and psychological stress and accelerating the process of liberation from mechanical ventilation.

Implications for Future Research

Replication of the study is recommended using large sample size; using a random selection technique and multiple sites.

References

1. Vu PH, Tran VD, Duong MC, Cong QT, Nguyen T. Predictive value of the negative inspiratory force index as a predictor of weaning success: a cross sectional study. Acute and critical care 2020;35(4):279-285.
2. Sepahyar M, Molavynejad S, Adineh M, Savaei M, Maraghi E. The effect of nursing interventions based on burns wean assessment program on successful weaning from mechanical ventilation: A randomized controlled clinical trial. Iran J Nurs Midwifery Res 2021;26:34-41.
3. Vetrugno L, Guadagnin GM, Brussa A *et al.* Mechanical ventilation weaning issues can be counted on the fingers of just one hand: part 1. Ultrasound J 2020;12:9.
4. Hirzallah FM, Alkaissi A, Do Céu Barbieri-Figueiredo M. A systematic review of nurse-led weaning protocol for mechanically ventilated adult patients. Nursing in critical care 2019;24(2):89-96.
5. Duyndam A, Houmes RJ, Van Rosmalen J, Tibboel D, Van Dijk M, Ista E. Implementation of a nurse-driven ventilation weaning protocol in critically ill children: can it improve patient outcome? Aust Crit Care 2019.
6. Magalhães P, Camillo CA, Langer D, Andrade LB, Duarte M, Gosselink R. Weaning failure and respiratory muscle function: What has been done and what can be improved. Respiratory medicine 2018;134:54-61.
7. Meade M, Guyatt G, Cook D *et al.* Predicting success in weaning from mechanical ventilation. Chest 2001;120:400S-24S.
8. Stawicki SP. Mechanical ventilation: Weaning and extubation. Int J Acad Med 2017;3(l):67-71.
9. De Souza L, Lugo J, Pneumol J. The rapid shallow breathing index as a predictor of successful mechanical ventilation weaning: clinical utility when calculated from ventilator data. J Bras Pneumol 2015;41(6):530-535.
10. Ebrahimabadi S, Moghadam A, Vakili M, Modanloo M, Khoddam H. Studying the power of the integrative weaning index in predicting the success rate of the spontaneous breathing trial in patients under mechanical ventilation. Indian J Crit Care Med 2017;21:488-93.
11. Nemer SN, Barbas CS, Caldeira JB, Cárias TC, Santos RG, Almeida LC, *et al.* A new integrative weaning index of discontinuation from mechanical ventilation. Crit Care 2009;13:R152.
12. Gupta D, Kumhar M, Singh V. Integrative Weaning Index (IWI) a better tool for weaning than Rapid Shallow Breathing Index (RSBI), IJMSIR J 2020;5(1):171:175.
13. Huo Y, Guo S, Zhang K, Zhang T, Li B, Zhang Q *et al.* A clinical study on the ability of the integrative

weaning index to predict weaning from mechanical ventilation. Ann Palliat Med 2020;9(5):3162-3169.
14. El-Daim A, El-Emery F, El-Dib A, El-Shamaa N. Study of different predictors of successful weaning off mechanical ventilation in ventilated patients with chronic obstructive pulmonary disease with acute respiratory failure. The Egyptian Journal of Chest Diseases and Tuberculosis 2020;69(3):485-492.
15. Burns SM, Ryan B, Burns JE. The weaning continuum: use of APACHE III, BWAP, TISS, and WI scores to establish stages of weaning. Crit Care Med 1990;28:2259-2267.
16. Eskandar N, Apostolakos MJ. Weaning from mechanical ventilation. Crit Care Clin 2007;23(2):263-74.
17. Horst HM, Mouro D, Hall-Jenssens RA *et al.* Decrease in ventilation time with a standardized weaning process. Arch Surg 1998;133:483-9.
18. Esteban A, Alia I, Tobin MJ *et al.* Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation. Spanish Lung Failure Collaborative Group. Am J Respir Crit Care Med 1999;159:512-8.
19. Wang CH, Lin HC, Chang YC, Maa SH, Wang JS, Tang WR. Predictive factors of in-hospital mortality in ventilated intensive care unit: A prospective cohort study. Medicine 2017;96(51):e9165.
20. Holzheimer R, Mannick J. Surgical Treatment: Evidence-Based and Problem-Oriented. (Hemodynamic monitoring). Kuhn, C. & Werdan, K. Munich 2001. Zuckschwerdt; Available from: https://www.ncbi.nlm.nih.gov/books/NBK6880.
21. Nicolas T, Cabrolier N, Bardonnet K, Davani S. Evaluation of a new blood gas analysis system: RapidPoint 500(®). Annales de Biologie Clinique Journal 2013;71(3):305-11.
22. MacIntyre N, Lawlor B, Carstens D, Yetsko D. Accuracy and precision of a point-of-care blood gas analyzer incorporating opt odes. Respiratory Care Journal 1996;41(9):800-804.
23. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. J Neurol Neurosurg Psychiatry 1974;2:81-4.
24. Vivek N, Jayawant N, Richard D, Alexander Y, Jennifer L, Eelco F. Validity of the four Score Coma Scale in the Medical Intensive Care Unit. Critical Care Neurology 2009;84(8):694-701.
25. Katz D, Alexander M. Traumatic brain injury. Predicting course of recovery and outcome for patients admitted to rehabilitation. Arch Neurol 1994, 51661-670.
26. Burns SM, Fisher C, Earven Tribble SS, Lewis R, Merrel P, Conaway MR *et al.* Multifactor clinical score and outcome of mechanical ventilation weaning trials: Burns Wean Assessment Program. American journal of critical care: an official publication, American Association of Critical-Care Nurses 2010;19(5):431-439.
27. Epstein CD, El-Mokadem N, Peerless JR. Weaning older patients from long-term mechanical ventilation: a pilot study. American journal of critical care: an official publication, American Association of Critical-Care Nurses 2002;11(4):369-377.
28. Georgakas I, Boutou A, Pitsiou G, Kioumis I, Bitzani M, Matei K *et al.* Central Venous Oxygen Saturation as a Predictor of a Successful Spontaneous Breathing Trial from Mechanical Ventilation: A Prospective, Nested Case-Control Study. The Open Respiratory Medicine Journal 2018;12(1):1-20.
29. El-Beheidy R, Abdulrahman D, Bayoumi S, Hassan W. Prediction of weaning failure of mechanical ventilation using clinical parameters in picu. Zagazig University Medical Journal 2018;24(5):386-393.
30. Mabrouk A, Mansour O, Amin A, Alhabashy M, Alasdoudy A. Evaluation of some predictors for successful weaning from mechanical ventilation. European Respiratory Journal 2015;46(59):PA2188.
31. Barbosa e Silva MG, Borges DL, Costa M, Baldez TE, Silva LN, Oliveira RL *et al.* Application of Mechanical Ventilation Weaning Predictors after Elective Cardiac Surgery. Brazilian journal of cardiovascular surgery 2015;30(6):605-609.
32. El-Baradey G, El-Shmaa N, Ganna S. Can integrative weaning index be a routine predictor for weaning success? Indian J Crit Care Med 2015;19:703-7.
33. Solsona JF, Díaz Y, Vázquez A, Pilar Gracia M, Zapatero A, Marrugat J. A pilot study of a new test to predict extubation failure. Crit Care 2009;13:R56.