IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 23, Issue 12 Ser. 6 (December. 2024), PP 18-23
www.iosrjournals.org

Role Of Integrative Weaning Index For Prediction Of Successful Weaning From Mechanical Ventilation

Dr. Md Harun Ur Rashid[1], Dr. Mohammad Abdul Hannan[2],
Dr. Md Amirul Islam[3], Dr. Md Kamrul Hasan[4], Dr. Md Abdul Alim[5]

Medical Officer, Department Of Anaesthesia, Analgesia And Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh

Assistant Professor, Department Of Anaesthesia, Analgesia And Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh

Assistant Professor, Department Of Anaesthesia, Analgesia And Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh

Assistant Professor, Department Of Anaesthesia, Analgesia And Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh

Assistant Professor, Department Of Anaesthesia, Analgesia And Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh

Abstract

Objective*: Weaning from mechanical ventilation (MV) requires a multidisciplinary care team. The Integrative Weaning Index (IWI) is a more objective measure compared to conventional methods, considering multiple system functions simultaneously. This study investigates the role of IWI in predicting successful weaning from MV.*

Material and Methods*: This prospective observational study was conducted over twelve months at the Department of Anesthesia, Analgesia and Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, from March 2021 to February 2022. A total of 56 patients on mechanical ventilation eligible for weaning were included after obtaining informed written consent. IWI was calculated using SaO2, Cst, and f/Vt. Success was defined as an index level ≥25, and failure as <25. Data were analyzed using SPSS version 24.*

Results*: The mean age of the subjects was 45.5 ± 8.93 years, with a male predominance of 60.7%. A successful spontaneous breathing trial (SBT) outcome was observed in 71.4% of patients. The receiver operating characteristics (ROC) curve determined a cut-off value of 25 for the IWI score, with sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of 90%, 75%, 90%, 75%, and 85.7%, respectively. IWI demonstrated the highest area under the curve (AUC) of 0.875 compared to SaO2 (0.801), GCS (0.744), and RSBI (0.807).*

Conclusion*: The Integrative Weaning Index is useful for predicting successful weaning from mechanical ventilation. However, larger multicenter studies are recommended.*

Keywords: *Weaning Index, Mechanical Ventilation, Predictive Value, Intensive Care, Respiratory Mechanics*

Date of Submission: 10-12-2024 Date of Acceptance: 20-12-2024

I. Introduction

Mechanical Ventilation (MV), or assisted ventilation, involves using mechanical means to support or replace spontaneous breathing. Weaning is the process of progressively reducing this support, ultimately leading to the removal of the endotracheal tube. This process can account for about 42% of the mechanical ventilation period (1). Various parameters have been employed to predict outcomes for weaning from MV and extubation (2), (3). Among these, the Rapid Shallow Breathing Index (RSBI), introduced by Yang and colleagues in 1991, stands out with a positive predictive value (PPV) of 0.85 (4). In 2009, Nemer and coworkers introduced the Integrative Weaning Index (IWI), which evaluates respiratory mechanics, oxygenation, and respiratory patterns in an integrated manner. The IWI showed a PPV of 0.99 and a negative predictive value (NPV) of 0.86, demonstrating higher accuracy for predicting weaning success compared to other indices (5). This index is calculated as the product of compliance of the respiratory system (Cst) and oxygen saturation (SaO2), divided by the f/Vt ratio (6). A threshold of >25 mL/cmH2O is used to discriminate between successful and failed weaning

(7). The IWI has proven useful in detecting patients who, despite passing the spontaneous breathing trial (SBT), required reintubation (8). The primary goal of weaning indexes is to accurately identify patients who can be successfully weaned from MV. Clinical judgment alone is insufficient for this task. Integrating key single functions into an index like the IWI enhances its predictive value compared to using individual components alone (9). Patients with a poor prognosis for weaning, indicated by a high f/Vt ratio, might still present a good prognosis if they have higher Cst and SaO2 values (10),(11). The IWI provides comprehensive information about the mechanical condition of the lungs and chest wall, the patient's ability to maintain desirable oxygenation, and the capacity to sustain unassisted breathing. The index's major benefits include reducing the total duration of mechanical ventilation, shortening ICU stays, and significantly increasing weaning success rates (5). Weaning success in ICU patients under mechanical ventilation is crucial. The IWI has shown higher sensitivity, specificity, positive and negative predictive values, and overall accuracy (12). However, there is limited literature on the accuracy of IWI in predicting weaning outcomes in Bangladesh. Thus, this study aims to investigate the role of the Integrative Weaning Index in predicting successful weaning from mechanical ventilation.

II. Methods

This observational study was conducted at the Department of Anesthesia, Analgesia, and Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, from March 2021 to February 2022. Ethical clearance was obtained from the Institutional Review Board (IRB) of BSMMU before data collection commenced. The study included 56 patients on mechanical ventilation eligible for weaning, based on the following criteria: improvement of the underlying disease, absence of fever, PaO2 >60 mmHg with an inspired O2 concentration of <0.4, positive end-expiratory pressure (PEEP) <8 cmH2O, hemodynamic stability without high-dose vasopressive drugs, readiness for spontaneous ventilation, favorable level of consciousness (awake or easily awakenable), and pH >7.3. The decision for weaning readiness and discontinuation of mechanical ventilation was made by the anesthesiologists/intensivists in charge, who were blinded to the study goals. Data were gathered using a semi-structured data collection sheet, which included demographic data (age, sex, hospitalization history, disease diagnosis, comorbidities, level of consciousness, length of intubation, and ICU stay) and physiological parameters (HR/min, RR/min, BP, PaO2, PaCO2, FiO2, PEEP, tidal volume, static compliance, temperature, level of consciousness, and pH). Before weaning, all patients were placed on spontaneous mode with a pressure support (PS) of 8–10 cmH2O, a PEEP of 5 cmH2O, and a FiO2 <0.4. Subsequently, PS was reduced to 7 cmH2O, and RR/tidal volume, PaO2, Cst, and hemodynamic status were recorded. Patients underwent a spontaneous breathing trial (SBT) using a T-tube. SBT was considered successful if patients tolerated the trial, while unsuccessful results were based on criteria such as SaO2 <90%, PaO2 <60 mmHg, PaCO2 >50 mmHg, pH <7.33 or >0.07 reduction in pH, RR >38/min or >50% increase during 5 min, HR >140/min, systolic BP >180 or <90 mmHg, agitation, perspiration, or reduced level of consciousness. The Integrative Weaning Index (IWI) was calculated using the formula: IWI = (SaO2 * Cst) / (f/Vt). An IWI value ≥25 was predictive of successful weaning, while an IWI <25 indicated potential failure. Data were analyzed using SPSS version 24, calculating the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of IWI in predicting successful weaning. The study was conducted following the Declaration of Helsinki. Informed consent was obtained from all participants. Clinical trial number: not applicable.

III. Results

Table 1: Distribution of demographic characteristics among the participants (n=56)

Variables	n (%)
Age	
20-30	8 (14.3)
31-40	6 (10.7)
41-50	16 (28.6)
>50	26 (46.4)
Mean ±SD	45.5 ±8.93
Gender	
Male	34 (60.7)
Female	22 (39.3)

The majority of the patients were from the 6th decade (46.4%) followed by 28.6% in the age group 41-50 years and the mean age of the patient was 45.5±8.93 years. The majority of the patients under study were male (60.7%) and 39.3% of the patients were female.

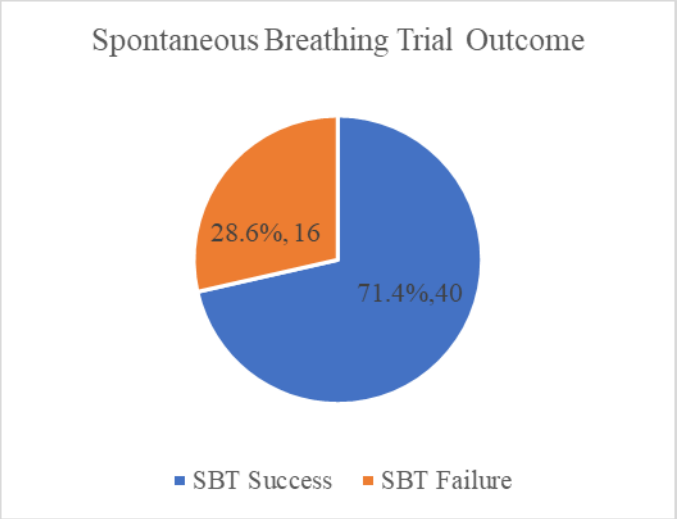

Figure 1: Distribution of participants by Spontaneous Breathing Trial (SBT) outcome (n=56)

Among the participants, 71.4% had a successful SBT, while the remaining 16 participants (28.6%) had unsuccessful SBT.

Table 2: Distribution of clinical parameters according to the SBT outcome (n=56)

Clinical parameters	SBT success n=20 Mean ±SD	SBT failure n=8 Mean ±SD	p-value*
Heart rate/min	85.8±1.82	86.62±3.92	0.204
Systolic BP/mmHg	128±6.36	130±7.69	0.372
Diastolic BP/mmHg	77.2±2.04	77.5±2.1	0.842
Duration of MV/in days	8.5±6.8	8.1±4.0	0.038
Duration of ICU stay/in days	5.7±1.1	6.2±1.9	0.048

Abbreviations: BP-blood pressure, MV-mechanical ventilation, ICU-intensive care unit, SBT-spontaneous breathing trial

***p-value obtained by student t-test.**

A statistically meaningful difference between the SBT success and failure group was seen in the duration of MV (p=0.038) and ICU stay (p=0.048).

Table 3: Distribution of ventilation parameters according to the SBT outcome (n=56)

Ventilation parameters	SBT success n=20 Mean ±SD	SBT failure n=8 Mean ±SD	p-value*
RR/min	20.4±0.99	32.2±4.26	<0.001
PaCO2(mmHg)	42.9±9.51	45.6±7.0	0.804
pH	7.3±0.19	7.01±0.07	0.101
LOC(GCS)	13.2±0.89	12.3±0.74	0.147
PEEP	5.7±0.09	5.6±0.11	0.263
IWI score	42.7±8.60	24.72±6.09	0.001
SaO2(%)	95.7±1.99	90±2.87	0.409
Static compliance(mmH2O)	28.3±4.33	21.7±7.1	0.04
RSBI	63.7±5.2	76±2.7	< 0.001

Abbreviations: RR-respiratory rate, $PaCO_2$-partial pressure of carbon dioxide, SaO_2-saturation of oxygen, LOC-loss of consciousness, GCS-Glasgow coma scale, RSBI-rapid shallow breathing index

***p-value obtained by student t-test**

Regarding the ventilation parameters, the respiratory rate was significantly lower in the SBT success group compared to the SBT failure group (p<0.001). The IWI score was statistically higher in the SBT success

group (42.7±8.60) compared to the failure group (27.2±11.6). The static compliance was significantly higher and RBSI was significantly lower in patients with SBT success outcomes compared to failure of SBT. The percentage saturation of oxygen was 95.7±1.9 and 90±2.87 in the SBT success and failure group respectively.

Table 4: Diagnostic test for IWI score to predict SBT success and failure (n=56)

IWI score	SBT outcome		Total
	Success	**Failure**	
≥25	True positive (TP) **36**	False positive (FP) **4**	TP+FP **40**
<25	False negative (FN) **4**	True negative (TN) **12**	FN+TN **16**
Total	TP+FN **40**	FP+TN **16**	**56**

The results show that among patients with an IWI score of ≥25, 18 were true positives (successful SBT) and 2 were false positives (unsuccessful SBT). For patients with an IWI score of <25, there were 2 false negatives (unsuccessful SBT) and 6 true negatives (successful SBT).

Table 5: Metric Measurements for Diagnostic Test of IWI Score (n=56)

Metric	Value
Sensitivity	90%
Specificity	75%
Accuracy	85.70%
Positive Predictive Value (PPV)	90%
Negative Predictive Value (NPV)	75%

Sensitivity, which measures the proportion of true positives correctly identified, was 90%. Specificity, indicating the proportion of true negatives correctly identified, was 75%. Accuracy, reflecting the overall correctness of the test, was 85.7%. Positive Predictive Value (PPV), showing the probability that patients with a positive test truly have the condition, was 90%. Negative Predictive Value (NPV), indicating the probability that patients with a negative test truly do not have the condition, was 75%.

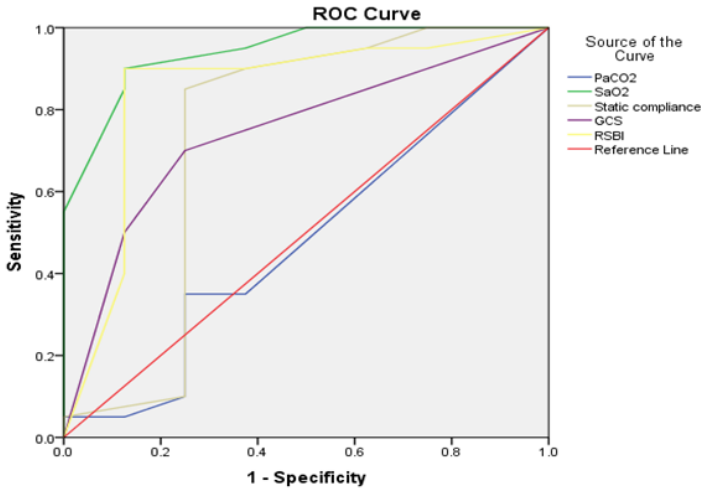

Figure 2: ROC Curve Analysis of Various Weaning Predictors

Figure 2 demonstrates the ROC curves for the various parameters measured in the study, including PaCO2, SaO2, Static Compliance, GCS, and RSBI. The area under the curve (AUC) for each parameter was calculated to assess their predictive power concerning the study outcomes. The Integrative Weaning Index (IWI) demonstrated the highest area under the curve (AUC), indicating superior predictive accuracy for successful weaning compared to other parameters. This suggests that IWI is the most reliable indicator among the tested metrics for predicting the success of spontaneous breathing trials in mechanically ventilated patients.

IV. Discussion

Weaning from the mechanical ventilator is crucial in determining ICU patient outcomes. Weaning indexes aim to identify patients who can be successfully weaned, as clinical judgment alone often falls short in accurately predicting weaning outcomes (13). This study assessed the use of the Integrative Weaning Index (IWI) to predict the outcome of spontaneous breathing trials (SBT) in mechanically ventilated patients. The study included 34 males (60.7%) and 22 females (39.3%), with a mean age of 45.5 ± 8.93 years. These findings align with a 2015 comparative study involving 100 mechanically ventilated patients at the Department of Chest Disease and Tuberculosis, Faculty of Medicine, Menoufia University (4). A significant relationship was observed between the duration of mechanical ventilation, length of ICU stay, and respiratory parameters (RR, Cst, rs) in our study. Similar results were reported in another prospective study with 105 mechanically ventilated patients hospitalized at Imam Reza Hospital, Mashhad, Iran (14). In the present study, 71.4% of the 28 patients had a successful SBT, while 28.6% failed. This success rate is slightly lower than a prospective randomized-controlled study with 105 patients, which reported an 85.7% SBT success rate and a 14.3% failure rate (4). Eskandar et al. indicated that despite medical treatments and care, the first attempt to wean often fails in nearly 22% of cases, possibly due to inadequate management and premature trials (15). Our findings showed that an IWI score of ≥25 predicted successful SBT outcomes with 90% sensitivity, 75% specificity, 90% positive predictive value (PPV), 75% negative predictive value (NPV), and 85.7% accuracy. These results are consistent with Nemer et al.'s 2009 study, which reported a PPV of 0.99 and an NPV of 0.86 for the IWI (5). Several studies have also validated the IWI as a reliable tool for predicting weaning outcomes, reporting 90%-97% sensitivity, 66.7%-94% specificity, a PPV of 90%-99%, an NPV of 50%-93%, and 87%-92% accuracy (5), (6),(15). The ROC curve analysis for predicting SBT outcomes indicated that the IWI had a good area under the curve (AUC) of 0.825, outperforming other indexes like PaCO2, RSBI, GCS, and static compliance. Similar findings were observed in a prospective study involving 216 mechanically ventilated patients, where IWI presented the highest accuracy, with a significantly larger AUC compared to static compliance (5). Additionally, our study demonstrated that the IWI, as an objective index, offers higher accuracy than other parameters used by physicians in predicting SBT outcomes. This aligns with another study comparing objective protocols with physician-oriented approaches (6). In conclusion, weaning indices that evaluate only one function typically have lower accuracy. The IWI, which integrates multiple functions such as respiratory rate, tidal volume, static compliance, and oxygenation, provides higher accuracy and serves as a more objective index for predicting weaning success or failure.

Limitations of The Study

The study was carried out in a single hospital with a small sample size. So, the results may not represent the whole community.

V. Conclusion

The Integrative Weaning Index (IWI) demonstrates high accuracy in predicting successful weaning from mechanical ventilation, surpassing traditional indices such as RSBI, PaCO2, and GCS. Our study found that an IWI score of ≥25 provides robust sensitivity, specificity, PPV, and NPV, making it a reliable tool for clinicians. By integrating multiple respiratory parameters, IWI offers a comprehensive assessment that can improve clinical decision-making and patient outcomes.

VI. Recommendation

Based on the findings of this study, it can be recommended that the Integrative Weaning Index (IWI) be utilized as a reliable tool for predicting successful weaning outcomes in mechanically ventilated patients. With its high sensitivity (90%), specificity (75%), and accuracy (85.7%), the IWI score provides valuable guidance in assessing weaning readiness, reducing unnecessary prolongation of mechanical ventilation, and minimizing associated complications. Further multicenter studies with larger sample sizes are suggested to validate these findings and refine weaning protocols.

Funding: No funding sources

Conflict of interest: None declared

Clinical trial number: not applicable.

References

[1] Baptistella Ar, Mantelli Lm, Matte L, Carvalho Me Da Ru, Fortunatti Ja, Costa Iz, Et Al. Prediction Of Extubation Outcome In Mechanically Ventilated Patients: Development And Validation Of The Extubation Predictive Score (Expres). Plos One. 2021;16(3):E0248868.

[2] Leonov Y, Kisil I, Perlov A, Stoichev V, Ginzburg Y, Nazarenko A, Et Al. Predictors Of Successful Weaning In Patients Requiring Extremely Prolonged Mechanical Ventilation. Adv Respir Med. 2020;88(6):477–84.

[3] Frutos-Vivar F, Ferguson Nd, Esteban A, Epstein Sk, Arabi Y, Apezteguía C, Et Al. Risk Factors For Extubation Failure In Patients Following A Successful Spontaneous Breathing Trial. Chest. 2006;130(6):1664–71.

[4] Mabrouk Aa, Mansour Of, Abd El-Aziz Aa, Elhabashy Mm, Alasdoudy Aa. Evaluation Of Some Predictors For Successful Weaning From Mechanical Ventilation. Egypt J Chest Dis Tuberc. 2015;64(3):703–7.

[5] 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 Sep 22;13(5):R152.

[6] Boniatti Vm, Boniatti Mm, Andrade Cf, Zigiotto Cc, Kaminski P, Gomes Sp, Et Al. The Modified Integrative Weaning Index As A Predictor Of Extubation Failure. Respir Care. 2014;59(7):1042–7.

[7] Bilan N, Dastranji A, Behbahani Ag. Comparison Of The Spo2/Fio2 Ratio And The Pao2/Fio2 Ratio In Patients With Acute Lung Injury Or Acute Respiratory Distress Syndrome. J Cardiovasc Thorac Res. 2015;7(1):28.

[8] Sayed Ss, Mohammed Hussein Aa, Elddin Khaleel Wg. Predictors Of Spontaneous Breathing Outcome In Mechanically Ventilated Chronic Obstructive Pulmonary Disease Patients. Egypt J Bronchol. 2019 Sep;13(3):335–42.

[9] El-Daim Aa, El-Emery F, El-Dib A, El-Shamaa N. A Study Of Different Predictors Of Successful Weaning Off Mechanical Ventilation In Ventilated Patients With Chronic Obstructive Pulmonary Disease With Acute Respiratory Failure. Egypt J Chest Dis Tuberc. 2020;69(3):485–92.

[10] Madani Sj, Saghafinia M, Nezhad Hs, Ebadi A, Ghochani A, Tavasoli Af, Et Al. Validity Of Integrative Weaning Index Of Discontinuation From Mechanical Ventilation In Iranian Icus. Thrita. 2013;2(4):62–8.

[11] Tu Cs, Chang Ch, Chang Sc, Lee Cs, Chang Ct. A Decision For Predicting Successful Extubation Of Patients In Intensive Care Unit. Biomed Res Int. 2018;2018:1–11.

[12] El-Baradey Gf, El-Shmaa Ns, Ganna Sa. Can Integrative Weaning Index Be A Routine Predictor For Weaning Success? Indian J Crit Care Med Peer-Rev Off Publ Indian Soc Crit Care Med. 2015;19(12):703.

[13] Macintyre N. Discontinuing Mechanical Ventilatory Support. Chest. 2007;132(3):1049–56.

[14] Amini S, Morovatdar N, Karrari Sp, Asadpour A, Abbasi Tashnizi M, Moeinipoor Aa, Et Al. The Risk Factors Of Prolonged Mechanical Ventilation After Isolated Coronary Artery Bypass Graft Surgery. Evid Based Care. 2023;13(1):7–14.

[15] Eskandar N, Apostolakos Mj. Weaning From Mechanical Ventilation. Crit Care Clin. 2007;23(2):263–74.