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Predictive Accuracy of Maximal Inspiratory Pressure, Airway Occlusion Pressure and its Ratio for Successful Liberation from Mechanical Ventilation

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Abstract

Background: Liberation from mechanical ventilation in critically ill patients is an integration of art and science. Most critical-care clinicians have tried to find weaning parameters which correctly predict the outcome of weaning from mechanical ventilation in those patients.

Aim of the work: To study the accuracy of the respiratory muscle power indices including (Pi_{max}, $P_{0.1}$ and lastly $P_{0.1}/Pi_{max}$ ratio) as predictors for successful weaning outcome.

Patients and methods: This prospective observational study included fifty patients who required invasive mechanical ventilation for at least 24 hours in the Surgical Intensive Care Unit (SICU) and met the criteria of the weaning protocol. The patients were classified according to the fate of spontaneous breathing trial (SBT) into a successful weaned group (30 patients) and a failed weaned group (20 patients).

Results: There was no significant difference regarding the demographic and clinical data between the two groups. Pi_{max}, $P_{0.1}$, and $P_{0.1}/Pi_{max}$ ratio were considerably different between the two groups of weaning (p-value<0.05). Pi_{max} with a cutoff value ≤ -22 showed the greatest sensitivity, PPV, NPV, and accuracy (91.67, 87.3, 87.2 and 87.25 respectively) compared with the other weaning indices ($P_{0.1}$, and $P_{0.1}/Pi_{max}$ ratio) as well as the AUC was highly precise (0.93).

Conclusion: Pi_{max} with a cutoff value less than -22 cm H_2O is a powerful predictor for successful weaning achievement in mechanically ventilated patients.

Keywords: Weaning; Mechanical Ventilation; Weaning predictor; $P_{0.1}$; Pi_{max}

Introduction

Mechanical ventilation is a life-saving treatment in critically ill patient; however it is also accompanied by many complications [1]. So, it is advisable to liberate patients from mechanical ventilation as soon as the underlying cause that led to the mechanical ventilation has improved, and the patient is able to preserve spontaneous breathing with good gas exchange [2].

Patients who wean successfully have less morbidity, mortality, and supply utilization than patients who require prolonged mechanical ventilation [3]. Therefore, once mechanical ventilation commenced; planning for weaning should starts [4].

Multiple predictors of successful weaning have been studied; mostly displaying good sensitivity but low specificity [5]. Weakness of diaphragmatic muscle considers a major cause of weaning failure from mechanical ventilation [6]. The maximal inspiratory pressure (Pi_{max}) represents the extreme pressure generated against an occluded airway during inspiration and is used frequently to evaluate the diaphragmatic muscle capacity in intensive care unit [7].

Airway occlusion pressure ($P_{0.1}$) represent the pressure generated at the airway opening at the first one hundred ml seconds after inhalation against an occluded airway and it is an adequate measure of the central respiratory drive [8].

The aim of this study was to measure the predictive power of the respiratory muscle determinants including Pi_{max}, $P_{0.1}$ and $P_{0.1}/Pi_{max}$ in weaning outcome of critically ill patients undergoing invasive mechanical ventilation.

Patients and Methods

This prospective observational study was conducted in the Surgical Intensive Care Unit (SICU) in Aswan University Hospital during the period from March 2017 to December 2017. The hospital ethics committee approved the study and a written informed consent was given by surrogate decision maker.

All adult patients who required invasive mechanical ventilation for at least 24 hours were included in the study and considered eligible for weaning when they attained the following criteria: resolution of the

acute episode for which the patient was placed on ventilator, low-level pressure support (8 cm H_2O) and PEEP level (≤ 5 cm H_2O), adequate oxygenation (partial pressure of arterial oxygen (PaO_2)/fraction of inspired oxygen (FiO_2) ≥ 150), FiO_2<0.5, alert and stable cardiovascular status (heart rate ≤ 120/min, systolic blood pressure higher than 90 mmHg and lower than 160 mmHg) in the absence of any vasoactive support therapy [9].

The patients underwent a SBT for two hours by putting them on spontaneous mode of weaning with low-level pressure support (8 cm H_2O) and PEEP level (≤ 5 cm H_2O) using GE ventilator (Carescape R860, USA).

Patients who had severe ICU acquired neuromyopathy, primary unilateral/bilateral absence of diaphragmatic mobility, previously failed SBT, or with tracheostomy, were excluded from the study.

All the eligible patients for the study were evaluated by Demographic data (Age, Sex, weight, and height), diagnosis on ICU admission, vital signs (Heart rate, Blood pressure, and Respiratory rate), oxygen status by pulse oximetry (SPO_2) and arterial blood gas. Ventilatory data including spontaneous exhaled tidal volume, respiratory rate, minute ventilation, and weaning predictors including, Pimax, $P_{0.1}$ (measured five times over a period of 60-90 s and the average of these measurements was taken) and lastly $P_{0.1}/Pi_{max}$, were measured using GE ventilator (Carescape R860, USA).

Patients who passed SBT without deterioration were extubated and received oxygen through Venturi mask 40%. However, SBT failure was considered if the patient developed a decreased level of consciousness, diaphoresis, RR>35 breaths/min, hemodynamic instability (heart rate>140, systolic blood pressure>180 or <90 mmHg) or signs of increased work of breathing [10].

Statistical analysis

SPSS (Statistical Package for Social Science) software program version 19.0 (SPSS Inc., Chicago, IL) was used for data recording and handling. Data presented as (mean ± SD) for continuous variables. Student's t tests were used for the comparison of continuous variables and chi-square tests were used to compare numerical variables.

Non-parametric tests were used for abnormal distributed data in the current study. To assess the accuracy of each weaning index, Receiver operator characteristic curves (ROC) were used and the non-parametric method of Delong was used to calculate the area under the ROC curves (AUC) for each weaning index [11]. p-value<0.05 considered significant.

Results

During the study period, we evaluated 55 patients ready for weaning. Five cases were excluded, three of which had hypotension (systolic blood pressure less than 90 mmHg) and two cases had disturbed conscious level. Among the fifty patients underwent SBT, 30 patients successfully passed SBT and weaned from mechanical ventilation (group A) while 20 patients failed SBT and not weaned from mechanical ventilation (group B).

The demographic and clinical data did not differ considerably between the two study groups (Table 1). Mean values for different weaning indices used to guide the success of weaning are shown in (Table 2) and there was a substantial difference between the two study groups as regard Pi_{max}, $P_{0.1}$, and $P_{0.1}/Pi_{max}$.

	Weaning outcome		p-value
	Weaned Group	**Not weaned Group**	
	(n=30)	(n=20)	
	Mean ± SD	Mean ± SD	
Age (years)	39.70 ± 12.36	32.19 ± 11.64	0.437
Sex: No. (%)			
Male	21 (70.0%)	14 (69.0%)	0.918
Female	9 (30.0%)	6 (31.0%)	
BMI (kg/m^2)	28.64 ± 6.83	27.62 ± 6.32	0.644
Diagnosis on admission to ICU:			
Polytrauma (%)	11 (36.7%)	7 (35%)	
Sepsis (%)	10 (33.3%)	7 (35%)	
Postoperative complications (%)	3 (10%)	2 (10%)	0.172
Acute pancreatitis (%)	2 (6.7)	1 (5%)	
Postpartum hemorrhage (%)	4 (13.3)	3 (15%)	

BMI: Body Mass Index; ICU: Intensive Care Unit; Data are presented as mean ± SD; or number and percentage (%); p-value is considered significant at <0.05

Table 1: Demographic and clinical data of the studied groups (n=50).

	Weaned Group	**Not weaned Group**	**p-value**
	(n=30)	**(n=20)**	
	Mean ± SD	**Mean ± SD**	
Pi_{max} (cm H_2O)	-22.82 ± 3.23	-15.83 ± 3.26	<0.001*
$P_{0.1}$ (cm H_2O)	2.40 ± 0.55	1.95 ± 0.63	<0.001*
$P_{0.1}/Pi_{max}$ ratio	0.10 ± 0.03	0.12 ± 0.04	<0.019*

Pi_{max}: Maximal Inspiratory Pressure; $P_{0.1}$: Airway Occlusion Pressure; Data are presented as mean ± standard deviation; p-value is considered significant at <0.05 *statistically significant.

Table 2: Weaning indices among the studied groups.

Analysis of the predictive values of the studied indices regarding weaning success showed that, Pi_{max} with a cutoff value of ≤ -22 cm H_2O had the greatest sensitivity, positive predictive value, and negative predictive value (91.67, 87.3, and 87.2 respectively) compared with $P_{0.1}$ and $P_{0.1}/Pi_{max}$ (Table 3). Also, Pi_{max} had an excellent area under the curve (AUC=0.93) with the highest diagnostic accuracy (0.87) among all the studied indices (Figures 1-3).

	Sensitivity	Specificity	PPV	NPP	Accuracy	AUC
Pi_{max} ≤ -22 cm H_2O	91.67	80.95	87.3	87.2	87.25	0.93
$P_{0.1}$>2 cm H_2O	56.67	80.95	81	56.7	66.67	0.72
P0.1/Pi_{max} ≤ 0.13	88.33	38.1	67.1	69.6	67.65	0.63
Pi_{max}: Maximal Inspiratory Pressure; $P_{0.1}$: Airway Occlusion Pressure; PPV: Positive Predictive Value; NPV: Negative Predictive Value; AUC: Area under the Receiving Operating Characteristic Curve						

Table 3: The diagnostic performance tests of each index used to predict weaning success in our study.

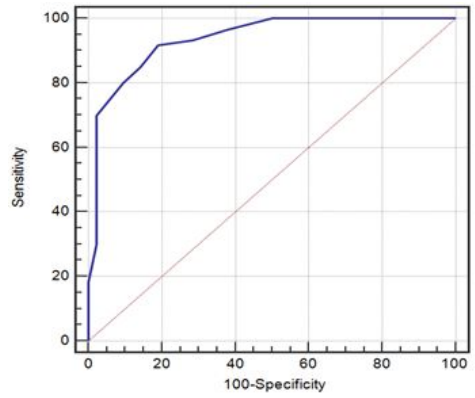

Figure 1: Area under receiving operating characteristic curve for Pimax ≤ -22 to predict successful weaning AUC=(0.93).

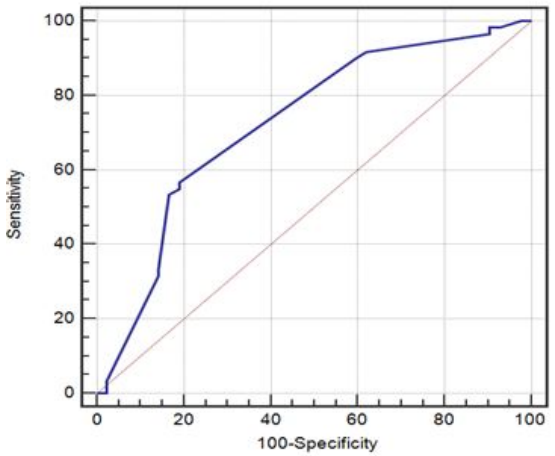

Figure 2: Area under receiving operating characteristic curve for central respiratory derive ($P_{0.1}$)>2 to predict successful weaning, AUC=(0.72).

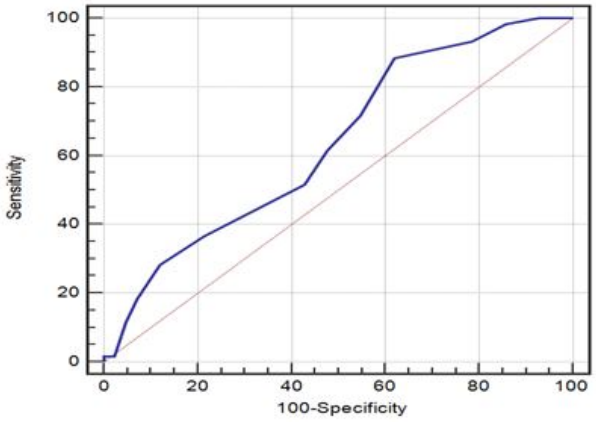

Figure 3: Area under receiving operating characteristic curve for $P_{0.1}/Pi_{max}$ ≤ 0.13 to predict successful weaning, AUC=0.63).

Discussion

The current study focused on evaluating the diagnostic accuracy of some weaning indices for respiratory muscle determinants including (Pi_{max}, $P_{0.1}$ and $P_{0.1}/Pi_{max}$) in predicting the outcome of weaning in critically ill patients undergoing mechanical ventilation [12,13]. The present study concluded that; Pi_{max}, $P_{0.1}$ and $P_{0.1}/Pi_{max}$ reading values were significantly different among the weaned and not weaned groups. the diagnostic performance tests, Pi_{max} demonstrated the highest accuracy in expecting spontaneous breathing trial (SBT) success than other indices. In the current study, both groups were similar as regards demographic and clinical data including; age, sex, body mass indices and diagnosis on admission to the intensive care unit where P>0.05.

During correlating weaning outcome with Pi_{max} values in our study, there was a higher negative value of Pi_{max} in the successfully weaned group compared with the failed one. Similar results were reported by dos Santos Bien et al. [14]; however those results were in contrast with previous studies [5].

Regarding $P_{0.1}$ values, they were significantly different between patients who had succeeded and those who had failed weaning (-2.40 ± 0.55) cm H_2O vs. (-1.95 ± 0.63) cm H_2O. This variation could be as this test mainly affected by impaired neurological drive which is widely variable between patients.

In the present work, when comparing the performance of the 3 studied parameters assessing the power of the respiratory muscle in the

prediction of successful weaning, a higher sensitivity was found for Pi_{max} (0.91) versus (0.56) and (0.88) for $P_{0.1}$ and P0.1/ Pimax correspondingly, the best diagnostic accuracy was summarized for Pi_{max} (0.87) versus (0.66), and (0.67) for ($P_{0.1}$ and $P_{0.1}$/ Pi_{max} respectively). Finally, the highest value of the AUC was found for Pimaxthis result was comparable with de Souza et al. [15], who summarized that, a higher sensitivity was found for $P_{0.1}$ (0.73), however, the greatest accuracy was found for Pi_{max} (0.72 vs. 0.66, and 0.69 for $P_{0.1}$ and $P_{0.1}/Pi_{max}$respectively).

The best cut off value of P0.1 that could predict weaning success varied among studies from 0.5 to 1.5 cm H_2O to lesser than 4.2 cm H_2O [16], Conversely, de Souza et al. suggested that a value of $P_{0.1}$ higher than 2.33 cm H_2O was associated with weaning failure [17], which is comparable with our result, in which the best cut off point of $P_{0.1}$ that predict weaning success was >2 cm H_2O.

Nemer et al. [18] found that, $P_{0.1}/Pi_{max}$ ratio<0.14 was highly associated with weaning success, this result was comparable with our study, in which $P_{0.1}/Pi_{max}$ ratio with a cutoff value less than 0.13 was associated with successful weaning, but area under ROC curve was inaccurate (0.63).

Limitations

Our study is a single center study with small sample size, so we need many future studies with a large numbers of subjects to emphasizing our results. Moreover, this study involved patients in the surgical intensive care unit that limited generalization of our results.

Conclusion

Pi_{max} provides appreciated data with greater accuracy to assess inspiratory muscle strength and predicting weaning success in mechanically ventilated patients than did $P_{0.1}$, and $P_{0.1}/Pi_{max}$ ratio.

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References

1. Ouellette DR, Patel S, Girard TD, Morris PE, Schmidt GA, et al. (2017) Liberation from mechanical ventilation in critically ill adults: An official American College of Chest Physicians/American Thoracic Society clinical practice guideline: inspiratory pressure augmentation during spontaneous breathing trials, protocols minimizing sedation, and noninvasive ventilation immediately after extubation. Chest 151: 166-180.
2. Gupta P, Giehler K, Walters RW, Meyerink K, Modrykamien AM (2014) The effect of a mechanical ventilation discontinuation protocol in patients with simple and difficult weaning: impact on clinical outcomes. Respir Care 59: 170-177.
3. Esteban A, Anzueto A, Frutos F, Alía I, Brochard L, et al. (2002) Characteristics and outcomes in adult patients receiving mechanical ventilation: A 28-day international study. JAMA 287: 345-355.
4. MacIntyre NR, Cook DJ, Ely EW, Epstein SK, Fink JB, et al. (2001) Evidence-based guidelines for weaning and discontinuing ventilatory support: A collective task force facilitated by the American College of Chest Physicians; the American Association of Respiratory Care; and the American College of Critical Care Medicine. Chest 120: 375S-395S.
5. Meade M, Guyatt G, Cook D, Griffith L, Sinuff T, et al. (2001) Predicting success in weaning from mechanical ventilation. Chest 120: 400S-424S.
6. Umbrello M, Formenti P, Longhi D, Galimberti A, Piva I, et al. (2015) Diaphragm ultrasound as indicator of respiratory effort in critically ill patients undergoing assisted mechanical ventilation: A pilot clinical study. Crit Care 19: 161.
7. Tzanis G, Vasileiadis I, Zervakis D, Karatzanos E, Dimopoulos S, et al. (2011) Maximum inspiratory pressure, a surrogate parameter for the assessment of ICU-acquired weakness. BMC Anesthesiol 11: 14.
8. Kuhlen R, Hausmann S, Pappert D, Slama K (1995) A new method for P0.1 measurement using standard respiratory equipment. Intensive Care Med 21: 554-560.
9. Esteban A, Alia I, Tobin M, Gil A, Gordo F, et al. (1999) Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation. Am J Respir Crit Care Med 159: 512-518.
10. Stawicki SP (2017) Mechanical ventilation: weaning and extubation. Int J Acad Med 3: 67.
11. DeLong ER, DeLong DM, Clarke-Pearson DL (1998) Comparing the areas under two or more correlated receiver operating characteristic curves: A nonparametric approach. Biometrics 1: 837-845.
12. Mabrouk AA, Mansour OF, El-Aziz AA, Elhabashy MM, Alasdoudy AA (2015) Evaluation of some predictors for successful weaning from mechanical ventilation. Egypt J Chest Dis Tuber 4: 7703-7707.
13. Savi A, Teixeira C, Silva JM, Borges LG, Pereira PA, et al. (2012) Weaning predictors do not predict extubation failure in simple-to-wean patients. J Crit Care 27: 221.
14. dos Santos Bien U, Souza GF, Campos ES, De Carvalho EF, Fernandes MG, et al. (2015) Maximum inspiratory pressure and rapid shallow breathing index as predictors of successful ventilator weaning. J Phys Ther Sci 27: 3723-3727.
15. de Souza LC, Guimarães FS, Lugon JR (2015) Evaluation of a new index of mechanical ventilation weaning: the timed inspiratory effort. J Intensive Care Med 30: 37-43.
16. Capdevila XJ, Perrigault PF, Perey PJ, Roustan JP, d' Athis F (1995) Occlusion pressure and its ratio to maximum inspiratory pressure are useful predictors for successful extubation following T-piece weaning trial. Chest 108: 482-489.
17. De Souza LC, da Silva CT, Almeida JR, Lugon JR (2012) Comparison of maximal inspiratory pressure, tracheal airway occlusion pressure, and its ratio in the prediction of weaning outcome: impact of the use of a digital vacuometer and the unidirectional valve. Respir Care 2012 57: 1285-1290.
18. Nemer SN, Barbas CS, Caldeira JB, Guimarães B, Azeredo LM, et al. (2009) Evaluation of maximal inspiratory pressure, tracheal airway occlusion pressure, and its ratio in the weaning outcome. J Crit Care 24: 441-446.