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The Predictive Value of the Integrated Weaning Indices in Mechanically Ventilated COPD Patients

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ABSTRACT
Background: COPD exacerbations necessitating mechanical ventilation representing important aspect of disease management. Attempts to search for better weaning index is a continuous process.
Aim of the work: was to study the accuracy of the integrated weaning indices including, CROP index and CORE index as predictors of weaning success in COPD exacerbation under mechanical ventilation.
Patients and Methods: 102 COPD patients necessitating mechanical ventilation >24 h underwent daily screen of subjective and objective indices for weaning readiness, and patients were classified according to weaning outcome into successful group (Group S) (60 patients) and failure group (Group F) (42 patients).
Results: There were no significant observed difference regarding the demographic data between the successful and the failure groups. There was highly significant difference between both weaning groups regarding dynamic compliance, NIF, $P_{0.1,}$ CROP index and CORE index (P value < 0.05). AUC of CROP index (0.80) was moderately precise compared with that of CORE index (0.63).
Conclusion: CROP index is superior to CORE index as a predictor of weaning success in mechanically ventilated COPD patients
Keywords: Weaning, COPD, mechanical ventilation, weaning predictor, CROP index, CROP index.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) considered a major epidemiological health problem worldwide. The prevalence and burden of COPD are projected to extend over the approaching decades because of aging of the world's population and continued exposure to COPD risk factors [1].

COPD exacerbation represents an acute deterioration of respiratory symptoms that demands additional therapy [2]. COPD exacerbations had deleterious effect on health status, rates of hospitalization and readmission and it can induce respiratory failure [3]. Severe COPD exacerbations necessitating invasive mechanical ventilation represent significant percentage of ICU admissions [4]. Once mechanical ventilation initiated; planning for weaning should starts [5].

Traditionally, decision to start weaning process was taken by attending physician after improvement of patient's clinical condition, arterial blood gas parameters and largely depends on clinical experience [6]. The rate of failure of the first trial of weaning reach about 20% in mechanically ventilated patients [7].

In patients of chronic obstructive pulmonary disease (COPD), the weaning failure percentage rise to 59% [8].

A topic of constant investigation for over many years is the searching for ideal predictors of successful weaning or liberation from mechanical ventilation in COPD exacerbation [9]. CROP index represents an integrative index first described by Yang and Tobin in 1991 (compliance, respiratory rate, oxygenation and pressure) [10]. Delisle and co-workers proposed CORE index (an integrated index of compliance, oxygenation, respiration and patient effort) which was developed by adding airway occlusion pressure ($P_{0.1)}$ to the CROP index, suggesting that it would improve its power to expect spontaneous breathing trial (SBT) outcome [11].

The aim of the current study was to define the accuracy of the integrated weaning indices including, CROP index and CORE index as predictors of weaning success in COPD exacerbation under mechanical ventilation.

PATIENTS AND METHODS

This prospective observational study included a total of 102 COPD patients who had achieved the weaning criteria and start weaning, attending at a RICU, Department of Chest Diseases and TB, Faculty of Medicine, Aswan University.

Approval of the ethical committee and a written informed consent was given by surrogate decision maker. This study was conducted between September 2017 to March 2018.

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Inclusion criteria

All COPD patients necessitating invasive mechanical ventilation with the following criteria: Respiratory rate ≥ 35 breath/min, disturbed conscious level, respiratory acidosis, $PaO_2/FiO_2 < 200$.

Exclusion criteria: noninvasive ventilation without subsequent invasive ventilation, previous tracheostomy, neurological and neuromuscular diseases hindering the respiratory drive, patients suffered unplanned extubation (UE) before or during the weaning process, patients with post arrest encephalopathy and patients with age < 18 years.

Study classification

Patients were classified according to the spontaneous breathing trial (SBT) outcome into two groups, weaning success group (Group S) included 60 patients who tolerated the 1st SBT, and weaning failure group (Group F) included 42 patients who failed the 1st SBT.

All patients were subjected to:

(1) Demographic data including age, sex, smoking and body mass index.
(2) Arterial blood gases (ABG).
(3) Full Laboratory assessment.
(4) Hemodynamic data, including mean arterial blood pressure (= diastolic pressure + 1/3 pulse pressure), respiratory rate, heart rate and temperature.
(5) Ventilatory data were recorded in admission and after 30 minutes of SBT, including spontaneous tidal volume, respiratory rate, minute ventilation (MV), peak pressure, plateau pressure, static compliance, dynamic compliance, negative inspiratory pressure (NIF), airway occlusion pressure ($P_{0.1}$), in addition to the different integrated weaning indices including:

- CROP index (was calculated as = $[C_{dyn} \times NIF \times (P_{aO2}/P_{AO2})]/f$). Cutoff value ≥ 13 ml/breath/min used to predict success of SBT, in which C_{dyn} is dynamic compliance, P_{aO2} is oxygen tension in arterial blood, P_{AO2} is oxygen tension in alveolar air and f is respiratory rate.
- CORE index (was calculated as = $[C_{dyn} \times (NIF/P_{0.1}) \times (P_{aO2}/P_{AO2})]$ /f), was calculated manually. Cutoff value ≥ 8 ml/breath/min used to predict success of SBT.

All patients who meet the following weaning criteria undergo SBT, which include, Improvement of disease acute phase which necessitated mechanical ventilation, absence of excessive tracheobronchial secretion (8 hours prior to weaning process), stable neurological status; no hemodynamic instability, $PaO_2 > 60$ mm Hg or $SaO_2 \geq 90\%$ or more with $FiO_2 \leq 0.4$, spontaneous respiratory rate (RR) <35/min, spontaneous respiratory volume (V_T) > 5 ml/kg of ideal body weight, Patient is afebrile and there were no significant abnormalities in the electrolyte levels.

Statistical Analysis

SPSS (Statistical Package for Social Science) software program version 21 (IBM Inc., Armonk, NY) and Medcalc v.11.6 were used for data recording and handling. Non-parametric tests were used in the current study.

ROC Curve used to assess the accuracy of each weaning index. The non parametric method of Delong used to measure the area under the ROC curves (AUC) for each weaning index [12]. P-value: considered significant if < 0.05.

RESULTS

Demographic data and patient characteristics of both groups of weaning were shown in Table (1). There was no significant difference was observed between both groups as regard age, sex, body mass index & smoking status.

Regarding the different weaning indices, there were significant difference between both weaning groups as regard NIF, $P_{0.1}$, $P_{0.1}$/ NIF ratio, CORE index and CROP index (Table 2).

Diagnostic test accuracy of each index used in the estimation of weaning achievement, was shown in (table 3), sensitivity and specificity of CROP index with a cutoff value (>= 13) at the end of the first trial of weaning was as follow 63.33, 97.62, & area under the ROC curve was moderately good (0.805). While, Sensitivity, Specificity, of CORE index (>= 8) at the end of the first trial of weaning was as follow 28.33, 97.62 & AUC was poorly precise (0.630).

The best serious cutoff value of CROP index in our study which could predict the weaning success from mechanical ventilation was >11.7 with a sensitivity of 85% and specificity of 92.86% & AUC was more precise (0.946).

While, the best serious cutoff value of CORE index which could predict the outcome of weaning from mechanical ventilation was > 6.2, with a sensitivity of 83.33% and specificity of 85.71%, & AUC was moderately good (0.889).

Table (1): Demographic data of patients included in the study (n=102)

	Group (S) (n= 60) Mean ± SD	**Group (F)** (n= 42) Mean ± SD	**P value**
Age (years)	59.70 ± 12.36	61.19 ± 11.64	0.437
Sex: No. (%)			0.918
Male	42 (70.0%)	29 (69.0%)	
Female	18 (30.0%)	13 (31.0%)	
BMI (kg/m^2)	28.64 ± 6.83	27.62 ± 6.32	0.644
Smoking			0.360
Smoker	41 (68.3%)	25 (59.5%)	
Non-smoker	19 (31.7%)	17 (40.5%)	
Smoking index (Packs/yr)	29.84 ± 6.04	28.88 ± 7.42	0.337

Data are presented as mean ± SD, or number and percentage (%). BMI: body mass index.

Table (2): Weaning indices

	Group (S) (n= 60) Mean ± SD	**Group (F)** (n= 42) Mean ± SD	**P value**
Dynamic compliance (ml/mmHg)	48.55 ± 13.88	31.31 10.32	0.001*
NIF (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*
$P_{0.1}$/NIF	0.10 ± 0.03	0.12 ± 0.04	0.019*
CORE index	7.75 ± 5.90	4.96 ± 1.96	0.001*
CROP index	17.08 ± 8.78	9.08 ± 4.04	0.001*

*CORE: compliance, oxygenation, respiration and effort. CROP: compliance, rate, oxygenation and pressure. $P_{0.1}$: Airway occlusion pressure/ NIF: negative inspiratory force. Data are presented as mean ± standard deviation. * statistically significant.*

Table (3): Diagnostic test performance of each weaning index

Cut-0ff	**Sensitivity**	**Specificity**	**+PV**	**-PV**	**Accuracy**	**AUC**
CROP ≥ 13	63.33	97.62	97.4	65.1	77.45	0.805
CROP >11.7	85.00	92.86	94.4	81.2	88.24	0.946
CORE ≥ 8	28.33	97.62	94.4	48.8	56.86	0.630
CORE > 6.2	83.33	85.71	89.3	78.3	84.31	0.889

AUC: area under the curve. CROP: compliance, rate, oxygenation and pressure. CORE: compliance, oxygenation, respiration and effort.

1- ROC curve for CROP index

a- ROC curve for CROP index ≥ 13
AUC= 0.80

b- ROC curve for CROP index > 11.7
AUC= 0.94

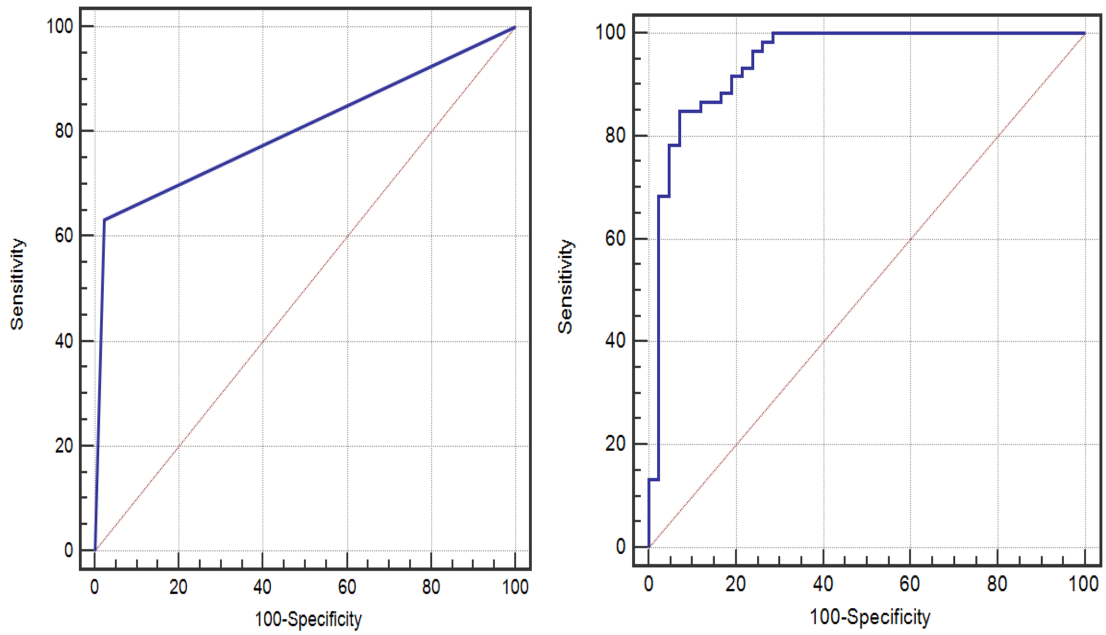

Figure (1); Receiver operator characteristic curve for CROP index

2- ROC curve for Core index

a- ROC curve for CORE index ≥ 8
AUC= 0.63

b- ROC curve for CORE index > 6.2
AUC= 0.80

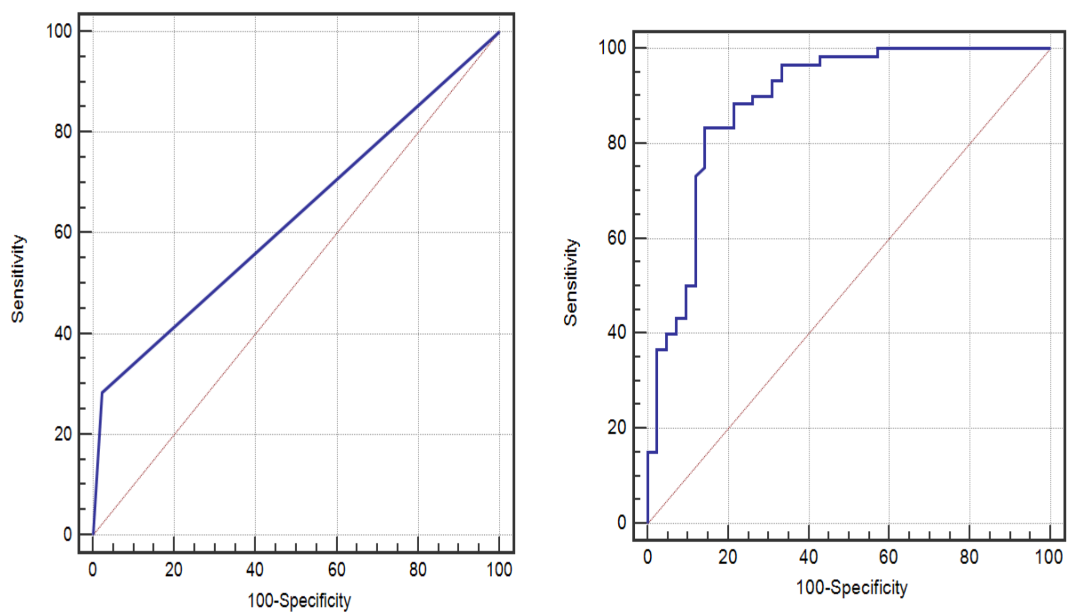

Figure (2); Receiver operator characteristic curve for CORE index

DISCUSSION

The risk of weaning failure and its complications that lead to potential morbidity and mortality can be reduced by the use of weaning indices [13]. In our sample of 102 patients, weaning failure occurred in approximately 41.2%, this result was consistant with El-Beheidy et al. who found that, the prevalence of weaning failure was 21 patients (39.6%) [14]. But, this percentage was higher than that described by ***Boles et al***. (i.e., 30%) [9].

In the current study, the demographic data of patients indicated that both groups were matched regarding age, sex, the disease duration, body mass indices and smoking status (P > 0.05). Similar results were demonstrated by ***Lee et al.*** who didn't found major differences between both groups in gender or body mass indices **[15].** Moreover, Afifia and colleagues found that the demographic data including (age, sex, cause of ICU admission, and the cause of MV dependence) were comparable between their studied weaning groups **[16].**

As regard the dynamic compliance, we found highly significant variances between 2 groups of weaning and this agree with one previous study, who found that the most important predictors of successful weaning in their study were higher levels of baseline PaO2, higher PaO2/FIO2, and dynamic compliance levels **[17].**

There was a significant variance between our groups, regarding the negative inspiratory force (NIF) (-15.83 ± 3.26 cmH2O) vs (-22.82 ± 3.23 cmH2O) respectively. This is in agreement with the result of previous studies [15,16], but in contrast with ***Elgazzar et al.*** **[18].**

In the present study, there was a significant difference between our groups regarding P0.1 (-2.40 ± 0.55) cm H2O vs. (-1.95 ± 0.63) cm H2O. This result was consistent with ***Metwally et al.*** ***[19]*****.** But, in contrast with ***Elgazzar et al.*** ***[18]*****,** this variation could be as this test mainly affected by impaired neurological drive which is widely variable between patients.

Regarding the new integrated weaning indexes in our work, we found highly significant differences between the 2 groups of weaning as regard CROP index, and CORE index. ***Mabrouk et al.*** reported similar results regarding CORE index, but opposite result as regards CROP index **[20],** however, Savi et al, reported similar results regarding CROP index **[21].**

Our results regarding assessment of the diagnostic test performance of CROP index used to predict weaning success with cut off value (≥ 13) had Sensitivity 0.63, specificity 0.97, PPV 0.8, NPV 0.86 and AUC 0.805, reflecting only moderate accuracy than CORE index. (0.635), this result in harmony with ***Montaño-Alonso et al.*** who found that, The CROP index with a cutoff value ≥ 13 was associated with successful weaning [22], however, ***John et al.*** summarized that CROP index with cutoff value ≥ 13 mL/breaths/min had very poor specificity of 33% and the AUC was imprecise (0.62) [23]. The best critical value of CROP index in our study which could expect the achievement of weaning from mechanical ventilation was >11.7 with sensitivity of .085 and specificity of 0.92 & AUC was highly precise (0.946). so, in keeping with our results we propose that CROP index > 11.7 - 13 is best index to discriminate the success or failure of weaning among COPD patients in a respiratory ICU.

Delisle et al. found that a CORE index > 8 was strongly associated with successful weaning achievement, with near precise sensitivity and specificity, and was superior to other weaning predictors tests [11]. However, ***John et al.*** found that CORE index was only fairly accurate in predicting weaning success with a sensitivity of 96% and specificity of 66% [23].

We proposed that the serious cutoff value of CORE index which could predict the success of weaning from mechanical ventilation was > 6.2 with a sensitivity of 83.33% & AUC was only moderately good (0.889). Similarly, John et al. found that the CORE index with a cutoff value > 6 was only moderately precise in expecting weaning success, with a sensitivity of 96% and specificity was 66% & AUC of 0.741 [23]. Limitations of the study: Our study is a single center study with small sample of selected patients, also Specific clinical characteristics of study population (COPD patients).

CONCLUSION

It could be concluded that CROP index is superior to CORE index as a predictor of weaning success in mechanically ventilated COPD patients. finally, we recommend that ICU physicians should not to perform any trial of extubation when CROP index less than 11.7 and to extubate any patient with minimal hesitation when CROP index > 13.

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