Monaldi Archives for Chest Disease

eISSN 2532-5264 https://www.monaldi-archives.org/

Monaldi Arch Chest Dis 2024 [Online ahead of print]

To cite this Article:
Eriş E, Mammadova A, Kara AT, et al. **Prognostic value of the oxygenation index measured during mechanical ventilation and weaning. A retrospective cohort study.** *Monaldi Arch Chest Dis* doi: 10.4081/monaldi.2024.2840

Prognostic value of the oxygenation index measured during mechanical ventilation and weaning. A retrospective cohort study

Esra Eriş,[1] Ayshan Mammadova,[2] Ayşe Taşçı Kara,[2] Aydın Atasoy,[1]
Zeynep Sena Solmaz,[1] Gül Gürsel[1,2]

[1]Critical Care Fellowship Program, Gazi University School of Medicine, Ankara; [2]Department of Pulmonary Critical Care Medicine, Gazi University School of Medicine, Ankara, Turkey

Correspondence: Esra Eriş, Critical Care Fellowship Program, Gazi University School of Medicine, Ankara
Tel.: +90 03122022000; Fax: +90 0312 221 32 02.
E-mail: e.kurtulgu@gmail.com

Contributions: EE, GG, designed and coordinated the study, participated in data acquisition and interpretation, and drafted the article; ZSS, AM, ATK, AA, participated in data collection. EE, AM, GG, participated in the interpretation of the data. All authors critically reviewed the article for important intellectual content and approved publishing the version.

Conflict of interest: the authors declare no potential conflicts of interest.

Ethics approval and consent to participate: this study was approved by the Gazi University Clinical Research Ethics Committee (date: 14.06.2021; decision No: 546).

Informed consent: all written consents are obtained from the patient's relatives during the hospitalization and are available in the patient's hospitalization files.

Funding: this research received no specific grant from public, commercial, or non-profit funding agencies.

Availability of data and materials: this single-centre retrospective cohort study of 107 patients was carried out by Gazi University Faculty of Medicine, Department of Pulmonary Critical Care Medicine. Upon reasonable request, data is available at this address.

Abstract

The aim of this study was to investigate the predictive value of the ratio of oxygen saturation (ROX) index calculated during mechanical ventilation (MV) and the weaning period in evaluating readiness to weaning and the success of the spontaneous breathing trial (SBT), extubation, and mortality. We also compared the results of the ROX index calculated with partial arterial oxygen pressure (PaO2), arterial oxygen saturation (SaO2%), and probe oxygen saturation (SpO2%). In this retrospective cohort study, the ROX index was calculated by SpO2%, PaO2, and SaO2% separately using the ROX index formula (PaO2 or SaO2 or SpO2 /FiO2)/respiratory rate. ROX was calculated during the first three days of MV treatment and the weaning period daily (SBT). Positive end-expiratory pressure and peak inspiratory pressure values were also recorded during these measurements. These ROX values were used to analyze whether they predict weaning readiness, SBT, extubation failure (EF), and mortality.

The study included 107 mechanically ventilated patients. Weaning could be tried in 64 (60%) of the 107 patients; 44 (69%) of the 64 patients succeeded, and extubation was performed. 19 (43%) of 44 patients had EF. ROX values calculated with PaO2 during MV and SBT predicted readiness to wean, EF, and mortality better than ROX values calculated with SaO2 and SpO2. ROX values calculated with PaO2 during the third day of MV had the highest sensitivity and specificity for EF (sensitivity: 81%, specificity: 70% for the ROX<11 value).

The results of this study suggest that the calculation of ROX index, not only with SpO2% but also with arterial blood gas PaO2 and SaO2% values, may be helpful in predicting the weaning readiness evaluation, SBT, and extubation success and mortality. Further studies with more patients are necessary to verify and standardize these results.

Key words: mechanical ventilation, respiratory failure, intensive care unit, ROX index, oxygenation index.

Introductıon

Hypoxic respiratory failure is the leading cause of intensive care unit admissions (ICU) and carries a hospital mortality risk of up to 20% [1]. Forty-two per cent of patients require mechanical ventilation (MV), and 14 % face weaning or extubation failure (EF) [1,2].

There are different oxygenation indices to evaluate the severity of the deterioration in oxygenation of patients, and the most commonly used one is PaO2/FiO2, which is the ratio of the oxygen partial pressure in arterial blood gas (PaO2) of the patient to the fraction of inspired oxygen (FiO2). PaO2/FiO2 is one of the most important methods to evaluate respiratory function and degree of hypoxia in critically ill patients [3,4]. The ratio of oxygen saturation (ROX) index ((%SpO2(Oxygen saturation)/FiO2)/respiratory rate (RR)) has been intensively studied in recent years. The ROX index has been evaluated extensively to evaluate intubation indication, especially during high-flow nasal oxygen therapy (HFNO) treatment. It has been helpful in patients with non-COVID and COVID-19 pneumonia [5-9].

The original ROX index uses SpO2% to calculate PaO2/FiO2 since it is practical and readily available. Much data supports the similarity and correlation between SpO2/FiO2 and PaO2/FiO2 [5,8]. On the other hand, in severely ill ICU patients using vasoactive drugs, PaO2-arterial oxygen saturation (SaO2) or SpO2 relation may change with the pressure of carbon dioxide (PaCO2) levels, pH, temperature and 2,3- diphosphoglycerate concentration. Furthermore, pulse oximeter devices can not consider increased methemoglobin (MetHb) or carboxyhemoglobin (COHb) levels or the interference of jaundice. Therefore, ROX values calculated during MV and weaning with PaO2, SaO2 and SpO2 might differ in [9-11].

Although MV is such a widely used treatment with frequent complications and high mortality risk, there is still no method with a high diagnostic value that predicts the patient's readiness for weaning, spontaneous breathing trial (SBT) failure or EF.

Early weaning from MV may impair gas exchange, leading to hypoxemia and hypercapnia, causing reintubation, which increases the risk of nosocomial pneumonia and mortality. On the other hand, delayed weaning leads to an increased risk of complications related to MV, prolonged stay in the ICU, and increased cost. Coplin et al. stated that the mortality is 12% when there is no delay in extubation and 27% when extubation is delayed. For this reason, "weaning" should be done as soon as possible at the appropriate time [12,13]. Various clinical and objective weaning readiness (WR) assessment criteria and weaning success predictors have been proposed to increase weaning and extubation success (ES). These predictors include criteria such as PaO2/FiO2 or rapid shallow breathing index (RSBI) [14].

On the other hand, RR is essential not only in intubation decisions but also in extubation. Therefore, the ROX index may help predict weaning or ES as it predicts intubation indication. As far as we know, there needs to be data in the literature to evaluate the ROX index as a weaning readiness, SBT or EF predictor.

In this study, we aimed to investigate the predictive value of the ROX index calculated during MV and weaning to evaluate the readiness of weaning, the success of SBT, and extubation and mortality. We also compared the ROX index results with PaO2, SpO2%, and SaO2.

Materials and Methods

This single-centre retrospective cohort study of 107 patients was carried out by Gazi University Faculty of Medicine, Department of Pulmonary Critical Care Medicine, Ankara, Türkiye. The study was approved by the Gazi University Clinical Research Ethics Committee (Date:14.06.2021, Decision No:546). All patients admitted to the Intensive Care Unit with a preliminary diagnosis of Type 1 and 2 respiratory failure and intubated and mechanically ventilated for at least four days between January 1, 2017 and December 31, 2020, were included in the study. Exclusion criteria were patients with do-not-resuscitate orders (DNR) and those who were tracheostomised.

Patients' data from hospitalisation until discharge or death were collected from electronic medical records and reviewed. Demographic (age, gender, body mass index (BMI)), medical history (diagnosis, comorbidities, having home oxygen or ventilation treatments), clinical (The Acute Physiology and Chronic Health Evaluation II (APACHE II), Sequential Organ Failure Assessment (SOFA) scores, presence of infection sepsis, source of infection, RR, SpO2%, FiO2%) laboratory (admission arterial blood gas values), management (noninvasive ventilation (NIV) treatment before and after MV therapy and their durations, intubation extubation times, and outcome data (if the patient is discharged or has died, readiness to WR or failure of SBT and, extubation) were obtained from the medical records.

Weaning protocol of our ICU and definitions

Our weaning protocol involves readiness assessments and SBT. To assess RW, we review parameters, including clinical improvement of the cause of respiratory failure, oxygenation and ventilation parameters, mental status, secretions and cardiovascular stability. These parameters are explained in the definitions part of the methods section.

SBT: For this aim, a T-tube trial entails disconnecting the patient from the ventilator and providing additional oxygen.

They are extubated if the patient can tolerate SBT for 30-120 minutes. Criteria to define SBT failure: $PaO_2 < 60$ mmHg and $FiO_2 > 0.5$, $SaO_2 < 90\%$ and $FiO_2 > 0.5$, $PaCO_2 > 50$ mmHg or increased by more than eight mmHg, pH < 7.32, RR > 35 breaths/min or increased by more than 50%, heart rate > 140 bpm or increased by more than 20% systolic blood pressure > 180 mmHg or < 90 mmHg, uncontrollable psychomotor agitation, reduced level of consciousness, excessive sweating and cyanosis evidence of increased respiratory muscle effort. Based on these criteria, the procedure is terminated if a patient can not tolerate an SBT. SBT is reattempted every 24 hours. Following failed SBT, patients receive ventilatory support [15].

Definitions

RW: Patients can be weaned from MV if they meet the following criteria: reduced secretions, having effective cough, haemoglobin> 8 g/dL, adequate oxygenation (PaO_2 /FiO_2 > 150 mmHg or SaO_2 > 90% when FiO_2 < 0.5), tolerance of pressure support mode (PSV), body temperature < 38.5°C, no need sedatives and vasopressor agents, no acidosis (pH ranging from 7.35 and 7.45), no electrolyte disturbances, adequate fluid balance. If these criteria are met, the SBT is performed [16,17].

SBT success: End of the SBT period with extubation [17].

SBT failure: Intolerance of SBT [17].

Successful extubation was defined as no need for reintubation for more than 48 hours, regardless of the need for sequential non-invasive positive pressure ventilation (NPPV); EF was defined as inevitable reintubation within 48 hours of extubation [18,19]. SpO_2%, PaO_2, SaO_2% FiO_2 and RR values were recorded daily during the first three days of MV and SBT. ROX index was calculated daily using SpO_2%, PaO_2, and SaO_2% separately using the ROX index (PaO_2 or SaO_2 or SpO_2 /FiO_2)/RR formula. MVD1PaO2, MVD2PaO2, MVD3PaO2 are the index calculated by PaO_2 on the first three days of MV of the patient; MVD1SaO2, MVD2SaO2, MVD3SaO2 represents the patient's ROX index calculated with SaO_2 on the first three days of MV, and MVD1SpO2, MVD2SpO2, MVD3SpO2 represent the ROX values calculated by the patient's SpO_2 on the first, 2^{nd} and 3 rd day of MV.

The first day of weaning was accepted as the day when the patient's hemodynamic and respiratory parameters were stable, and PSV was tried. Weaning ROX indices were calculated from the values taken during the SBT application in the first trial. ROX indexes were calculated separately for PaO_2, SaO_2%, and SpO_2% (WSBTPaO2, WSBTSaO2, WSBTSpO2). Peak inspiratory pressure (PIP), pressure support (PS), and positive end-expiratory pressure (PEEP) values were also recorded when ROX values were calculated.

According to our ICUs' MV protocol, mechanical ventilation was initiated with a tidal volume (VT) of 6 ml/kg of ideal body weight and minimal PEEP titrated with FiO_2 to target oxygen saturation [20,21]. Ventilation adjustments were made daily based on arterial blood gas (ABG) analysis, and when patients' reasons for intubation and MV stabilised, hemodynamics stabilised, and oxygenation improved, PSV was tried.

Statistical analysis

Variables with normal distributions were presented as mean $\pm$ standard deviation (SD) and were compared by independent samples *t*-test. For non-normally distributed variables, the Mann–Whitney *U* test was used. Categorical variables were described as percentages and compared using the Chi-squared or Fisher's exact test when appropriate. For weaning readiness, SBT, extubation success or failure, the ROX values calculated during the first three days of MV and the weaning period (SBT) were compared with the student t-test. ROC curve analysis was performed to determine the cut-off values of the ROX index for weaning readiness, SBT, extubation success or failure and mortality. Logistic regression analysis was performed for significant parameters in the Students' t-test and ROC curve analysis to check whether they were independent risk factors for weaning failure, extubation failure and mortality. Other factors (sepsis, comorbidities, etc.) that may be risk factors for these outcome criteria were also included in this analysis.

Results

Two hundred thirty-five patients were screened for the study (Figure 1). When non-intubated, tracheostomised, and DNR-ordered patients were excluded, the remaining 107 patients were included in the study. Tables 1 and 2 summarise the patients' demographics, comorbidities, diagnoses, and clinical and laboratory measurements. Forty-nine (46%) of the patients were smokers, 26 (24%) of them were using home oxygen therapy, and 7 (6.5%) of them were using home MV. Their mean BMI was 29± 24 kg/m2.

All calculations were made with the worse values recorded during MV (on the 1st, 2nd and 3rd day of MV), the weaning readiness evaluation period (on the first day of weaning during PSV) and the day of SBT. Of our patient population, 43% had pulmonary comorbidity, and 26% had cardiac comorbidity. Chronic obstructive pulmonary disease (COPD-AE) exacerbation and pneumonia were the most common admission diagnoses. In our study, MVROX values calculated during the first seven days of MV were recorded, and we presented the results of the first three days because they had significant results. The weaning duration was seven days; nearly half of the patients mechanically ventilated for more than 14 days, and 35% of them ventilated longer than 21 days. WR was evaluated in 107 (46%) of the patients; 64 (60%) were ready to wean and SBT, and 44 (69%) of them passed the SBT trial and were extubated. EF occurred in 19 (43%) of the extubated patients. Mean± SD MV, weaning, and ICU LOS durations were 14±18, 7±7, and 17±20 days respectively (Table 2).

Readiness to weaning

ROX values calculated with PaO2, SaO2% and SpO2% during the first three days of MV were used to evaluate readiness to weaning. MVD1PaO2, MVD2PaO2, MVD1SaO2, MVD2 SaO2, and MVD1SpO2, MVD2SpO2 ROX values calculated in the first two days were significantly lower in the not ready to wean (NRW) group than in the RW group. They predicted NRW from the first two days of MV with a cut-off point between 8-11, sensitivity between 66%-71%, and specificity between 52% and 60% (Table 3). Among MVD3PaO2, MVD3SaO2 and

MVD3SpO2% ROX values, only MVD3PaO2 was significantly lower in the (NRW) group than in the RW group (Table 4).
The highest sensitivity and specificity values were obtained with the MVD3PaO2 value below 11 for NRW (sensitivity: 74%, specificity: 67%). The mean±SD inspiratory and expiratory pressure values recorded during the first three days of MV were as follows: PIP (26±7, 25±7, 26±7 mmHg respectively), and PEEP (6±2, 6±2, 5±2 mmHg, respectively).
In the logistic regression analysis, none of these ROX values was found to be an independent risk factor for NRW.
Among ROX values calculated during SBT, only WSBTPaO2 wasn't significantly lower in the NRW group than in the RW group (Table 4). WSBTSaO2 and WSBTSpO2 lower than 11 predicted SBT failure with 71%, 76% sensitivity, and 60% specificity, respectively.

Extubation failure

When we compared ROX values calculated from PaO2, SaO2%, and SpO2% values for the first three days of MV and the first day of weaning, MVPaO2 values calculated in the first and third days were significantly lower in the EF group than the ES group (Table 4). In the ROC curve analysis, the cut-off value of 11 for MVD3PaO2 had the highest sensitivity and specificity values (sensitivity: 81%, specificity: 70%) (Table 3).
ROX values calculated during SBT (WSBTPaO2-SaO2-SpO2) were not significantly different between ES and EF groups (Table 4).

Mortality

Among ROX values calculated from PaO2, SaO2% and SpO2% values in the first three days of MV and the first day of weaning MVD2 PaO2, MVD2SaO2 and MVD2SpO2 values were not significantly different between exitus and discharge groups. The significant ROX value for mortality prediction was MVD3PaO2 (Table 4).
The highest sensitivity and specificity values were found for the MVD3PaO2 cut-off value 11 (sensitivity: 74%, specificity: 66%)(Tables 3 and 4).

Discussion

This study aimed to determine if the ROX index calculated with PaO2, SaO2 and SpO2 during the mechanical ventilation and weaning period can predict weaning readiness, SBT, EF, and mortality. Our results suggest that ROX values calculated with PaO2 during 3rd day of MV (<11) predicted not to be ready for weaning, SBT failure, EF and mortality. Additionally, MVD1,2 PaO2, MVD1,2 SaO2, and MVD1,2SpO2 values (>8) measured during the first two days of MV predicted WR with relatively low sensitivity and specificity values. Again, WSBTSaO2 and WSBTSpO2 values (>11) predicted SBT success.

In this study, many ROX values calculated during the first three days of MV, SBT, and post-extubation periods predicted the weaning and extubation outcomes. The best sensitivity specificity values to predict RW, EF and mortality were obtained with ROX values calculated with PaO2. The original definition of the ROX index uses SpO2 to calculate noninvasive measurement for PaO2/FiO2 since there is no need for ABG data [5]. Additionally, since pulse oximetric measurement of SpO2/FiO2 is widely used and validated as a surrogate for PaO2/FiO2, SpO2/FiO2 can be utilised for diagnosis and assessment of severity of acute respiratory distress syndrome (ARDS) if SpO2 is <97% according to recent American Thoracic Society (ATS) ARDS definition [22]. On the other hand, in severely ill intensive care patients, the oxyhemoglobin dissociation curve position changes with acidosis and hypercapnia, and these factors influence the PaO2 and SaO2 relationship. Moreover, these patients frequently have low blood pressures and higher doses of vasopressor usage, causing lower SpO2 values than SaO2; because of all these reasons, ROX values obtained with PaO2 might have been found more sensitive and specific in this study.

Previous studies investigating a correlation between SpO2/FiO2 and PaO2/FiO2 ratio found some differences supporting our results. In Rice et al.'s study to evaluate the SpO2/FiO2 ratio and PaO2/FiO2 ratio relationship for ARDS diagnosis, they found that the SpO2/FiO2 ratio correlated well with simultaneously obtained PaO2/FiO2 ratios, but SpO2/FiO2 ratios of 235 and 315 were found to have corresponded to PaO2/FiO2 ratios of 200 and 300 respectively in ARDS patients [23]. In another study, researchers aimed to derive SpO2/FiO2 ratio correlations with the PaO2/FiO2 ratio to calculate the respiratory parameter of the SOFA score. There was a good correlation between the ratios in this study. Still, for the respiratory component of SOFA, corresponding PaO2/FiO2 and SpO2/FiO2 values for score one were <400 and <512, respectively, and for score 2, <300 and 357, respectively [8].

The ROX index was first described and validated in patients with hypoxemic respiratory failure and has been applied to predict the need for endotracheal intubation after HFNO application in patients with COVID-19. The ROX index has also been used to determine patients who may ultimately be weaned from HFNO. Results of these studies have shown that depending on the evaluation time or study, ROX values less than 3 or 5 indicate HFNO failure and intubation indication [5,6]. In addition to its initial purpose, the ROX index was also applied to predict successful HFNO weaning.

Rodriguez et al. found that the ROX index was higher in the subjects who were successfully weaned from HFNO at the first trial than in those who failed (12.7 vs 10.2, p = 0.002) [24]. In another retrospective study conducted in the medical-surgical intensive care unit, ROX after 8 hours of treatment was one of the best predictors of HFNO success (ROX >5.98 was associated with a lower risk of MV) [25]. Limited data reported values of the ROX index for weaning failure and EF exist. In a recent study, Filho et al. reported a 6.36 cut-off value for the prediction of EF. In this study, authors reported that they calculated the ROX index during the extubation process, probably during SBT, without any pressure [26]. This ROX value was also calculated with SpO2. In our study, a ROX value less than 11 calculated with PaO2 on the 3rd day of MV predicted worse outcomes, including NRW, SBT failure, EF and mortality.

All these results show that cut-off points change according to when and why they are calculated, such as to predict intubation during HFNO treatment, low flow O2 treatment, or to predict EF. Using PaO2, SpO2, or SaO2 may also change the cut-off value. While there are very few studies evaluating the ROX index for WF and EF, it is possible to find many studies that assessed the PaO2/FiO2 ratio for weaning and EF. In a recent study performed on patients with COVID-19, Guzatti et al. reported that while PaO2/FiO2>300 decreased, the probability of EF, PaO2/FiO2<200 is an independent predictor for EF [27].

The number of patients with chronic respiratory failure (24%) and comorbidities (43% pulmonary, 26% cardiac) was higher in our study population, and their MV and weaning durations were longer. Prediction of WR is significant in patient populations like ours. Because of this, not surprisingly, weaning could have been tried in only 60% of the patients 69% of them were successful and extubated, but 43% of them failed and were reentubated within five days. ROX index predicted EF from the 3rd day of MV with 81 % sensitivity and 70% specificity. Several weaning parameters have been assessed and used in clinical studies, but they are not very sensitive or specific when considered individually [5,13]. The most common weaning parameters to consider when initiating the SBT are RSBI (RR / VT) measured over one minute in a spontaneously breathing patient on low-level PEEP only has a higher sensitivity of 97% and moderate specificity of 65% for predicting patients who will subsequently pass the SBT [6]. Minute ventilation (tidal volume x respiratory rate) of less than 10 L per minute only correlates with a positive predictive value of 50% and a negative predictive value of 40%. These parameters are calculated during the weaning period, but in our study, we estimated the ROX index not only during the weaning period but also during the beginning of MV, and our results suggest that the ROX index can predict WR, SBT failure and EF from the beginning of MV when it is calculated with PaO2. Possible reasons for this may be that patients begin to recover on the 3rd day of MV, their sedation and vasopressor needs decrease, and their respiratory drive begins to return to normal. The fact that ROX values calculated with PaO2 are more valuable than those calculated with saturation may be because the oxyhemoglobin curve starts to plateau with decreasing affinity to oxygen. In other words, after 90% saturation, PaO2 rises while saturation increases more slowly. This may also be caused by conditions such as metabolic acidosis due to renal failure or sepsis, which shifts this curve to the right and reduces the affinity of haemoglobin to oxygen.

Similar to our results in another study evaluating venous blood gas values, researchers found that reduction of venous oxygenation saturation (ScvO2 over 4.5%) after 30 minutes of the SBT in patients who failed their first SBT is an independent predictor of reintubation with a sensitivity of 88% and specificity of 95% [28]. Our results suggest that the ROX index calculated during MV and weaning has high sensitivity and specificity in identifying SBT failure (76% and 60%, respectively) and EF (81% and 70%, respectively) in respiratory failure. It may help select patients who are ready to wean and extubate. We identified ROX index cutoffs that may be useful in selecting patients who could be successfully weaned from MV and EF.

ROX index calculated during the early days of MV also predicted mortality in this study population. Similar to our results, Lee et al. found significant mortality prediction in septic patients, but our sensitivity and specificity values are higher than this study's results [29].

Limitations of the study

Our retrospective and observational study may have caused some problems in evaluating the WR status of the patients. If the number of patients in the study had been more significant, we could have had more patients in the EF and ES groups. Since the study was single-centre and included many patients with chronic respiratory failure and comorbidities, our cut-off values cannot be generalised for patients with acute respiratory failure and non-hypercapnic patients. Again, when comparing cut-off values with the results obtained in other studies, it should be taken into account that the ROX values calculated during MV were obtained under specific inspiration and expiration pressure values.

Conclusions

The results of this study suggest that calculating the ROX index using SpO2%, ABG PaO2, and SaO2% values may also be helpful in predicting the WR evaluation, SBT, ES, and mortality. Further studies with more patients are necessary to verify and standardise these results.

References

1. Stefan MS, Shieh MS, Pekow PS, et al. Epidemiology and outcomes of acute respiratory failure in the United States, 2001 to 2009: a national survey. J Hosp Med 2013;8:76-82.
2. Epstein SK, Ciubotaru RL. Independent effects of etiology of failure and time to reintubation on outcome for patients failing extubation. Am J Respir Crit Care Med 1998;158:489-93.
3. Bernard GR, Artigas A, Brigham KL, et al. The American-European Consensus Conference on ARDS. Definitions, mechanisms, relevant outcomes, and clinical trial coordination. Am J Respir Crit Care Med 1994;149:818-24.
4. Demiselle J, Calzia E, Hartmann C, et al. Target arterial PO_2 according to the underlying pathology: a mini-review of the available data in mechanically ventilated patients. Ann Intensive Care 2021;11:88.
5. Roca O, Messika J, Caralt B, et al. Predicting success of high-flow nasal cannula in pneumonia patients with hypoxemic respiratory failure: the utility of the ROX index. J Crit Care 2016;35:200-5.
6. Roca O, Caralt B, Messika J, et al. An index combining respiratory rate and oxygenation to predict outcome of nasal high-flow therapy. Am J Respir Crit Care Med 2019;199:1368-76.
7. Suliman LA, Abdelgawad TT, Farrag NS, Abdelwahab HW. Validity of ROX index in prediction of risk of intubation in patients with COVID-19 pneumonia. Adv Respir Med 2021;89:1-7.
8. Pandharipande PP, Shintani AK, Hagerman HE, et al. Derivation and validation of Spo2/Fio2 ratio to impute for Pao2/Fio2 ratio in the respiratory component of the Sequential Organ Failure Assessment score. Crit Care Med 2009;37:1317-21.
9. Van de Louw A, Cracco C, Cerf C, et al. Accuracy of pulse oximetry in the intensive care unit. Intensive Care Med 2001;27:1606-13.
10. Perkins GD, McAuley DF, Giles S, et al. Do changes in pulse oximeter oxygen saturation predict equivalent changes in arterial oxygen saturation?. Crit Care 2003;7:R67-71.
11. Jubran A, Tobin MJ. Reliability of pulse oximetry in titrating supplemental oxygen therapy in ventilator-dependent patients. Chest 1990;97:1420-25.
12. Coplin WM, Pierson DJ, Cooley KD, et al. Implications of extubation delay in brain-injured patients meeting standard weaning criteria. Am J Respir Crit Care Med 2000;161:1530-36.

13. Macintyre NR, Cook DJ, Ely EW Jr, et al. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians, the American Association for Respiratory Care, and the American College of Critical Care Medicine. Chest 2001;120:375S-95S.
14. Akella P, Voigt LP, Chawla S. To wean or not to wean: a practical patient focused guide to ventilator weaning. J Intensive Care Med 2022;37:1417-25.
15. Haas CF, Loik PS. Ventilator discontinuation protocols. Respir Care 2012;57:1649-62.
16. Nemer SN, Barbas CS. Predictive parameters for weaning from mechanical ventilation. J Bras Pneumol 2011;37:669-79.
17. Boles JM, Bion J, Connors A, et al. Weaning from mechanical ventilation. Eur Respir J 2007;29:1033-56.
18. Esteban A, Frutos F, Tobin MJ, et al. A comparison of four methods of weaning patients from mechanical ventilation. Spanish Lung Failure Collaborative Group. N Engl J Med 1995;332:345-50.
19. Vallverdú I, Calaf N, Subirana M, et al. Clinical characteristics, respiratory functional parameters, and outcome of a two-hour T-piece trial in patients weaning from mechanical ventilation. Am J Respir Crit Care Med 1998;158:1855-62.
20. Acute Respiratory Distress Syndrome Network, Brower RG, Matthay MA, et al. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. N Engl J Med 2000;342:1301-8.
21. Amato MB, Barbas CS, Medeiros DM, et al. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. N Engl J Med 1998;338:347-54.
22. Matthay MA, Arabi Y, Arroliga AC, et al. A new global definition of acute respiratory distress syndrome. Am J Respir Crit Care Med 2024;209:37-47.
23. Rice TW, Wheeler AP, Bernard GR, et al. Comparison of the SpO2/FIO2 ratio and the PaO2/FIO2 ratio in patients with acute lung injury or ARDS. Chest 2007;132:410-17.
24. Rodriguez M, Thille AW, Boissier F, et al. Predictors of successful separation from high-flow nasal oxygen therapy in patients with acute respiratory failure: a retrospective monocenter study. Ann Intensive Care 2019;9:101.
25. Artacho Ruiz R, Artacho Jurado B, Caballero Güeto F, et al. Predictors of success of high-flow nasal cannula in the treatment of acute hypoxemic respiratory failure. Med Intensiva 2021;45:80-7.
26. Andrade Filho PH, Brasil ESA, Costa LG, et al. Prediction of extubation failure in COVID-19. Respir Care 2021;66:1323-29.

27. Guzatti NG, Klein F, Oliveira JA, et al. Predictive factors of extubation failure in COVID-19 mechanically ventilated patients. J Intensive Care Med 2022;37:1250-55.

28. Jubran A, Mathru M, Dries D, Tobin MJ. Continuous recordings of mixed venous oxygen saturation during weaning from mechanical ventilation and the ramifications thereof. Am J Respir Crit Care Med 1998;158:1763-69.

29. Lee CU, Jo YH, Lee JH, et al. The index of oxygenation to respiratory rate as a prognostic factor for mortality in Sepsis. Am J Emerg Med 2021;45:426-32.

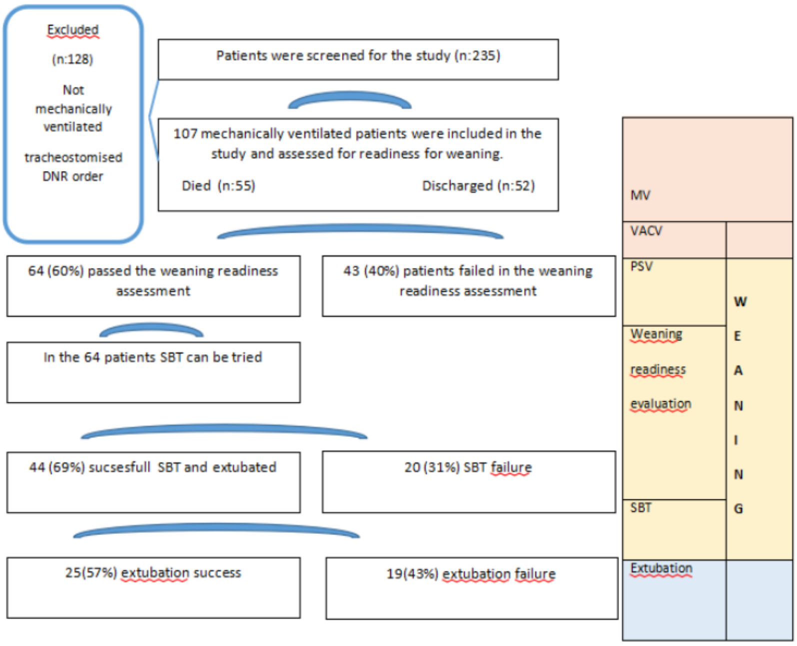

Figure 1. Flowchart. MV, mechanical ventilation; VACV, volume assist control; PSV, pressure support ventilation. SBT, spontaneous breathing trial.

Table 1. Demographics and admission diagnosis.

	% or mean±SD
Age, years	69 ±17
Gender (female)	47(44%)
GCS	8±4
APACHE II	25± 8
SOFA score	7± 3
MV SOFA	8±3
Weaning SOFA	5±3
SBT SOFA	5±2
Admission diagnosis	
Pneumonia	62(58%)
Sepsis, septic shock	56(52%)
COPD exacerbation	15(14%)
Neurologic	14(13%)
Congestive heart failure	22(21%)
Acute kidney injury	11(10%)
Venous thromboembolism	8(8%)
Physical examination findings	
Mean arterial pressure, mmHg	83±18
Heart rate, min-1	102± 23
Respiratory rate, min-1	27±8
Admission SpO2, %	91±10
PaO2/FiO2, mmHg	155±93
Baseline arterial blood gas values	
pH	7.54±2
PaO2, mmHg	77± 32
PaCO2, mmHg	48±22
HCO3, mEq	24±6
SaO2, %	91±10

GCS, Glasgow coma scale; APACHE II, acute physiologic and chronic health evaluation; MV, mechanical ventilation; SOFA, sequential organ failure score; SBT, spontaneous breathing trial; COPD, chronic obstructive lung disease; SpO2, probe oxygen saturation; PaO2/FiO2, partial arterial oxygen pressure/fraction of inspired oxygen; PaO2, partial arterial oxygen pressure; PaCO2, partial arterial carbon dioxide pressure; HCO3, bicarbonate; SaO2, arterial oxygen saturation.

Table 2. Parameters related to mechanical ventilation and weaning outcome.

Outcomes of MV	N(%) or mean±SD
Readiness to weaning assessment	107/235(46%)
Passed weaning readiness and ready to SBT	64/107(60%)
Extubation failure	19/64(30%)
Durations	
Weaning duration, days	7±7
MV duration, days	14±18
ICU Time, days	17±20
Reintubation time, day	7±7
Mortality rate,%	55(51%)
Duration of MV >7 days >14 days >21 Days	Rates 63% 46% 35%

MV, mechanical ventilation; SBT, spontaneous breathing trial; ICU, intensive care unit.

Table 3. Threshold values determined for WR EF and mortality from the ROX values calculated during MV and weaning*.

	AUC	(CI 95%)	p	Threshold	Sensitivity (%)	Specificity (%)
WR Evaluation						
MVD1PaO2	.655	(.548-.762)	0,008	<8	69%	60%
MVD1SaO2	.669	(.563-.774)	0,004	<9	66%	60%
MVD1SpO2	.667	(.561-.772)	0,004	<8	66%	55%
MVD2PaO2	.664	(.506-.773)	0,006	<10	70%	59%
MVD2SaO2	.655	(.544-.766)	0,009	<11	71%	52%
MVD2SpO2	.664	(.554-.774)	0,006	<11	71%	52%
MVD3PaO2	.762	(.655-.868)	0,005	<11	74%	67%
Weaning SBT						
WSBTSaO2	.728	(.575.-.880)	0,024	<11	71%	60%
WSBTSpO2	.741	(.586-.895)	0,017	<11	76%	60%
Extubation						
MVD3PaO2	.801	(.660-.943)	0,001	<11	81%	70%
Mortality						
MVD3PaO2	.740	(.637-.843)	0,005	<11	74%	66%

*Only significant parameters were given; EF, extubation failure; ROX, respiratory rate-oxygenation; MV, mechanical ventilation; WR, weaning readiness; SpO2, oxygen saturation; PaO2, partial arterial oxygen pressure; SaO2, arterial oxygen saturation; SBT, spontaneous breathing trial. MVD1,2,3PaO2: ROX value calculated with PaO2 during first three days of MV, MVD1,2SaO2: ROX value calculated with SaO2 during first two days of MV; MVD1,2, SpO2: ROX value calculated with SpO2 during first two days of MV; WSBTSaO2: ROX value calculated with SaO2 during SBT; WSBTSpO2: ROX value calculated with SpO2 during SBT.

Table 4. Comparison of ROX values calculated during the first three days of mechanical ventilation and weaning in terms of WR, SBT and EF success and mortality.

ROX values calculated during MV. (n:107), mean ±SD									
	Weaning readiness			**SBT success and failure groups**			**Mortality**		
ROX values calculated during the day 1-3 with PaO2, SaO2 and SpO2	NRW (n=43)	RW (n=64)	p	SBT success (n=44)	SBT failure (n=20)	p	Exitus (n=55)	Discharge (n=52)	p
MVD1PaO2	8±5	15±21	0,017	17±24	9±4	0,045	12±20	12±12	0,772
MVD1SaO2	9±5	15±18	0,008	17±21	11±5	0,067	11±13	14±16	0,402
MVD1SpO2	9±5	15±19	0,009	17±22	11±5	0,068	11±13	14±17	0,386
MVD2PaO2	10±5	13±5	0,004	13±6	12±6	0,351	10±5	13±5	0,100
MVD2SaO2	11±5	14±5	0,007	14±5	13±5	0,788	12±6	14±5	0,113
MVD2SpO2	11±5	15±6	0,005	14±5	14±5	0,998	12±6	14±5	0,143
MVD3PaO2	9±6	15±6	0,005	16±5	11±5	0,001	10±7	15±5	0,001
MVD3SaO2	13±16	17±12	0,203	16±4	17±20	0,696	15±17	15±4	0,938
MVD3SpO2	13±15	17±12	0,204	16±5	18±20	0,601	15±17	15±5	0,974
ROX values calculated during SBT (n:64), mean ±SD									
	SBT success and failure			ES	EF		Mortality		p
ROX values calculated during SBT with PaO2, SaO2 and SpO2	SBT failure (n:20)	SBT success (n:44)	p	(n=25)	(n=19)	p	Exitus(30)	Discharge (34)	
WSBTPaO2	11±4	14±5	0,098	14±5	13±5	0,458	12±4	14±5	0,367
WSBTSaO2	10±3	14±4	0,020	14±3	12±5	0,274	12±4	14±4	0,131
WSBTSpO2	10±3	15±13	0,022	16±15	12±5	0,328	12±4	16±14	0,214

ROX, respiratory rate-oxygenation; WR, weaning readiness; NRW, not ready to wean; SBT, spontaneous breathing trial; EF, extubation failure; MV, mechanical ventilation; SpO2, oxygen saturation; PaO2, partial arterial oxygen pressure; SaO2, arterial oxygen saturation. MVD1,2,3PaO2: ROX value calculated with PaO2 during first three days of MV; MVD1,2,3SaO2: ROX value calculated with SaO2 during first three days of MV; MVD1,2,3SpO2: ROX value calculated with SpO2 during first three days of MV; WSBTPaO2: ROX value calculated with PaO2 during SBT, WSBTSaO2: ROX value calculated with SaO2 during SBT; WSBTSpO2: ROX value calculated with SpO2 during SBT.