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Testing the prognostic value of the rapid shallow breathing index in predicting successful weaning in patients requiring prolonged mechanical ventilation

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ARTICLE INFO

Article history:
Received 29 January 2012
Revised 4 June 2012
Accepted 5 June 2012
Online 6 July 2012

Keywords:
Mechanical ventilation
Prolonged mechanical ventilation
Rapid shallow breathing index
Respiratory failure
Spontaneous breathing trial
Weaning

ABSTRACT

Objective: The study objective was to assess the prognostic value of the rapid shallow breathing index (RSBI) in predicting successful weaning of patients from prolonged mechanical ventilation (PMV) in long-term acute care (LTAC) facilities. The RSBI predicts successful ventilator weaning in acutely ill patients. However, its value in PMV is unclear.

Methods: A retrospective cohort study of patients receiving PMV in LTAC facilities was performed. RSBI was measured daily, with weaning per protocol. Initial, mean, and final RSBI; RSBI $\leq$ 105; rate of change; and variability were assessed.

Results: Twenty-five of 52 patients were weaned from PMV. Only the mean RSBI and the RSBI on the last day of weaning predicted success (78.7 $\pm$ 14.2 vs 99.3 $\pm$ 30.2, $P = .007$; 71.7 $\pm$ 31.2 vs 123.3 $\pm$ 92.5, $P = .005$, respectively). RSBI variability and rate of change were different between groups (coefficient of variation, .37 $\pm$ .12 vs .51 $\pm$ .30, $P = .02$, rate of change: -3.40 ± 9.40 vs 4.40 $\pm$ 11.1 RSBI points/day, $P = .005$, weaned vs failed).

Conclusion: Although isolated RSBI measurements do not predict successful weaning from PMV, RSBI trends may have prognostic value.

Cite this article: Verceles, A. C., Diaz-Abad, M., Geiger-Brown, J., & Scharf, S. M. (2012, NOVEMBER–DECEMBER). Testing the prognostic value of the rapid shallow breathing index in predicting successful weaning in patients requiring prolonged mechanical ventilation. Heart & Lung, 41(6), 546-552. http://dx.doi.org/10.1016/j.hrtlng.2012.06.003.

Patients receiving prolonged mechanical ventilation (PMV) have been recognized as a distinct population with "chronic critical illness,"[1,2] in contrast to acutely ill patients in intensive care units (ICUs). These patients are usually survivors of catastrophic illness, are severely physically debilitated, and often have chronic metabolic, neuroendocrine, neuropsychiatric, and immunologic conditions.[3] Improved intensive care

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http://dx.doi.org/10.1016/j.hrtlng.2012.06.003

has led to an increasing number of patients surviving catastrophic illness and receiving PMV. Thus, patients who recover from critical illness but require ongoing complex medical needs preventing their discharge (eg, intravenous antibiotics, wound management, PMV) receive care at long-term acute care (LTAC) hospitals. These facilities were initially created in the 1990s as a means to offload ICUs, providing a venue where weaning from mechanical ventilation and continued care could be provided.[4]

Studies focused on Medicare data have demonstrated increasing LTAC hospital expenditures, totaling approximately $1.325 billion in 2006.[5] A recent multicenter, observational study of more than 1400 patients on PMV noted that on discharge from LTAC hospitals, 54% of patients were no longer on ventilators, 21% remained ventilator dependent, and 25% died.[6] Thus, the growing patient population with "chronic critical illness" demonstrates the need for greater attention, both from a financial standpoint[7] and a personnel and resource use perspective.[8,9]

The inability to wean from mechanical ventilation is one of the greatest obstacles for patients in LTAC hospitals to overcome before discharge. Because approximately half of these patients die or are lifelong ventilator dependent, many efforts have been directed toward determining accurate predictors of successful weaning in different populations on PMV,[10-12] including scoring systems, physiologic measurements, and protocol-driven screening assessments. For patients with acute respiratory failure, the rapid shallow breathing index (RSBI) measured during spontaneous breathing trials (SBTs) was demonstrated to be a successful predictor of weaning from the ventilator within 24 hours.[13] The RSBI is easy to measure and inexpensive, and an RSBI of $\leq$ 105 has high sensitivity (.97), specificity (.64), and positive and negative predictive values (.78 and .95, respectively).[14] However, few studies have assessed the efficacy of the RSBI in predicting successful weaning from mechanical ventilation in the patient on PMV.[12,15]

The current study assessed the prognostic value of the RSBI with respect to predicting successful weaning from the ventilator in patients on PMV in LTAC hospitals. We tested the hypothesis that lower RSBI measurements were associated with successful weaning from mechanical ventilation in this population. We further postulated that comorbid conditions, as well as variability, and RSBI trends over the weaning period are associated with success in weaning from PMV.

Materials and Methods

This retrospective, observational cohort study assessed the respiratory records of patients requiring PMV who were admitted to the Pulmonary Rehabilitation and Ventilator Weaning Unit at the University Specialty Hospital (USH). This study was approved by the University of Maryland Institutional Review Board with a waiver of consent. The USH is a 180-bed LTAC hospital operated by the University of Maryland Medical System. The Ventilator Unit has 60 beds, a patient–nurse ratio of 6.5:1, a respiratory therapist–patient ratio of 9:1, 24-hour hospitalist coverage, hemodialysis unit, and a multidisciplinary support team consisting of physical, occupational, recreational, and speech therapists; clinical pharmacist services; social worker; psychiatric liaisons; and nutritionists. Criteria for transfer from acute care hospitals to the ventilator unit include hemodynamic stability, tracheostomy, inspired oxygen fraction $\leq$ 60% with oxygen saturation $\geq$ 90%, positive end-expiratory pressure (PEEP) $\leq$ 10 cm H_2O, and no need for cardiac monitoring, intravenous vasoactive medications, or continuous intravenous drips. The potential ability to wean from mechanical ventilation is not a requirement for admission into the unit. Patients were classified according to primary cause of respiratory failure. All patients on mechanical ventilation were followed in consultation by board-certified pulmonologists from the Division of Pulmonary and Critical Care Medicine from the University of Maryland School of Medicine.

All study patients had undergone tracheostomy and were ventilator dependent for $\geq$ 21 days before admission to USH, consistent with the National Association for Medical Direction of Respiratory Care criteria for PMV.[16] Patients admitted between June 2007 and January 2008 were included in the analysis. The age-adjusted Charlson Comorbidity Index (CCI) with Deyo modification was calculated for each patient as an assessment of comorbidity burden.[17] Patients who were weaned from mechanical ventilation, were transferred to an acute care facility, or died within $\leq$ 3 days of admission to the LTAC hospital were excluded from the review because these patients had insufficient data for analysis.

All patients were supported with the same mechanical ventilators (Vela, VIASYS Healthcare, Yorba Linda, CA). At baseline, patients were supported using 1 of 2 modes: volume assist–control or pressure support. SBTs were conducted daily by respiratory therapists per protocol on all patients who were deemed to be fit for weaning by the attending pulmonologist. The SBT was initiated by placing the patient on continuous positive airway pressure of 5 to 8 cm H_2O (to match the assumed physiologic baseline PEEP) with a 1-minute acclimatization period. After this acclimatization period, RSBI measurements were calculated by respiratory therapists on all patients who received an SBT using the equation RSBI = respiratory rate (breaths/min) ÷ average tidal volume (liters).

For this calculation, the respiratory rate and average tidal volume were measured after the first 1 minute of the SBT and reported in the daily respiratory records. Although these calculations were available to the pulmonary physician on request, the RSBI did not drive the decision to continue or terminate weaning trials. Weaning modes included decremental pressure