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Identifying Predictors of Successful Weaning off Prolonged Mechanical Ventilation among the Elderly in an Israeli Respiratory Care Facility

Edward Kaykov MD

Department of Geriatrics, Shoham Medical Center, Pardes Hana, Israel affiliated to Rappaport-Faculty of Medicine, Technion-Israel Institute of Technology, Israel

Carola Vigder MD

Department of Geriatrics, Shoham Medical Center, Pardes Hana, Israel affiliated to Rappaport-Faculty of Medicine, Technion-Israel Institute of Technology, Israel

Merav Ben Nathan, PhD, RN

Hillel Yaffe Medical Center, Hadera, Israel

Svetlana Zheludkov MD

Department of Geriatrics, Shoham Medical Center, Pardes Hana, Israel affiliated to Rappaport-Faculty of Medicine, Technion-Israel Institute of Technology, Israel

Yoshua Ben Israel MD

Department of Geriatrics, Shoham Medical Center, Pardes Hana, Israel affiliated to Rappaport-Faculty of Medicine, Technion-Israel Institute of Technology, Israel

Correspondence: Dr Merav Ben-Natan, Pat Matthews Academic School of Nursing, Hillel Yaffe Medical Center, P.O.B. 169, Hadera 38100 Israel E-mail: meraav@hy.health.gov.il

Abstract

Background: Outcomes for patients undergoing prolonged mechanical ventilation remain less than desirable; costs, morbidity, and mortality are notably high. Therefore, patients should be weaned from mechanical ventilation as soon as possible. Weaning is a complex process in the case of elderly patients with comorbidities on prolonged mechanical ventilation.

Aims: To determine predictors of successful weaning off prolonged mechanical ventilation among the elderly patients.

Methodology: It is a retrospective chart review study. Medical records of 58 patients in the respiratory care unit of a large long-term care facility for the elderly in central Israel, divided to those successfully weaned off prolonged mechanical ventilation and those whose weaning had failed, were analyzed for their demographic and clinical data. Twenty-eight patients had been successfully weaned.

Results: Twenty-eight patients had been successfully weaned. Successful SBT (spontaneous breathing trial), less comorbidities, and lower PCO₂ levels one month post-admission, were found as significant predictors of successful weaning off prolonged mechanical ventilation among the elderly patients.

Conclusion: These factors might serve as a predictive tool of weaning outcome of the elderly patients from prolonged mechanical ventilation.

Key words: Predictors, prolonged mechanical ventilation, weaning off

Introduction

As a consequence of advances in intensive care that have allowed increasing numbers of patients to survive, there is a large and growing population of patients with dependence on mechanical ventilation (Ambrosino & Gabbrielli, 2010). Most patients who require mechanical ventilation during critical illness can be successfully liberated from respiratory support on recovery from the precipitating illness. For 2–5% of patients, however, the weaning process fails, conventionally defined as dependency on mechanical ventilation more than 3 weeks after resolution of the precipitating cause for admission to the ICU (Pilcher et al., 2005). Outcomes for patients undergoing prolonged mechanical ventilation remain less than desirable; costs, morbidity, and mortality are notably high (Burns et al., 2012). Therefore, patients should be weaned from mechanical ventilation as soon as possible (Boles et al., 2007).

Weaning from mechanical ventilation is an essential and universal element in the care of critically ill intubated patients receiving mechanical ventilation. Weaning covers the entire process of liberating the patient from mechanical support and from the endotracheal tube. There is uncertainty about the best methods for conducting this process, which will generally require the cooperation of the patient during the phase of recovery from critical illness. This makes weaning an important clinical issue for patients and clinicians (Boles et al., 2007). Weaning is all the more complex in the case of elderly patients with comorbidities on prolonged mechanical ventilation (Lermitte & Garfield, 2005).

The number of elderly in Israel is growing, and by late 2009 there were 741,500 people aged 65 and older in the country, constituting about 10% of the entire population. Nearly one half (about 48%) of those aged 65 and older are over 75. This group is predicted to rise to 14% of the population by 2030, while the number of those aged 65 and older will double and reach nearly 1.4 million (Central Bureau of Statistics, 2010). As the number of elderly rises, their need for healthcare services in general and care including prolonged ventilation in particular is rising as well. Research shows a rise in acute respiratory failure requiring mechanical ventilation among those over 65 (Behrendt, 2000).

Therefore, the purpose of the present study is to explore predictors of successful weaning off prolonged mechanical ventilation among the elderly patients in a big respiratory care facility in central Israel.

Methodology

Study design

The study is a retrospective chart review study.

Participants

The subjects of the present study are mechanically ventilated patients which were admitted to the respiratory care unit of a large long-term facility for the elderly in central Israel in 2008-2010. The unit is comprised of two wards with room for a total of 72 ventilated patients. The doctor-patient ratio in the unit is 1:10 and the nurse-patient ratio is 1:6. Consultation services are provided to patients by experts as necessary. Admission criteria to the unit includes prolonged mechanical ventilation (i.e. at least 3 weeks of ventilation), presence of a tracheostomy tube, hemodynamic stability, positive end expiratory pressure ≤ 8 cm H₂O, FiO₂ < 60%, and failure of weaning attempts in the referring general hospital ward. Criteria for readiness to begin weaning are systematically evaluated each day to allow prompt initiation of weaning as soon as the patient is ready. The weaning protocol in the unit includes therapist-driven protocols. Discharge from the unit is based on successful wean or failure of multiple weaning attempts after all potential impediments to weaning have been identified and addressed.

Prolonged ventilated patients who were deemed unlikely to be weaned, patients who were transferred from the respiratory care unit to another specialized unit and were not readmitted to the respiratory care unit, and patients who died during their stay in the unit, were excluded from the study. The remaining 58 patients were the subjects of the present study. Subjects were 64-89 years old. Most of them (> 80%) were COPD patients, with COPD exacerbation as the cause of respiratory failure leading to prolonged mechanical ventilation.

Measurements and Procedures

Data collection was performed by retrospective analysis of patients' medical records. The patients were divided into two groups: those who had been successfully weaned during their stay in the respiratory care unit and those whose weaning had failed. Successful weaning was defined as independent breathing through a tracheostomy for at least 7 consecutive days during the 60 days since admission to the unit. Failed weaning was defined as not managing to achieve independent breathing for at least 7 consecutive days during the 60 days since

admission. A period of 60 days was set as a time frame according to the evidence that if a patient fails to wean from ventilator dependence within 60 days, he will probably not do so later (Ambrosino & Gabbrielli, 2010). For each of the two groups, demographic (age and gender) and clinical data upon admission to the unit were collected. Since Norton Scale score and blood gases were parameters that were likely to change during the patients' stay in the unit, and since all the participants were on mechanical ventilation for at least 30 days during their stay in the respiratory care unit, Norton Scale score and blood gases were collected twice: on admission to the unit (1) and 30 days post-admission (2). Clinical data that were collected: Ventilation time pre-admission to the unit

Success or failure of SBT (spontaneous breathing trial), i.e. whether a patient managed to breathe on CPAP (continuous positive airway pressure) for a period of 30 min. SBT was initiated as soon as a patient was considered ready for weaning, according to clinical assessment, subjective indices and objective measurements. In patients who did not tolerate the SBT, the discontinuation of mechanical ventilation was done with progressive reduction of the pressure-support level.

Cognitive status, i.e. preserved/demented

BMI (body mass index)

Number of comorbid illnesses, as stated in the patient's medical record. Mild diagnoses such as eczema or mild arthritis were not counted.

Risk of developing ulcers, as measured by the Norton Scale: Norton 1 and 2

Blood tests: levels of albumin, hemoglobin, creatinine, urea, PO₂(1), PCO₂(1), HCO₃(1), pH(1); and PO₂(2), PCO₂(2), HCO₃(2), pH(2)

Ethical Considerations

The study was approved by the facility's Helsinki Committee.

Data Analysis

Data analysis was performed with the SPSS program (SPSS 19.0, Chicago, Illinois). Continuous variables such as ventilation time until admission to the unit were presented by means and standard deviations (SD). Categorical variables such as cognitive status were presented by percentages. T-tests or Wilcoxon rank sum tests were used to determine the significance of differences in various parameters between those weaned and those not weaned. Multivariate forward logistic regression was

performed to examine the ability of the various factors to predict successful weaning. Factors with a significance of $p < .05$ were considered as statistically significant.

Results

The research findings show that of the 58 elderly patients, 28 were successfully weaned off the prolonged mechanical ventilation, while 30 failed. Table 1 presents the participants' demographic and clinical characteristics. The findings reveal that no significant difference was found between the two groups in age and gender. Additionally, no significant difference was found between the groups in ventilation time before admission to the unit. In contrast, a significant difference was found between the groups by the success or failure of SBT. The findings show that 76% of those weaned performed successful SBT, versus 17% of those not weaned.

No significant differences were found between the groups in cognitive status and BMI upon admission. In fact, most of the participants seemed to be of normal weight. In contrast, a significant difference was found between the groups in the number of comorbidities. Patients that were weaned tended to have less comorbidities, than those not weaned. The findings show that only 3.6% of those weaned had over 10 medical diagnoses, versus 43.3% of those not weaned.

Nearly all participants were at risk of developing pressure ulcers, as measured by Norton Scale scores. However, significant differences were found between the groups in mean scores, both on admission to the unit (10.9 versus 10.3) and 30 days post-admission (11.4 versus 10.3). That is, patients that were weaned seemed to be at a lower risk of developing pressure ulcers, than those not weaned.

Examination of parameters of blood tests upon admission to the unit reveals a significant difference between the groups in creatinine levels. The mean creatinine level was lower among those weaned (0.9 mg %) versus those not weaned (1.4 mg %). Urea levels as well seem to be higher among those not weaned, however, this finding is not statistically significant. Moreover, no significant differences were found between the groups in their albumin and hemoglobin levels. It should be noted that most of the participants were characterized by low albumin and hemoglobin levels.

Examination of parameters related to acid-base balance shows a significant difference between those weaned and those not weaned in PCO₂ levels 30 days post-admission to the unit, and its mean level

was lower among those weaned (39.6 mm Hg) versus those not weaned (44.1 mm Hg). However, no significant differences were found between the two groups in other blood gases parameters. Table 2 presents the results of the multivariate forward

logistic regression. The results show that successful SBT, less comorbidities, and lower PCO₂ levels 30 days post-admission, were found as significant predictors of successful weaning off prolonged mechanical ventilation among the elderly patients.

Table 1: Demographic and clinical characteristics of the participants: Weaned vs. not weaned (N=58)

Variable	Weaned n = 28)(Not weaned (n = 30)	p
Age (years)	69.7±10	68.5±12	NS
Gender male/female (%)	61%/39%	43%/ 57%	NS
Ventilation time pre-admission (days)	40±16.2	42.6±12.2	NS
SBT success/failure (%)	76%/24%	17%/83%	0.001
Cognitive status preserved/demented (%)	59%/41%	63%/37%	NS
BMI	24.8±3.7	24.2±4.3	NS
Comorbidities (%)	1-6 (25%) 7-10 (71.4%) >10 (3.6%)	1-6 (10%) 7-10 (46.7%) >10 (43.3%)	0.02
Norton 1	10.9±1.5	10.3±0.8	0.01
Norton 2	11.4±1.7	10.3±0.8	0.001
Albumin (g %)	3.19±0.3	3.13±0.3	NS
Hemoglobin (g %)	10.4±1.9	10.6±1.5	NS
Urea (mg %)	48.7±26.2	57±34.2	NS
Creatinine (mg %)	0.9±0.38	1.4±0.58	0.036
PO ₂ (mm Hg) (1)	90.8±29.1	88.9±24.1	NS
PCO ₂ (mm Hg) (1)	46±8.4	46.1±9.1	NS
HCO ₃ (mEq/L) (1)	27.3±4.2	28.8±2.6	NS
pH (1)	7.3±0.05	7.3±0.04	NS
PO ₂ (mm Hg) (2)	88.5±16.7	88.9±24.1	NS
PCO ₂ (mm Hg) (2)	39.6±4.6	44.1±8	0.001
HCO ₃ (mEq/L) (2)	27.4±4.1	28.8±2.7	NS
pH (2)	7.3±0.03	7.3±0.04	NS

Note. Data are presented as mean ± SD or %.

Table 2: Multivariate logistic regression for factors predicting successful weaning from prolonged mechanical ventilation among the elderly

Variable	B Coefficient	S.E. Standard error	Wald	Sig.	Exp(B)	95% C.I. for Exp(B)
						Lower
SBT	-3.096	0.864	12.853	.000	.045	.008
Comorbidities	-1.904	0.741	6.597	.010	.149	.035
PCO ₂ (2)	-.202	0.087	5.364	.021	.817	.689

Discussion

In the present study, ability to perform successful SBT was found as a predictor of successful weaning. SBTs have been recognized as the best way to assess whether a patient is able to breathe independently. Moreover, it has been demonstrated that SBTs may hasten the weaning process. SBTs of increasing duration can be used to aid the weaning process (Lermitte & Garfield, 2005). However, weaning success cannot be established by SBT alone (Nemer & Barbas, 2011). Consistently with this statement, in the present study, 17% of patients whose weaning failed, had performed successful SBT.

The number of comorbidities was found as another predictor of successful weaning in the present study. This finding is consistent with other studies, as reviewed by Ambrosino and Gabbrielli (2010), which stated that weaning success seems to strongly depend on patients' complexity and comorbidities.

Another predictor of successful weaning in the present study was lower PCO₂ levels one month post-admission to the unit. However, no significant differences were found in other blood gases parameters. No studies that compared blood gases

parameters of ventilated patients and explored their relation to future weaning success, have been identified. Why this difference in PCO₂ levels existed, and why PCO₂ levels were lower in ventilated patients who were afterwards successfully weaned, is unclear.

Nearly all participants were at risk of developing pressure ulcers. The chronic critically-ill population is almost universally at high risk for pressure ulcers, as typically they are of advanced age, and have multiple comorbid illnesses in addition to debilitation resulting from prolonged mechanical ventilation and immobility (Scheinhorn et al., 2007). Weaned patients were characterized by a lower risk of developing pressure ulcers, especially one month post-admission. This finding is consistent with those of Couchmana, Wetzig, and Coyerc (2007), who found that multiple pressure ulcers predicted failed weaning. The Norton Scale score reflects the patient overall physical condition. Thus, patients who are more physically active and able to participate in self-care, are more likely to sustain the weaning process workload.

Weaned patients were characterized by lower creatinine and urea (however, the latter is not

statistically significant) levels upon admission. Some studies have shown that patients undergoing prolonged mechanical ventilation with lower creatinine and urea levels were well correlated with successful weaning (Wu et al., 2009). On the contrary, Moçin et al. (2013) demonstrated that low serum creatinine may indicate a longer duration of ventilation weaning in COPD patients as a result of muscle wasting/atrophy.

No significant difference was found between the two groups in age and gender. There is controversy on age as a predictor of successful weaning from prolonged mechanical ventilation. Thus, age per se was not a predictor in the study of Pilcher et al. (2005), however, in a pilot study of Epstein, El-Mokadem, and Peerless (2002), subjects successfully weaned off ventilation were younger than those who failed. Similarly, studies present controversial results on gender as a predictor of successful weaning (Pilcher et al., 2005).

No significant difference was found between the groups in ventilation time before admission to the unit, the average ventilation time of all participants pre-admission to the unit being 40 days. This finding suggests that the patients had received similar quality of care at various locations before being admitted to the unit. Additionally, no significant differences were found between the groups in cognitive status, suggesting that demented patients have the potential to be successfully weaned.

No significant differences were found between the groups in BMI. In fact, most of the participants seemed to be of normal weight. This finding is not consistent with that mentioned by Boles et al. (2007), who reported that malnutrition, that is, BMI < 20 is related to weaning difficulty. However, BMI in critically-ill patients may be influenced by fluid imbalance (overload) due to mechanical ventilation, and thus be higher than in reality (O'Brien et al., 2012).

Most of the participants were characterized by low albumin and hemoglobin levels upon admission. The etiology of hypoalbuminemia on long-term care hospital admission is most likely multifactorial, with the catabolic effects of the inflammatory response, difficulties with provision of nutrition in the ICU, and fluid balance (overload) playing roles in most patients. Similarly, anemia is a common comorbid condition in the ICU, and is found in virtually all critically ill patients (Scheinhorn et al., 2007). In the present study albumin levels were not found associated with weaning success. This result is not

consistent with those of other studies (Modawal et al., 2002; Chan et al., 2011). Moreover, hemoglobin levels were not found associated with weaning success. Boles et al. (2007) referred to the considerable debate as to the desired hemoglobin level when considering whether a patient is suitable for weaning.

The study has several limitations. It is observational and retrospective, therefore, making it difficult to establish cause and effect. Additionally, it was conducted in a single institution, thus possibly hampering generalizability of the findings to the general population of elderly patients on prolonged mechanical ventilation. Moreover, the sample size is small, which means the likelihood of Type II errors is substantial.

Conclusion

In conclusion, elderly patients that are likely to be successfully weaned from prolonged mechanical ventilation during two months post-admission to the respiratory care unit, are characterized by successful SBT, less comorbidities, a lower risk of developing pressure ulcers according to the Norton Scale both upon admission to the respiratory care unit and one month post-admission, lower creatinine levels upon admission, and lower PCO₂ levels one month post-admission. Successful SBT, less comorbidities, and lower PCO₂ levels one month post-admission, seem to be significant predictors of successful weaning off prolonged mechanical ventilation among the elderly patients. These factors might serve physicians as a predictive tool of weaning outcome of the elderly patients from prolonged mechanical ventilation.

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