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The Effect of a Mechanical Ventilation Discontinuation Protocol in Patients with Simple and Difficult Weaning: Impact on Clinical Outcomes

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ABSTRACT

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Objective: To determine whether the utilization of an RT-driven mechanical ventilation weaning protocol is associated with improvement in clinical outcomes within a group of patients with simple and difficult weaning.

Design: Retrospective analysis of prospectively collected data obtained during a quality improvement project.

Patients: A total of 803 mechanically ventilated consecutive patients admitted to the intensive care unit of an academic tertiary care hospital

Interventions: RT-driven weaning protocol vs. physician-driven weaning strategy

Measurements and Main Results: Of 803 patients, 651 with simple and 131 with difficult weaning were included in the analysis. Within the group of subjects with simple weaning, 514 (79%) patients were weaned with utilization of the RT-driven protocol. Among subjects with difficult weaning, 101(77.1%) were liberated with the aforementioned protocol. A multivariate analysis including APACHE II, BMI, and type of primary ICU team under which patients were admitted revealed a significant statistical difference in 28-day ventilator free-days supporting the utilization of RT-driven protocols over physician driven strategies. Specifically, RT-driven protocols increased ventilator-free days by 20.92% and 68.2% among patients with simple and difficult weaning, respectively. A multivariate analysis for the assessment of ICU mortality and extubation failure did not show any impact of RT-driven protocol compared with physician-driven strategy.

Conclusions: RT-driven weaning protocols increase ventilator-free days among patients with simple and difficult weaning, compared with a physician-driven strategy. RT-driven protocols do

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not show significant differences in regard to ICU mortality or extubation failure when compared with a physician driven strategy.

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INTRODUCTION

The process of mechanical ventilation discontinuation consists on a systematic number of steps, which involve screening patients for reversal of the underlying cause of respiratory failure, spontaneous breathing trial (SBT), and assessment of airway patency. Over the last few years, guidelines on ventilator discontinuation have been published allowing clinicians to organize their practice, but also providing them with flexibility to fill existing gaps when uncertainty remained.[1] Nevertheless, with the current need of standardization of 'best-care-practices', the evaluation and application of respiratory care protocols have dramatically expanded. Particularly, mechanical ventilation weaning protocols have been studied since 1989[2], and the number of publications have grown ever since.[3] In fact, based on a survey of Directors of Respiratory Therapy Departments published in 2012, 96.2% of surveyed hospitals (N=663) responded that they relied on protocols for ventilator management.[4]

Recently, an international task force on ventilator discontinuation recommended categorization of weaning patients into 3 groups: a- simple weaning, defined as successful liberation and extubation after the first SBT; b- difficult weaning, defined as patients who require up to 3 SBTs or as long as 7 days after the initial SBT attempt; and c- prolonged weaning, defined as the need of more than 3 SBTs or more than 7 days after the first SBT.[5] Despite clear evidence supporting the utilization of mechanical ventilation weaning protocols in clinical practice, many gaps in our understanding still remain. Specifically, how do ventilator protocols perform when applied to patients with simple weaning compared with those in whom weaning is difficult or prolonged? In order to answer the aforementioned question, we assessed a consecutive series of mechanically ventilated patients admitted to the Intensive Care Unit at Creighton University Medical Center. These patients underwent the process of weaning from the

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ventilator, based on a respiratory therapist (RT)-driven weaning protocol or a physician-driven weaning order. We aimed to compare the effect on clinical outcomes of a mechanical ventilation liberation protocol vs. a physician-ordered weaning strategy, within groups of patients with simple and difficult weaning.

METHODS

In September 2011, Creighton University Medical Center (CUMC) adopted a mechanical ventilation weaning protocol (Figure 1). This protocol was approved based on prior evidence suggesting benefits of RT-driven weaning protocols compared with physician-ordered weaning strategies. Hence, as an institutional policy, all patients in our mixed (medical, surgical, trauma, and neurological) ICU started to be liberated from mechanical ventilation following the previously described protocol, unless the attending physician of the primary service 'opted-out' from protocol participation. The decision to opt-out was based on physician preference, physician comfort and prior training. In order to assess the clinical effect of opting-out from the protocol, we initiated a quality improvement (QI) project to assess whether this decision (opting-out) was associated with worse clinical outcomes. This study was exempt from the CUMC institutional review board. From September 2011 to August 2012, a group of respiratory therapists initiated a prospective collection of data on every mechanically ventilated patient admitted to the ICU at CUMC. Demographic information, severity of disease based on the *Acute Physiology and Chronic Health Evaluation II* (APACHE II) score, diagnosis on ICU admission, type of primary ICU team (medical, surgical, trauma, neuro), length of stay on mechanical ventilation per intubation episode, weaning attempts per intubation episode, need of re-intubation or non-invasive positive pressure ventilation (NIV) within 48 hours post-extubation, need of tracheostomy, and ICU mortality were prospectively collected on a daily basis.

In the present study, we retrospectively reviewed the data to assess whether opting-in vs. opting-out of a ventilator weaning protocol affected clinical outcomes in patients with simple or difficult weaning. All patients who were deemed ready for weaning underwent a spontaneous breathing trial after fulfilling certain parameters, as shown in figure 1). We divided the consecutive series of patients according to the number of weaning attempts in the following groups: simple weaning (1 attempt), difficult weaning (more than 1 and up to 3 attempts or upto 7days after initial spontaneous breathing trial), and prolonged weaning (more than 3 attempts or more than 7 days after the initial spontaneous breathing trial.). Patient with prolonged weaning were not included in the analysis, as many of them were transferred to long-term acute care facilities precluding evaluation of outcomes. Within the simple weaning and difficult weaning groups, we divided the patients based on whether the attending physicians opted-in or out of the ventilator discontinuation protocol. Clinical outcomes were compared between those groups. Of note, patients who were re-intubated after 48 hours of extubation were considered independent patients. The primary outcome of interest was ventilator-free days at 28 days. Secondary outcomes were extubation failure, defined as the need of re-intubation or NIV within 48 hours after extubation, and ICU mortality. Furthermore, within each group (simple or difficult weaning groups) we assessed the outcomes mentioned above according to the type of primary ICU team (medical, surgical, trauma, neuro) the patients were admitted to, and their severity on admission. Every patient who was opted in, received sedation vacation in the morning and the weaning protocol was initiated when RAAS was 0 to -2. In the opt out-group sedation vacation and weaning was per physician preference.

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STATISTICAL METHODS

Within each group, patients were stratified by whether the attending physician opted in or out of the ventilator discontinuation protocol. Continuous baseline demographic and clinical variables are presented as mean ± standard deviation, whereas categorical variables are presented as frequency and percent. Univariate analyses were conducted separately for patients within the simple and difficult weaning groups and employed independent-samples *t*-tests and Fisher's exact tests for continuous and categorical variables, respectively.

We evaluated for differences between patients whose physician opted in or out of the ventilator discontinuation protocol in both ventilator free days and the ratio of ventilator free days to length of stay after adjusting for APACHE II score, body mass index (BMI), and the type of ICU. For both primary outcomes, multiple regression models were estimated separately within the simple and difficult weaning groups.

Two issues were encountered when modeling data for both primary outcomes. First, for ventilator free days, severely negatively skewed residuals were observed within the analyses for both groups. Therefore, the number of ventilator free days was reflected so the value of the highest number of ventilator free days became the lowest value and vice versa. Reflecting the data resulted in distributions of residuals with severe positive skewness, which was accounted for by using a natural log transformation of the reflected ventilator free day values. It is important to note that both reflecting the outcome data and using a natural log transformation significantly affected how regression estimates are interpreted. Specifically, using reflected data resulted in positive regression estimates being associated with decreases in the ventilator free days. Further, a natural log transformation produced regression estimates that are associated with changes in the natural log ventilator free days. For example, using reflected and natural log transformed ventilator free days, a regression estimate of +2.0 would indicate that for every one-unit increase in the independent variable, the natural log of ventilator free days decreases by 2.0.

Second, for the ratio of ventilator free days to length of stay, severe positive skewness was indicated, which was remedied by using a natural log transformation. Similar to above, this transformation affected interpretation, with increases in an independent variable resulting in increases in the natural log of the ratio of ventilator free days to length of stay. For all primary analyses, non-constant variance was indicated in residual values, which was accounted for using a technique described by MacKinnon and White.[15]

For the secondary outcomes, multiple logistic regression analyses were employed to evaluate differences in both the probability of ICU death and extubation failure between patients whose physician opted in or out of the ventilator discontinuation protocol after adjusting for APACHE II score, BMI, and the type of ICU. No differences in ICU death could be evaluated within the difficult weaning group as only one patient died.

For all regression-type models, continuous predictors were centered near their mean. All analyses were conducted using SAS v. 9.3 (SAS Institute, Inc, Cary, NC); $p < .05$ was considered statistically significant.

RESULTS

Over the year post-implementation of the RT-driven ventilator weaning protocol, 803 patients were admitted and mechanically ventilated in our ICU. Of those patients, 651 (81.1%) required simple weaning, whereas 131 (16.3%) and 1 (0.1%) were difficult and prolonged weaning cases, respectively. Demographic information, APACHE II scores, and type of required ICUs for all patients in the simple and difficult weaning groups are shown in Table 1. Among patients who required simple weaning, 514 (79.0%) were weaned with the RT-driven protocol, whereas 137 (21.0%) were liberated from the ventilator by physician orders. In the group of patients with difficult weaning, 101 (77.1%) used the weaning protocol, whereas only 30 (22.9%) were weaned based on physician orders. Of these patients, 49 (simple n = 48; difficult n = 1) died in the ICU and an additional 18 were missing predictor variables (simple n = 16; difficult n = 2). Because the regression-type models used in this study only consider patients with complete data, sample sizes differed between analyses. That is, a patient with missing data on any variable was excluded from analysis. Therefore, given the missing data, the primary analyses included 590 patients in the simple weaning group and 129 patients in the difficult weaning group, ICU death included 636 patients (simple weaning group only), and extubation failure included 638 and 130 patients for the simple and difficult weaning groups, respectively.

Results for ventilator free days are presented in Table 2. For the simple weaning group, a statistically significant difference in the number of ventilator free days was indicated for patients whose attending physician opted in or out of the ventilator discontinuation protocol. After adjusting for APACHE II score, BMI, and ICU type, opting in was associated with a 20.92% increase in ventilator free days compared to opting out (i.e., $((1/exp(-0.19)) - 1)*100$). As explained in the statistical methods section, the increase in ventilator free days associated with a negative regression coefficient is a direct result reflecting ventilator free days prior to analysis. A similar pattern of results was observed for the difficult weaning group, in that, after adjusting for APACHE II score, BMI, and ICU type, opting in was associated with a 68.20% increase in ventilator free days compared to opting out.

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Results for the ratio of ventilator free days to length of stay are presented in Table 3. For the difficult weaning group, a statistically significant difference in the ratio of ventilator free days to length of stay was indicated for patients whose attending physician opted in or out of the protocol. After adjusting for APACHE II score, BMI, and ICU type, opting in was associated with an 32.29% increase in this ratio compared to opting out (i.e., (1 – *exp*(-0.39))*100). For the simple weaning group, opting in or out of the ventilator discontinuation protocol was not associated with changes in the ratio.

Results for ICU death and extubation failure are presented in Tables 4 and 5. No statistically significant differences were observed between patients with attending physicians who opted in or opted out for the probability of death or extubation failure.

DISCUSSION

The main findings of this study are: 1- the application of a mechanical ventilation liberation protocol increases ventilator-free days compared with a physician-driven strategy. The positive result is seen in patients with both simple and difficult weaning, and after adjustments by severity of disease, BMI, and type of ICU; 2- When the number of ventilator free days were adjusted for the total number of hospital days, opting out of the protocol resulted in decrease in ventilator free days for patients in the difficult to wean group; 3-There are no differences in ICU mortality and extubation failure with or without the utilization of the aforementioned protocol in both simple and difficult weaning groups.

To the best of our knowledge, this is the first study that compares an RT-driven weaning protocol vs. a physician-driven strategy within groups of patients with different weaning complexity (simple and difficult). Prior studies assessed the effectiveness of RT-driven weaning protocols but did not specify whether patients were classified as simple, difficult or prolonged weaning. Specifically, Ely and colleagues[6] studied 300 mechanically ventilated subjects in medical and coronary ICUs. After a daily screening by RTs and nurses, the intervention group underwent a 2-hour spontaneous breathing trial with CPAP of 5 cm H2O, whereas the control group was liberated based on standard practice. Notably, the study revealed a reduction of duration on mechanical ventilation, re-intubation rate, and costs within the group assigned to the SBT strategy. The following year, Kollef and collleagues[7] published a study comparing a protocol-directed vs. a physician-directed weaning strategy. Three hundred and fifty-seven subjects admitted to the medical and surgical ICUs were included. Patients randomized to the protocol-directed strategy had a median duration on mechanical ventilation of 35 hours, compared with 44 hours among the subjects included in the physician-directed liberation strategy ($p=0.024$). Differences in hospital mortality and costs were not statistically significant between both groups. It is noteworthy to mention that Ely's[6], Kollef's[7] and our study included patients with similar severity of disease (average APACHE II scores of 18.85, 17.05, and 19.75, respectively). Nevertheless, ICU mortality comparing each of these studies had important variation, with ranges of 22-23% (Ely), 38-40% (Kollef), and 1-13% (ours). These differences may be related to improvement in overall ICU care over the last 16 years, and further application of evidence-based bundles (sepsis, low-tidal volumes, etc.). A third study, published by Marelich and colleagues[8], randomized 335 patients from medical and surgical ICUs to a 30-minute SBT performed either by PSV or T-piece vs. standard ICU care. Patients included in the SBT strategy had a decreased duration of ventilation and a trend toward a reduced rate of ventilator-associated pneumonia. Interestingly, this study applied different weaning strategies depending on whether

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patients had been ventilated for more or less than 72 hours. Subjects ventilated less than 72 hours were liberated after an SBT, whereas those ventilated for > 72 hours were gradually weaned to specific goals and then were performed an SBT. A more recent study published by Krishnan and colleagues[9] found no differences in clinical outcomes when comparing an RT-driven weaning protocol vs. a physician-driven strategy. Interestingly, the staffing model applied in their closed ICU could have explained the lack of differences in outcomes. Particularly, the usual group had a staffing model with a physician-hour/bed/day of 9.5, compared with Ely[6] (3.5 hours), Kollef[7] (4.0 hours), Marelich[8] (4.7 hours), and ours (≅4.5 hours), which had a lower physician-hour/bed ratio. Therefore, it is likely that the control group in Krishnan study received a higher intensity care compared with most usual practices.

Among studies that addressed weaning in organ-specific ICUs, Navalesi and colleagues[10] randomized 318 subjects from a neuro-ICU to a liberation protocol consisting of a 1-hours SBT vs. usual care (physician-driven strategy). There was a lower incidence of extubation failure (5% vs. 12%, p =0.047) in the intervention group compared with the control one. Secondary outcomes, such as length of stay on mechanical ventilation and ICU, rate of tracheostomy, and ICU mortality were not different between groups. Finally, a recent meta-analysis by Blackwood and colleagues[11], which included 11 randomized-control trials (1,971 patients) revealed that the utilization of weaning protocols were associated with a 25% reduction in the mean duration of mechanical ventilation (p=0.006), with highest impact on surgical ICU patients.

Our work adds to the current knowledge as this is the first study that addresses the effect of a weaning protocol on patients with different weaning classification. Secondly, we studied a large number of patients. Seven hundred and eighty two mechanically ventilated subjects were included in the analysis, which is the largest number of weaning patients considered in a weaning

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study. Last, all patients were admitted in one mixed ICU, which shares same protocols for other ICU aspects (sepsis bundle, low-tidal volumes, glucose control, etc.). Therefore, it is unlikely that our results are associated to heterogeneity in patient care. Despite the aforementioned strength, our study still presents several limitations. First, as we analyzed our data retrospectively, it is likely that we incurred on selection and information biases. We did not collect the reasons why providers opted-out from the protocol. It is possible that some of these patients had contraindications to undergo an RT-driven protocol (i.e. need for deep sedation due to airway instability). Secondly, there were imbalances in the distribution of patients within groups. For example, more post-cardiac surgery patients were included in the opt-in group, whereas post-abdominal surgery subjects were most frequently weaned by physician-driven strategies. These imbalances may have impacted in the results, as post-cardiac surgery patients usually remain shortly on mechanical ventilation.[12, 13] Conversely, post-abdominal surgery patients are exposed to multiple complications[14] (i.e. abdomen compartment syndrome, atelectasis, etc.), which can prolong ventilation duration. By performing multivariate analysis we attempted to adjust based on type of ICU patients. However, our analysis did not include adjustments within surgical ICU patients. Last, the approach to weaning in the physician-driven group may have been affected by behavioral reasons. Providers within certain ICUs may have decided to wean patients in a more conservative fashion based on their prior experiences, training, etc.

In summary, our study demonstrated that the utilization of an RT-driven weaning protocol increases ventilator-free days compared with a physician-driven strategy. This positive result is seen in patients with simple and difficult weaning, and also when adjusted for severity of disease, BMI, and type of ICU. Rate of extubation failure and ICU mortality are not affected by weaning strategies within these two groups.

REFERENCES

1. MacIntyre NR, Cook DJ, Ely EW, Jr., Epstein SK, Fink JB, Heffner JE, 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(6 Suppl):375S-95S.
2. Tomlinson JR, Miller KS, Lorch DG, Smith L, Reines HD, Sahn SA. A prospective comparison of IMV and T-piece weaning from mechanical ventilation. Chest. 1989 ;96(2):348-52.
3. Haas CF, Loik PS. Ventilator discontinuation protocols. Respir Care. 2012 ;57(10):1649-62.
4. Kacmarek RM, Barnes TA, Durbin CG, Jr. Survey of directors of respiratory therapy departments regarding the future education and credentialing of respiratory care students and staff. Respir Care. 2012 ;57(5):710-20.
5. Boles JM, Bion J, Connors A, Herridge M, Marsh B, Melot C, et al. Weaning from mechanical ventilation. Eur Respir J. 2007 ;29(5):1033-56.
6. Ely EW, Baker AM, Dunagan DP, Burke HL, Smith AC, Kelly PT, et al. Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. N Engl J Med. 1996 ;335(25):1864-9.
7. Kollef MH, Shapiro SD, Silver P, St John RE, Prentice D, Sauer S, et al. A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. Crit Care Med. 1997;25(4):567-74.
8. Marelich GP, Murin S, Battistella F, Inciardi J, Vierra T, Roby M. Protocol weaning of mechanical ventilation in medical and surgical patients by respiratory care practitioners and nurses: effect on weaning time and incidence of ventilator-associated pneumonia. Chest. 2000 ;118(2):459-67.

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9. Krishnan JA, Moore D, Robeson C, Rand CS, Fessler HE. A prospective, controlled trial of a protocol-based strategy to discontinue mechanical ventilation. Am J Respir Crit Care Med. 2004;169(6):673-8.
10. Navalesi P, Frigerio P, Moretti MP, Sommariva M, Vesconi S, Baiardi P, et al. Rate of reintubation in mechanically ventilated neurosurgical and neurologic patients: evaluation of a systematic approach to weaning and extubation. Crit Care Med. 2008; 36(11):2986-92.
11. Blackwood B, Alderdice F, Burns K, Cardwell C, Lavery G, O'Halloran P. Use of weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: Cochrane systematic review and meta-analysis. BMJ. 2011;342:c7237.
12. Gruber PC, Gomersall CD, Leung P, Joynt GM, Ng SK, Ho KM, et al. Randomized controlled trial comparing adaptive-support ventilation with pressure-regulated volume-controlled ventilation with automode in weaning patients after cardiac surgery. Anesthesiology. 2008;109(1):81-7.
13. Dongelmans DA, Veelo DP, Paulus F, de Mol BA, Korevaar JC, Kudoga A, et al. Weaning automation with adaptive support ventilation: a randomized controlled trial in cardiothoracic surgery patients. Anesth Analg. 2009;108(2):565-71.
14. Sachdev G, Napolitano LM. Postoperative pulmonary complications: pneumonia and acute respiratory failure. Surg Clin North Am. 2012; 92(2):321-44, ix.
15. MacKinnon JG, White H. Some heteroscedasticity-consistent covariance matrix estimators with improved finite sample properties. J Econometrics 1985; 29:305-325.

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Table 1. Univariate Analyses of Demographic and Clinical Variables

	Simple Weaning			Difficult Weaning		
	Opt In (*n* = 500)	Opt Out (*n* = 136)	*p*	Opt In (*n* = 97)	Opt Out (*n* = 136)	*p*
Age, y	57.95 ± 18.21	54.61 ± 18.97	0.062	61.16 ± 15.07	54.50 ± 18.29	<0.05
Weight, kg	84.65 ± 24.69	84.11 ± 24.68	0.822	87.48 ± 33.22	87.02 ± 22.06	0.943
Height, in	67.81 ± 3.93	67.83 ± 4.45	0.944	67.32 ± 4.01	67.83 ± 4.15	0.543
BMI	28.49 ± 8.40	28.15 ± 7.77	0.678	29.44 ± 11.90	30.86 ± 11.38	0.565
APACHE	19.23 ± 6.17	19.91 ± 6.58	0.265	19.74 ± 5.52	20.20 ± 7.25	0.750
Vent Free Days (VFD)	24.39 ± 7.08	22.53 ± 8.47	<0.05	23.26 ± 5.54	20.68 ± 6.66	<0.05
Length of Stay (LOS)	12.44 ± 17.22	17.96 ± 23.67	<0.05	18.84 ± 14.97	26.10 ± 23.33	<0.05
VFD-to-LOS Ratio	0.23 ± 0.30	0.26 ± 0.31	0.466	0.24 ± 0.20	0.35 ± 0.25	<0.05
Male	321 (64.1)	92 (68.7)	0.356	56 (56.0)	16 (53.3)	0.836
ICU Type						
Medical	228 (45.5)	48 (35.8)	0.050	47 (47.0)	9 (30.0)	0.141
Surgical	175 (34.9)	38 (28.4)	0.180	34 (34.0)	13 (43.3)	0.390
Trauma	98 (19.6)	48 (35.8)	<0.05	19 (19.0)	8 (26.7)	0.442
ICU Death	31 (6.2)	14 (10.4)	0.091	1 (1.0)	0 (0.0)	1.000
Surgery ICU[a]						
Cardiac	106 (60.6)	6 (15.8)	<0.05	26 (76.5)	1 (7.7)	<0.05
Abdominal	49 (28.0)	26 (68.4)	<0.05	4 (11.8)	6 (46.2)	<0.05
Thoracic	17 (9.7)	3 (7.9)	1.000	3 (8.8)	2 (15.4)	0.607
Trauma ICU[b]						

Cardiac	3 (3.1)	1 (2.1)	1.000	1 (5.3)	0 (0.0)	1.000
Abdominal	15 (15.3)	6 (12.5)	0.803	2 (10.5)	0 (0.0)	1.000
Thoracic	14 (14.3)	7 (14.6)	1.000	2 (10.5)	0 (0.0)	1.000

Values are presented as either mean ± SD or as *n* (%).

[a] Simple Opt-In *N* = 175; Simple Opt-Out *N* = 38; Difficult Opt-In *N* = 34; Difficult Opt-Out *N* = 13.

[b] Simple Opt-In *N* = 98; Simple Opt-Out *N* = 48; Difficult Opt-In *N* = 18; Difficult Opt-Out *N* = 8.

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Table 2. Multiple Regression Results for Number of Ventilator Free Days[a,b]

	Simple Weaning			Difficult Weaning		
	Estimate	*SE*	95% CI	Estimate	*SE*	95% CI
Intercept	1.13	0.07		2.03	0.16	
APACHE II (0=20)	**0.03**	0.01	0.02 to 0.04	0.02	0.01	0.00 to 0.04
BMI (0=30)	0.00	0.00	-0.01 to 0.01	0.00	0.01	-0.01 to 0.01
ICU Type						
Surgery vs. Medical	**-0.37**	0.06	-0.49 to -0.25	**-0.68**	0.15	-0.97 to -0.38
Trauma vs. Medical	0.09	0.08	-0.08 to 0.25	0.35	0.18	0.00 to 0.70
Surgery vs. Trauma	**-0.46**	0.08	-0.62 to -0.29	**-1.03**	0.18	-1.38 to -0.68
Opt Out vs. Opt In	**-0.19**	0.07	-0.33 to -0.04	**-0.52**	0.15	-0.82 to -0.21

[a] Bolded estimates are statistically significant at $p < .05$.

[b] Because we natural log transformed ventilator free days, a one-unit increase in any predictor variable is associated with a change in *natural log* of ventilator free days. Second, because the number of ventilator free days was reflected prior to analysis, a positive regression estimate (i.e., Estimate) is associated with a *decrease* in ventilator free days.

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Table 3. Multiple Regression Results for Ratio of Ventilator Free Days to Length of Stay[a,b]

	Simple Weaning			Difficult Weaning		
	Estimate	*SE*	95% CI	Estimate	*SE*	95% CI
Intercept	-1.79	0.12		-0.93		
APACHE II (0=20)	**0.03**	0.01	0.02 to 0.05	0.02	0.02	-0.01 to 0.05
BMI (0=30)	-0.01	0.01	-0.02 to 0.01	0.00	0.01	-0.01 to 0.02
ICU Type						
Surgery vs. Medical	**-1.17**	0.11	-1.39 to -0.96	**-1.13**	0.20	-1.53 to -0.73
Trauma vs. Medical	0.13	0.13	-0.12 to 0.39	0.12	0.24	-0.35 to 0.59
Surgery vs. Trauma	**-1.31**	0.12	-1.56 to -1.05	**-1.25**	0.24	-1.72 to -0.78
Opt Out vs. Opt In	-0.01	0.13	-0.24 to 0.22	**-0.62**	0.21	-1.03 to -0.22

[a] Bolded estimates are statistically significant at $p < .05$.

[b] Because we natural log transformed the ratio, a one-unit increase in any predictor variable is associated with a change in the *natural log* of the ratio.

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Table 4. Multiple Logistic Regression Results for ICU Death for Simple Weaning Group[a]

	Estimate	*SE*	OR	95% CI for OR
Intercept	-1.78	0.39		
APACHE II (0=20)	**0.12**	0.02	1.13	1.07 to 1.18
BMI (0=30)	0.00	0.02	1.00	0.96 to 1.04
ICU Type				
Surgery vs. Medical	-0.81	0.47	0.45	0.17 to 1.16
Trauma vs. Medical	-0.66	0.40	1.93	0.88 to 4.27
Surgery vs. Trauma	-1.47	0.52	0.23	0.08 to 0.63
Opt Out vs. Opt In	-0.39	0.36	0.68	0.34 to 1.36

[a] Bolded estimates are statistically significant at $p < .05$.

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Table 5 Multiple Logistic Regression Results for Extubation Failure[a]

	Simple Weaning				Difficult Weaning			
	Estimate	*SE*	OR	95% CI for OR	Estimate	SE	OR	95% CI for OR
Intercept	-2.37	0.42			-1.75	0.71		
APACHE II (0=20)	-0.02	0.03	0.98	0.93 to 1.04	0.03	0.05	1.03	0.93 to 1.14
BMI (0=30)	-0.04	0.03	0.96	0.91 to 1.01	**0.06**	0.02	1.06	1.02 to 1.11
ICU Type								
Surgery vs. Medical	-0.84	0.45	0.43	0.18 to 1.05	0.11	0.70	1.11	0.28 to 4.42
Trauma vs. Medical	-0.98	0.53	0.37	0.13 to 1.06	-0.60	0.97	0.55	0.08 to 3.66
Surgery vs. Trauma	0.14	0.61	1.15	0.35 to 3.80	0.71	0.97	2.02	0.30 to 13.64
Opt Out vs. Opt In	-0.30	0.43	0.74	0.32 to 1.72	-0.62	0.65	0.54	0.15 to 1.92

[a] Bolded estimates are statistically significant at $p < .05$.

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Figure 1.

1. The ventilator patient on the ICU must meet all of the following criteria to enter ventilator-weaning protocol.

2. Hemodynamic stability
   HR>50 and <120
   BP >90 and <180
   No pressors
   SpO2 > 90%
   FIO2 $\leq$ 0.50
   PEEP $\leq$ 8 CWP

3. Presence of spontaneous breathing

4. Obtain the following weaning parameters on PSV of 0 and PEEP of 0:
   Tidal Volume (TV) ------------------------------------ Goal > 5 cc/kg
   Negative Inspiratory Force (NIF) ---------------------Goal more negative than – 20 Cm H2O
   Rapid Shallow Breathing Index (RSBI)--------------Goal < 105/L
   Minute ventilation (VE) -------------------------------Goal < 15 L/min

If ALL parameters are within goal, then proceed with spontaneous breathing trial (SBT). If AT LEAST one parameter not at goal, leave patient on prior mode and contact physician.

5. SBT: PSV of 5 cm H2O and PEEP of 5 cm H2O 60 minutes

6. Assess for signs of distress &/or failure during SBT, as follows:

- RR >35
- SpO2 < 90%
- Vt $\leq$ 5ml/kg IBW w/PSV
- Increased/decrease HR or blood pressure by 20% from baseline
- Significant agitation/anxiety/diaphoresis

If any of above signs is present, place the patient back on previous ventilator settings and notify physician. Reevaluate in AM. If above parameters are acceptable, the patient is WEANED.

7. Assess for extubation using the following criteria:
- Adequate cough/gag reflex
- Minimal secretions (suction no more often than q2 hours)

8. Contact physician on service responsible for ventilator management for extubation order.