CHEST

Official publication of the American College of Chest Physicians

Cough Peak Flows and Extubation Outcomes*

Mihai Smina, Adil Salam, Mohammad Khamiees, Pritee Gada, Yaw Amoateng-Adjepong and Constantine A. Manthous

Chest 2003;124;262-268
DOI 10.1378/chest.124.1.262

Cough Peak Flows and Extubation Outcomes*

Mihai Smina, MD; Adil Salam, MD; Mohammad Khamiees, MD; Pritee Gada, MD; Yaw Amoateng-Adjepong, MD, PhD; and Constantine A. Manthous, MD, FCCP

Background: **Semiobjective methods of quantifying cough strength and endotracheal secretions have been demonstrated to predict extubation outcomes of patients who have passed a spontaneous breathing trial (SBT).**
Hypothesis: **Cough strength, measured by voluntary cough peak expiratory flow (PEF), and endotracheal secretions, measured volumetrically, predict extubation outcomes of patients who have passed an SBT.**
Patient population: **Critically ill patients admitted to the medical ICU of a 300-bed community teaching hospital.**
Methods: **All patients who passed an SBT and were about to be extubated were studied. The best of three cough attempts, measured with an in-line spirometer, and the average hourly rate of suctioned secretions prior to extubation were recorded with other weaning parameters and demographic data.**
Results: **Ninety-five patients were studied before and after 115 extubations. There were 13 unsuccessful extubations. There were no differences in age, gender, duration of intubation, or APACHE (acute physiology and chronic health evaluation) II scores between successful and unsuccessful extubations. The magnitude of endotracheal secretions was not associated with outcomes. The PEF of patients with unsuccessful extubations was significantly lower than that of those with successful extubations (64.2 ± 6.8 L/min vs 81.9 ± 2.7 L/min, p = 0.03). Patients with unsuccessful extubations stayed longer in the ICU than those with successful extubations (11.7 ± 2.1 days vs 5.3 ± 0.4 days, p = 0.009). Those with PEF ≤ 60 L/min were five times as likely to have unsuccessful extubations and were 19 times as likely to die on that hospital stay. PEF and the rapid shallow breathing index were independently associated with extubation outcomes, while only the PEF (≤ 60 L/min) was independently associated with in-hospital mortality.**
Conclusion: **These data suggest that cough strength, measured objectively, is a predictor of extubation outcome, morbidity, and mortality.** ***(CHEST 2003; 124:262–268)***

Key words: extubation; mechanical ventilation; mortality; outcomes; weaning

Abbreviations: APACHE = acute physiology and chronic health evaluation; CI = confidence interval; F_{IO_2} = fraction of inspired oxygen; PEF = peak expiratory flow; ROC = receiver operator characteristic; RR = risk ratio; RSBI = rapid shallow breathing index; SBT = spontaneous breathing trial

*From Pulmonary and Critical Care, Bridgeport Hospital and Yale University School of Medicine, Bridgeport, CT.
Manuscript received May 17, 2002; revision accepted October 18, 2002.

Correspondence to: Constantine A. Manthous, MD, FCCP, Bridgeport Hospital, 267 Grant St, Bridgeport, CT 06610; e-mail: pcmant@bpthosp.org

Discontinuation of invasive positive pressure ventilation includes two steps: separation of the patient from the ventilator, and removal of the artificial airway. Liberation from the ventilator occurs when the patient has passed a spontaneous breathing trial (SBT) and no longer requires the ventilator. A trial of extubation can follow when caregivers are confident that the endotracheal tube is no longer required. In some patients, a trial of extubation may precede separation from the ventilator if patients are transitioned from invasive to noninvasive mechanical ventilation. Numerous studies have examined the characteristics of "weaning parameters" to predict combined liberation and extubation outcomes.[1,2] In a recent study,[3] we demonstrated that conventional weaning parameters, which are very good at predicting combined outcomes, are not helpful in predicting extubation outcomes of patients who had passed SBTs. Instead, airway parameters, namely cough strength and endotracheal secretions, were highly predictive of extubation outcomes. In that study, the measurement tools of cough strength and magnitude of secretions were semiobjective and therefore may not be reproducible in other ICUs. In the current study, we further examined this hypothesis using objective measurement tools. We hypothesize that the strength of a patient's cough, measured by peak flow, and the magnitude of suctioned endotracheal secretions per hour predict extubation outcomes.

Materials and Methods

The investigational review board of our hospital approved the study protocol. All patients in our medical-cardiac ICUs who were receiving mechanical ventilation via an endotracheal tube between June 2001 and December 2001 were eligible for the study. Patients were assessed when they had successfully completed an SBT and when extubation was about to be performed. In our ICU, weaning is guided by a nonmandatory protocol that is carried out by bedside nurses, respiratory therapists, and resident trainees who are supervised by five board-certified intensivists. Patients who are no longer receiving pressors or inotropes and whose Pao_2/fraction of inspired oxygen (Fio_2) ratio is > 120 are generally assessed, after cessation of sedatives, with 2 to 3 min of unassisted breathing through the endotracheal tube with or without continuous positive airway pressure. Patients whose observed respiratory frequency divided by the tidal volume (rapid shallow breathing index [RSBI]) measured through a spirometer or on continuous positive airway pressure of 5 cm H_2O is < 105 breaths/min/L usually undergo an SBT via T-piece or pressure support ≤ 7 cm H_2O for 0.5 to 2 h. The SBT is terminated if patients have severe distress despite attempts of bedside personnel to attenuate anxiety, increments of heart rate > 20 beats/min or systolic BP > 20 mm Hg, respiratory rate > 35 breaths/min, tidal volumes < 0.3 L, or sustained pulse oximetry desaturations to $< 90\%$ while breathing 50% oxygen. Patients who successfully complete an SBT are further assessed with an arterial blood gas analysis; if the result is favorable (no acute respiratory acidosis and Pao_2/Fio_2 ratio > 120), the patient is considered for a trial of endotracheal extubation. In our ICU, some patients successfully complete the SBT and are not extubated if the clinician feels they still require an artificial airway. Patients were excluded from this study if they were being extubated to comfort care (withdrawal of life-sustaining therapies, no reintubation) or if they had a tracheostomy.

The following data of each patient were gathered: age, ICU admission APACHE (acute physiology and chronic health evaluation) II score measured on admission to the ICU, duration of endotracheal intubation/mechanical ventilation, endotracheal tube size, hemoglobin on the morning of the SBT, peak and plateau airway pressures on mechanical ventilation, arterial blood gas levels on full ventilatory support prior to and during the SBT, RSBI, SBT modality, and cardiorespiratory variables after 30 min of spontaneous breathing.

When patients had passed an SBT and extubation was being considered by their physicians, they were asked to cough into a peak flowmeter placed in series with the endotracheal tube via SIMS Portex (Keene, NH) filters. Patients were positioned at 30 to 45° and coached by study personnel to cough through the endotracheal tube spirometer. The best of three attempts was recorded as the cough peak expiratory flow (PEF). Caregivers were not made aware of the PEF. The peak flowmeter was calibrated with a pneumotachograph using different cough flows of three healthy subjects prior to beginning the study (Fig 1). Endotracheal secretions were routinely collected in a suction trap starting at 6 AM each morning. The volume of suctioned endotracheal secretions per hour, 2 to 6 h prior to endotracheal extubation, was recorded.

Patients were extubated as per instructions of their attending physicians. Patients who remained extubated at 72 h were classified as having a successful extubation, even if they required reintubation later during the same hospitalization. Patients were classified as extubation failures if and only if they required reintubation within 72 h. The reasons for reintubation were categorized into three general groups: (1) hypoxemia, defined as Pao_2/Fio_2 ratio < 120 or pulse oximetry desaturations on a 100% oxygen nonrebreather facemask; (2) hypercapnia, if arterial blood gas analysis revealed acute hypercapnic respiratory failure; and (3) failure to maintain an adequate airway for either mental status changes or inadequate expectoration. Patients were followed up for this study until discharge from the hospital or until death.

For purposes of analysis, PEF, volume of suctioned secretions, RSBI, hemoglobin, admission APACHE II scores, and age were

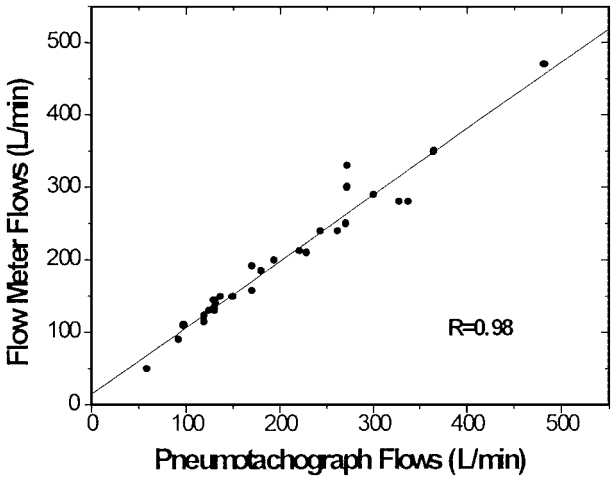

Figure 1. Calibration curve of the Aztech peak flowmeter.

categorized into binary variables. Where appropriate, threshold levels were defined using standard norms. There are no known normative data for PEF in this population. Accordingly, a receiver operator characteristic (ROC) curve was constructed using interim data from the first 72 extubations. An optimum threshold value of 60 L/min (PEF $\leq$ 60 L/min) was obtained. This value was used to categorize PEF in the final analysis. Additionally, a ROC curve was constructed from the complete cohort data. The sensitivity and specificity of using PEF $\leq$ 60 L/min in predicting extubation failure is reported as well.

The main outcome of interest was extubation failure or success. Secondary outcomes considered include in-hospital mortality, and durations of ICU and hospital stay. Risk ratios (RRs) were computed as the preferred measure of the strength of association between the predictive variables and the binary outcomes of interest. Multivariate logistic regression and stratified analyses were used to adjust for confounders, assess effect modifiers, and identify variables that independently predicted extubation outcome and in-hospital mortality. The variables included in the logistic models were determined by the biological plausibility of each variable and/or evidence of an association in the univariate analysis. Also, mean values of the continuous outcome variables were compared across the categories of potential predictors using analysis of variance. Comparisons of median values were made using nonparametric methods (Kruskal-Wallis/Mann-Whitney tests). For grouped data, χ^2 and/or the Fisher exact test were used in comparing differences in proportions between the two groups and in deriving p values. The analyses were facilitated by use of the Epi Info 2000 program[4] (Centers for Disease Control and Prevention; Atlanta, GA) and Statistica (StatSoft; Tulsa, OK); $p < 0.05$ was used to signify statistical significance.

Results

Cohort Characteristics

There were 99 separate hospitalizations involving 95 patients who met eligibility criteria. These patients contributed a total of 115 separate extubations. Their ages ranged from 24 to 93 years (mean ± SE, 63.9 ± 1.7 years; Table 1). Forty-four percent of the patients were men. The patients varied in acuity of illness, with a range of ICU admission APACHE II scores of 4 to 42 (mean, 23.2 ± 0.8). The primary reasons for their ICU admissions and intubation were airway protection (for a variety of medical conditions) in 42 patients, pneumonia in 19 patients, congestive heart failure in 18 patients, COPD exacerbations in 17 patients, asthma in 6 patients, sepsis in 6 patients, cardiac arrest in 5 patients, and pulmonary embolus in 2 patients. Patients were intubated for a median of 3 days (range, 1 to 15 days); 62 patients were weaned by T-piece, and 53 patients were weaned by pressure support or continuous positive airway pressure. The quantity of suctioned endotracheal secretions ranged from 0 to 27 mL/h, with a mean of 6.2 mL/h (median, 4 mL/h). Nine patients had no measurable secretions, whereas six patients had secretions > 20 mL/h. The RSBI was

Table 1—*Selected Patient Characteristics of the Cohort Stratified by Extubation Outcome

Variables	Total Cohort	Extubation Successes	Extubation Failures	p Value
Sex	115	102	13	
Male	51	46	5	
Female	64	56	8	
Age, yr†	63.9 ± 1.7 (68; 24–93)	64.1 ± 1.7 (68; 24–93)	62.5 ± 5.8 (67; 40–85)	0.8
< 65	41	41	5	
≥ 65	58	47	6	
APACHE II score	23.2 ± 0.8 (23; 4–42)	22.9 ± 0.9 (23; 4–42)	25.8 ± 2.5 (26; 14–42)	0.4
< 24	62	56	6	
≥ 24	53	46	7	
Duration of intubation, d	3.4 ± 0.2 (3; 1–15)	3.3 ± 0.2 (3; 1–14)	3.7 ± 0.1 (3; 1–15)	0.7
< 3	53	48	5	
≥ 3	62	54	8	
RSBI, breaths/min/L‡	67.4 ± 2.9 (61; 17–179)	64.9 ± 3.0 (60; 17–179)	86.2 ± 8.4 (88; 28–122)	0.03
< 100	85	78	7	
≥ 100	14	9	5	
Hemoglobin, g/dL	11.1 ± 0.2 (10.9; 7.2–16)	11.2 ± 0.2 (10.9; 8–16)	10.8 ± 0.6 (11; 7.2–14.8)	0.6
< 10	28	23	5	
≥ 10	87	79	8	
PEF, L/min	79.8 ± 2.6 (80; 30–180)	81.9 ± 2.7 (80; 30–180)	64.2 ± 6.8 (55; 40–120)	0.03
≤ 60	34	25	9	0.003
> 60	77	73	4	
Secretions, mL/h	6.2 ± 0.6 (4; 0–27)	6.2 ± 0.6 (4; 0–25)	6.6 ± 2.2 (4.5; 0–27)	0.9
< 10	87	78	9	0.9
≥ 10	25	22	3	
ICU stay, d	6 ± 0.5 (4; 1–26)	5.3 ± 0.4 (4; 1–22)	11.7 ± 2.1 (10; 3–26)	0.009
Hospital stay, d	17.7 ± 1.2 (14; 1–76)	17.0 ± 1.3 (14; 1–76)	23.2 ± 4.3 (15; 9–56)	0.2

*Data are presented as mean ± SE (median; range) or No.

†Based on distinct hospitalizations (n = 99 for total cohort, n = 88 for extubation successes, and n = 11 for extubation failures).

‡All patients had RSBI measured before extubation, and four patients with successful extubation were unable to cough.

measured in 99 patients and ranged from 17 to 179 breaths/min/L (mean, 67 breaths/min/L).

Cough PEFs were measured in all but four separate extubations. These four patients were unable to comprehend the instruction to cough. The PEFs for the whole cohort ranged from 30 to 180 L/min; 31% of measurements were ≤ 60 L/min. There were no statistically significant differences in age, admission APACHE II score, and endotracheal tube size among patients with PEF ≤ 60 L/min vs > 60 L/min.

Fifteen patients required re-intubation during the same hospitalization. There were a total of 13 unsuccessful extubations within the 72-h period following the initial extubations. They were classified as extubation failures. These included two patients who failed twice. The reasons for reintubation were inability to protect the airway (n = 5), hypoxemia (n = 3), stridor due to airway edema (n = 2), acute hypercapnia (n = 2), and cardiac arrest (n = 1).

Cough PEF was the strongest predictor of extubation outcome. The mean PEFs were significantly lower in unsuccessful extubations compared with successful extubations (64.2 ± 6.8 L/min vs 81.9 ± 2.7 L/min, p = 0.03). Figure 2 shows an ROC curve for the cohort using varied thresholds for PEF in predicting extubation outcomes. A PEF threshold of 60 L/min offered the optimum cut-off point. A PEF ≤ 60 L/min had a sensitivity of 69% and specificity of 74% in predicting extubation failure. If a patient who failed twice due to stridor is excluded, the sensitivity increases to 82%. Overall, patients with PEF ≤ 60 L/min were 5.1 times as likely to fail as those with PEF > 60 L/min (RR, 5.1; 95% confidence interval [CI], 1.7 to 15.4; p = 0.003).

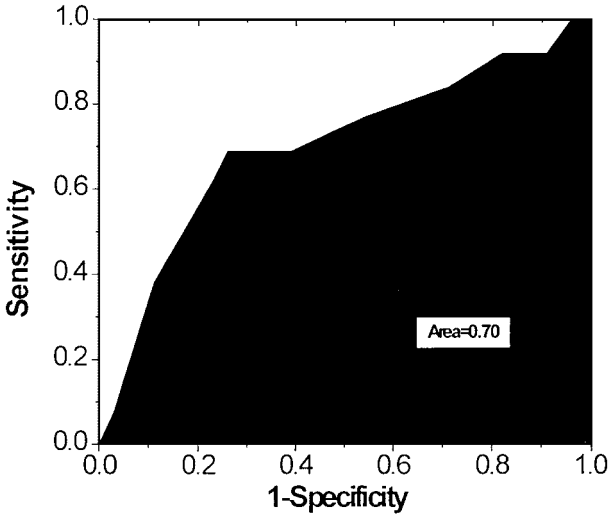

FIGURE 2. ROC curve for glottic-free cough PEF and extubation outcomes.

Table 2 shows the risk of extubation failure among patients with PEF ≤ 60 L/min compared to those with PEF > 60 L/min within categories of APACHE II score, RSBI, age, and hemoglobin concentration. For instance, among those with RSBI ≥ 100 breaths/min/L, the risk of extubation failure for those with PEF ≤ 60 L/min was 4.0 times those with PEF > 60 L/min (95% CI, 0.6 to 27.4). Similarly, among those with RSBI < 100 breaths/min/L, patients with PEF ≤ 60 L/min were 6.3 times as likely to have unsuccessful extubation (95% CI, 1.3 to 30.2). Adjusting for RSBI, patients with PEF ≤ 60 L/min were 5.2 times as likely to have unsuccessful extubation compared to those with PEF > 60 L/min (95% CI, 1.6 to 17.5). Similar results were seen across strata of age, APACHE II scores, quantity of secretions, and hemoglobin levels.

The mean RSBI was lower in extubation successes than in failures (64.9 ± 3.0 vs 86.2 ± 8.4, p = 0.03). The sensitivity and specificity for RSBI ≥ 100 breaths/min/L in predicting extubation failure were 42% and 90%, respectively. Patients with RSBI ≥ 100 breaths/L/min were 4.1 times as likely to have unsuccessful extubation as those with RSBI < 100 breaths/L/min (RR, 4.1; 95% CI, 1.5 to 11.2). The association of RSBI with extubation outcome was confounded in part by the PEF (adjusted RR, 2.8; 95% CI, 1.1 to 7.2). Nonetheless, RSBI and PEF were both independent predictors of extubation

Table 2—*Stratum-Specific and Summary RRs for Extubation Failure Among Patients With PEF ≤ 60 L/min Compared to PEF > 60 L/min Across Selected Stratified Variables*

Variables	Patients, No.	RR*	95% CI
APACHE II score			
≥ 24	52	12.4	1.6–94.6
< 24	59	2.5	0.6–11.0
Combined (adjusted)	111	5.2	1.7–16.3
RSBI			
≥ 100	14	4.0	0.6–27.4
< 100	81	6.3	1.3–30.2
Combined	95	5.2	1.6–17.5
Age, yr			
≥ 65	61	11.4	1.5–88.8
< 65	50	2.8	0.7–12.3
Combined	111	5.5	1.7–17.6
Hemoglobin, mg/dL			
≤ 10	28	∞†	3.8–∞
> 10	83	2.3	0.6–8.5
Combined	111	5.1	1.6–16.3

*Expressed as the risk of extubation failure with PEF ≤ 60 L/min vs > 60 L/min for each stratum, *eg* the risk of failure of those with APACHE II scores ≥ 24 and PEF ≤ 60 L/min is 12.4 times that of those with APACHE II scores ≥ 24 and PEF > 60 L/min.
†55% vs 0%.

outcomes from both the multivariate logistic regression and stratified analyses.

Patients with neurologic problems (chronic dementia, cerebral vascular accident, and seizures) tended to be more likely to have unsuccessful extubation compared to those without neurologic problems (RR, 2.7; 95% CI, 1.0 to 7.3). When those with chronic dementia were excluded, patients with acute neurologic problems (*ie*, cerebral vascular accident and seizures) were 3.3 times as likely to have unsuccessful extubations compared to those without acute neurologic problems (95% CI, 1.2 to 8.8). Neurologic status was not associated with PEF, and both neurologic status and PEF were independent predictors of extubation outcomes.

Those whose pre-extubation SBT was a T-piece trial tended to have unsuccessful extubations more often than those who performed pressure support trials ($p = 0.05$). There were no statistically significant differences in the hemoglobin concentration, airway mechanics, APACHE II scores, and quantity of measured secretions between extubation successes and failures.

Nine patients died during hospitalization. These decedents tended to be older (72.8 years vs 63.0 years, $p = 0.09$) than survivors. There was no statistically significant difference in the admission APACHE II scores (mean, 25.3 vs 22.4; $p = 0.3$) or RSBI (RR, 1.0; 95% CI, 0.2 to 7.4; $p = 0.7$) between the decedents and survivors, respectively. Overall, patients with PEF $\leq$ 60 L/min were 19.1 times as likely to die during the hospitalization compared to those with PEF $>$ 60 L/min (RR, 19.1; 95% CI, 2.5 to 145.9; $p = 0.0002$). Four of the seven patients who died in the group with PEF $\leq$ 60 L/min had aspiration demonstrated on swallowing evaluation prior to death. Patients with unsuccessful initial extubations were 6.4 times as likely to die during that hospitalization compared to those with successful extubation at the first attempt (RR, 6.4; 95% CI, 2.0 to 20.3; $p = 0.008$).

The median lengths of stay in the ICU and the hospital were 4 days and 14 days, respectively, for the cohort as a whole. Patients with PEF $\leq$ 60 L/min had longer median lengths of total hospitalization compared to those with PEF $>$ 60 L/min (18 days vs 12 days, $p = 0.02$). Also, those with PEF $\leq$ 60 L/min tended to have longer durations of ventilation (median, 3.0 days vs 2.0 days; $p = 0.1$) and longer ICU durations (median, 4.5 days vs 4.0 days; $p = 0.2$), but these differences were not statistically significant. Patients with unsuccessful extubations stayed longer in the ICUs (11.7 ± 2.1 days vs 5.3 ± 0.4 days, $p = 0.009$). Similarly, patients who died had prolonged total hospitalization (median, 22 days vs 12 days; $p = 0.02$), due in part to prolonged duration of mechanical ventilation (median, 3 days vs 2 days; $p = 0.07$) and prolonged ICU stay (median, 9 days vs 4 days; $p = 0.02$).

Discussion

This study confirms that cough strength is a potent predictor of extubation outcomes in patients without primary neuromuscular disease who have passed an SBT. Also, the findings suggest that cough strength is a good predictor of in-hospital mortality in this population of critically ill patients. The study failed to find a statistically significant association between the quantity of suctioned secretions and outcomes.

The finding of an association between cough strength and extubation outcomes is not new[3,5]; however, to our knowledge, this is the first study to use an objective, inexpensive, reproducible measure of cough strength, before extubation, to demonstrate this association. The strengths of the association observed in the current study (RR, 5.1) and in our previous study (RR, 3.0 to 4.0) are similar, in spite of the differences in the measurement tools for cough strength. In the previous study, cough strength was assessed semiobjectively using a white card placed 1 to 2 cm from the open end of the endotracheal tube and subjectively on a 6-point scale.[3] The similarity of results of both studies lends credence to the validity of our hypothesis. Given that the cough PEF is more objective and potentially reproducible across centers, we suggest that it should become the preferred method of assessing cough strength, particularly if our findings are replicated at other centers.

Only one previous study has examined the effects of cough peak flows on extubation outcomes. Bach and Saporito[6] studied 49 tracheotomized patients with chronic respiratory failure due to neuromuscular disease. They found that cough PEFs were greater in those who were successfully decannulated, and that flows of 160 L/min following decannulation demarcated successes from failures. However, the method used to elicit PEFs was different: patients coughed from a maximal insufflation with a manual assist. Our cohort consisted of a general medical population of critically ill patients and had very few patients with primary neuromuscular disease. Moreover, peak flows through an endotracheal tube are bound to be lower than those in decannulated patients because intubated patients cannot close their glottis, thereby limiting the pressure generated when one attempts to cough. Thus, the reason for the lower threshold described in our study is a result of the different method insofar as our patients performed a "glotic-free cough PEF." Finally, the small number of failures makes the discriminative

utility of the threshold value (60 L/min) less robust than would be the case had there been more failures. Nonetheless, the concordance of our findings (*ie*, peak flows predict outcomes) suggests that this variable is of prognostic significance in predicting extubation outcomes.

The magnitude of the association between poor cough strength and mortality was surprising though not totally unexpected. A previous study[7] of ambulatory elderly patients demonstrated that peak flow rates were highly correlated with 5-year mortality. To our knowledge, no similar findings have been reported in critically ill patients recovering from respiratory failure. A strong voluntary cough requires effective co-ordination and intact respiratory neuromuscular activity. We speculate that patients with weak coughs have decreased ability to sustain long-term spontaneous ventilation or to adequately protect the airway, factors that are known to be associated with increased morbidity and mortality. Indeed, the observation of aspiration (antemortem) in four of the nine deaths supports such a hypothesis. Nonetheless, the small number of deaths and lack of information regarding the mechanism of death precludes drawing conclusions regarding this finding, which should be considered a simple observation that requires confirmation in future, larger, cross-sectional studies.

The failure to demonstrate an association between the quantity of suctioned secretions and extubation outcomes was surprising. Our previous study found a strong association between suctioning frequency and extubation outcomes. It is possible that because of that prior finding, our critical care physicians were not considering patients with obvious abundant secretions for SBTs or extubation. This is supported in part by the small number of patients (4%) with > 20 mL of secretions per hour prior to extubation; however, we also suspect that the lack of a standardized methodology (and frequency of suctioning) may account partly for lack of association between magnitude of secretions and extubation outcomes. Also, it is possible that the differing findings may be explained by chance (random variation), by differing methods of assessing endotracheal secretions, or by differing cohort characteristics.

Unlike our previous study,[3] our current data do not support the idea that a hemoglobin concentration < 10 mg/dL increases the risk of extubation failure in patients who have passed an SBT. There are no apparent differences of the demographics of the populations to readily explain this difference. Although some unmeasured subtle differences of patients (*eg*, degree of subclinical coronary artery disease) could explain this difference, it could also be that our previous findings were errant or not generalizable to other samples. Finally, the relatively small numbers (especially of extubation failures) in both studies could lead to varying samples that are not necessarily reflective of the general, larger population of medical critically ill patients.

The study is limited by the relatively small study size and by the fact that maximal voluntary cough is effort dependent. The small sample size resulted in imprecise parameter estimates (with very wide CIs). Given that voluntary cough is effort dependent, failure to generate a strong cough may reflect simple lack of cooperation or effort rather than insufficient muscle strength. Moreover, the cumulative effects of sedatives, not measured in this study, could also affect patient cooperation and cough strength. In fact, four patients in our study did not attempt to cough on prompting. As per *a priori* study design, they were excluded from analysis because it was unclear as to whether such patients understood the instructions. In reality, these patients either had underlying dementia and/or were generally unable to follow commands due to concurrent encephalopathy; therefore, the voluntary PEF cannot be used in all patients. Perhaps the suctioned, involuntary cough may be a reasonable substitute. The relationship of neurologic variables and cough flows (not well examined in our study) and their effect on extubation outcomes requires further investigation. Moreover, we had few patients with neuromuscular disease, in whom cough flows may not be as helpful, and the majority of patients had acute critical illness (median duration of ventilation of 3 days, maximum of 15 days). Accordingly, it is important to emphasize that the PEF results of this study apply to this and perhaps other similar populations of acutely medically ill patients.

The above limitations notwithstanding, this study has demonstrated that voluntary cough PEF is associated with extubation outcome and in-hospital mortality in a heterogenous sample of medical critically ill patients. If replicated at other centers, this may provide clinicians with an inexpensive, objective extubation predictor to be used for patients who have passed an SBT.

ACKNOWLEDGMENT: The authors thank Joseph Horne, RRT, Bridgeport Hospital Pulmonary Function Laboratory, who assisted in calibrations of the peak flowmeters used in this study.

References

1 MacIntyre NR. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physiciains; the American Association for Respiratory Care; and the American College of Critical Care Medicine. Chest 2001; 120(Suppl): 375S–395S

2 Epstein SK. Weaning parameters. Respir Care Clin North Am 2000; 6:253–302

3 Khamiees M, Raju P, DeGirolamo A, et al. Predictors of extubation outcome in patients who have passed a trial of spontaneous breathing. Chest 2001; 120:1262–1270
4 Dean AG, Arner TG, Sangam S, et al. Epi Info 2000, a database and statistics program for public health professionals for use on Windows 95, 98, NT and 2000 computers. Atlanta, GA: Centers for Disease Control and Prevention, 2000
5 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: 1530–1536
6 Bach JR, Saporito LR. Criteria for extubation and tracheostomy tube removal for patients with ventilatory failure: a different approach to weaning. Chest 1996; 110:1566–1571
7 Cook NR, Evans DA, Scherr PA, et al. Peak expiratory flow rate and 5-year mortality in an elderly population. Am J Epidemiol 1991; 133:784–794

Cough Peak Flows and Extubation Outcomes*

Mihai Smina, Adil Salam, Mohammad Khamiees, Pritee Gada, Yaw Amoateng-Adjepong and Constantine A. Manthous

Chest 2003;124; 262-268
DOI 10.1378/chest.124.1.262