

# COLLABORATIVE PRACTICE: DEVELOPMENT, IMPLEMENTATION, AND EVALUATION OF A WEANING PROTOCOL FOR PATIENTS RECEIVING MECHANICAL VENTILATION

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- **BACKGROUND** Use of protocols to reduce weaning time for patients receiving mechanical ventilation helps reduce cost and length of stay. However, implementation of this type of protocol is not easy and requires a consistent collaborative effort.
- **OBJECTIVE** To provide a systematic approach to the weaning process by developing, implementing, and evaluating a protocol for weaning patients from mechanical ventilation in a medical respiratory intensive care unit.
- **METHODS** The weaning protocol used was a modification of a protocol developed by Ely et al. Modifications included a more aggressive approach in proceeding to the spontaneous breathing trial, inclusion of the Richmond Agitation-Sedation Scale, and documentation of the production of secretions.
- **RESULTS** Implementation of the protocol significantly reduced the duration of mechanical ventilation as measured by 8-hour shifts and ventilator days. Although length of stay in the intensive care unit was not significantly reduced ( $P = .29$ ), a continuing downward trend occurred, from a mean of 8.6 days before the protocol was implemented to 7.9 days during the last 6 months of data collection ( $P = .07$ ).
- **CONCLUSIONS** The need to provide efficient care requires the collaboration of all disciplines involved in providing patients' care. The weaning protocol introduced in this study demonstrates the benefits of using a collaborative team to identify best practices and implement them in a practice setting. (*American Journal of Critical Care*. 2003;12:454-460).

Use of mechanical ventilation is often lifesaving, but it has high associated healthcare costs and requires many hours of skilled nursing care. Costs for a patient in an intensive care unit (ICU) are approximately 4 times greater than costs for a patient who is not in an ICU,<sup>1</sup> and much of the added costs are related to mechanical ventilation. Healthcare professionals today continually struggle to decrease the length of stay (LOS) of ICU patients.

More than one third of critically ill patients require mechanical ventilation, and 41% of the time required for mechanical ventilation is spent weaning

patients from the treatment.<sup>2</sup> Care of patients receiving mechanical ventilation is "high risk" and "high cost." High mortality rates and iatrogenic complications commonly associated with mechanical ventilation focus attention on finding ways to reduce the duration of mechanical ventilation by reducing the time required for weaning.

Conceptually, weaning from mechanical ventilation includes both the assessment of a patient's readiness to breathe independently and the systematic reduction of ventilatory support. A variety of weaning strategies and approaches have been used to assess weaning readiness and to reduce ventilatory support with various degrees of success. In the past, determining a patient's readiness to be weaned and reducing ventilatory support were based on the judgments of individual physicians, who considered objective

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indicators of gas exchange, respiratory mechanics, and the patient's ability to protect the airway. Use and evaluation of these indicators often resulted in wide variations in weaning practices among providers. This variability in weaning practice may be magnified in academic medical centers because of the frequent turnover among attending physicians and house staff.

*Patients receiving mechanical ventilation have shorter hospital stays and lower costs when a weaning protocol is used.*

More recently, the use of multidisciplinary weaning protocols has markedly reduced the duration of mechanical ventilation.<sup>3-7</sup> Cohen et al<sup>6</sup> found that use of a multidisciplinary team that included physicians, respiratory therapists, and nurses reduced duration and costs of mechanical ventilation when compared with weaning done by critical care fellows. Costs of care were lower as a result of shorter ventilation time and a reduction in arterial blood gas levels and use of arterial catheters. Cohen et al found that the multidisciplinary team relied more on a systematic approach to weaning than did the house staff, who may rely more on expensive laboratory diagnostics. Ely et al<sup>5</sup> found that daily screening of a patient's respiratory function and subsequent trials of spontaneous breathing and notification of the patient's physician when the trials were successful reduced the duration of mechanical ventilation and the cost of intensive care. Likewise, in a randomized, controlled trial of protocol-versus physician-directed weaning, Kollef et al<sup>3</sup> found that protocol-guided weaning of patients from mechanical ventilation, as performed by nurses and respiratory therapists, was safe and led to extubation more rapidly than did physician-directed weaning. A systematic approach to weaning may prevent lapses in care that occur in ICUs, where emergencies have precedence over rehabilitative care.

The key to successful weaning may be that a protocol is used, rather than specifically how the protocol is constructed or what method of weaning is used.<sup>8</sup> Kollef et al<sup>3</sup> noted shorter weaning times in a study comparing use of protocols to no protocol. Burns et al<sup>9</sup> compared the effects of an outcome approach that used critical pathways with effects of an approach in which outcomes were not managed. Outcome-managed patients had 1.3 fewer days of mechanical ventilation and an LOS 2.1 days shorter than did patients whose outcomes were not managed, with a cost savings of \$3341 per case. The positive trends noted dur-

ing the study interval persisted for 2 years, and the variables of cost, LOS, and ventilator duration continue to be favorably affected.<sup>10</sup> Use of an outcomes-managed approach includes an outcome manager, a respected and valued member of the team who is central to the ongoing success of the approach. The protocol is an integral part of the process but is continually evaluated and changed as needed.<sup>9</sup>

These studies just described indicate that systematic methods of weaning patients from mechanical ventilation may result in beneficial outcomes. The use of protocols and interdisciplinary teams provides consistency in the weaning process across all types and levels of provider experience, allows for easy communication of weaning status, and ultimately assists patients in progressing to extubation in a timely fashion.<sup>10</sup> Recently, in a consensus project<sup>11</sup> to create a set of evidence-based clinical practice guidelines for weaning patients from mechanical ventilation, several important issues were identified. First, the evidence suggests that independent clinical judgment of or experience with patients' readiness to be weaned is a relatively poor predictor of weaning success. Second, clinical assessments (respiratory pattern, cardiovascular response, comfort/anxiety, oxygenation) are better predictors of success than are more complex weaning parameters. Third, daily spontaneous breathing trials are superior to gradual reductions in ventilatory support (ie, gradual reduction in synchronized mandatory ventilation or pressure-support ventilation). Finally, it is clear that nurses and respiratory therapists can effectively achieve weaning goals by using protocols. Importantly, implementation of weaning protocols requires a consistent team effort that may be difficult to sustain in the complex critical care environment.

### **Identification of Need and Protocol Development**

The nursing practice committee in our 12-bed medical respiratory ICU (MRICU) at the Virginia Commonwealth University Health System, Richmond, Va, a large, urban, academic medical center, and the MRICU's medical director identified weaning from mechanical ventilation as an opportunity to improve consistency in practice and patients' outcomes. The MRICU nursing practice committee (a group of experienced nurse clinicians) and respiratory therapists reviewed the current procedure for weaning. In collaboration with the MRICU acute care nurse practitioner (ACNP), the MRICU respiratory therapists, and the MRICU medical director, team meetings were held to coordinate the activities and establish goals. The ACNP served as the liaison between the parties.

**Table 1** Weaning protocol for the medical respiratory intensive care unit

**Screen 1\***

All patients receiving mechanical ventilation are assessed by using screen 1 every day, and results are documented on the weaning assessment form.

Parameter	Results	
1. Hemodynamics stable?	Yes	No
2. Off vasopressors?	Yes	No
3. PaO <sub>2</sub> /Fio <sub>2</sub> ratio ≥150? (If ABGs not available: SaO <sub>2</sub> ≥95% on Fio <sub>2</sub> of 0.50 or less)	Yes	No
4. PEEP set at 8 cm H <sub>2</sub> O or less?	Yes	No
5. RASS <sup>†</sup> of -2 or higher?	Yes	No

If NO to any question, STOP! Otherwise, ALWAYS proceed to screen 2.

**Screen 2\*: Rapid Shallow Breathing Index (RSBI).** For 1 minute, through ventilator with “flow trigger” mode rate set to 0, PSV set to 0, PEEP allowed up to 5 cm H<sub>2</sub>O. Start measurement 1 minute after setup. At the end of 1 minute, measure respiratory rate (f), and minute ventilation (V<sub>E</sub>) and calculate tidal volume (V<sub>T</sub>) in liters. RSBI = f/V<sub>T</sub>

RSBI of 125 or less	Yes	No
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If YES, proceed to spontaneous breathing trial. If NO, rest patient until the next day and reassess starting with screen 1.

**Spontaneous breathing trial\***

Spontaneous breathing for 120 minutes through ventilator with “flow trigger” mode rate set to 0, PSV set to 0, PEEP allowed up to 5 cm H<sub>2</sub>O. A 2-hour continuous trial without termination indicates a successful spontaneous breathing trial. Successful spontaneous breathing trial?

Yes	No
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Termination criteria (document cause if terminated):

- Respiratory rate >35/min for 5 minutes or more
- SaO<sub>2</sub> <90%
- Heart rate > 140/min, or sustained increase 20% greater than baseline
- Systolic blood pressure >180 mm Hg or <90 mm Hg
- Increased anxiety

If spontaneous breathing trial is unsuccessful, rest patient until the next day and begin with screen 1 again.

**Extubation:** \_\_\_\_\_ Date \_\_\_\_\_ Time Reason for not extubating, if all criteria met:

ABGs indicates arterial blood gases; Fio<sub>2</sub>, fraction of inspired oxygen; PEEP, positive end-expiratory pressure; PSV, pressure-support ventilation; RASS, Richmond Agitation-Sedation Scale, SaO<sub>2</sub>, oxygen saturation.  
\*Screens 1 and 2 were done without direction of a physician. The spontaneous breathing trial was conducted originally with physician approval and evolved to more independent decisions by nurses and respiratory therapists. Decision to extubate was made by a physician.  
†The RASS is a 10-level objective measure of sedation or agitation.<sup>15</sup> If patients were too sedated, doses of sedatives were adjusted and patients were reevaluated.

**Protocol Development**

The protocol was developed through a collaborative process among the MRICU ACNP, the medical director, the MRICU nursing practice committee, and the respiratory therapy staff after a thorough review of the literature. Once developed and critiqued by all participants, the protocol was presented to all MRICU attending physicians for review and feedback.

**The MRICU Weaning Protocol**

The protocol comprises weaning algorithms that were practical and evidence based as described by Esteban and Alia<sup>12</sup> and Ely et al<sup>13,14</sup> (Table 1). The final

form of the protocol is a modification of the protocol originally developed by Ely et al.<sup>13,14</sup> Several modifications deserve mention. First, the threshold for the ratio of PaO<sub>2</sub> to fraction of inspired oxygen was decreased from 200 to 150 for proceeding to the next step. Our experience suggested that patients who had a PaO<sub>2</sub> of 76 to 100 mm Hg at a fraction of inspired oxygen of 0.5 did not often require reintubation as a result of hypoxemia. We also included the rapid shallow breathing index (respiratory rate/tidal volume) as a separate, second screen, once the patient had passed all items on the first screen. We also liberalized the threshold for the rapid shallow breathing index from

**Table 2** Richmond Agitation-Sedation Scale

Score and term	Description
+4 Combative	Overtly combative or violent, immediate danger to staff
+3 Very agitated	Pulls on or removes tube(s) or catheter(s), or has aggressive behavior toward staff
+2 Agitated	Frequent nonpurposeful movement or patient-ventilator dyssynchrony
+1 Restless	Anxious or apprehensive but movements not aggressive or vigorous
0 Alert and calm	
-1 Drowsy	Not fully alert, but has sustained (>10 seconds) awakening, with eye contact, to voice
-2 Light sedation	Briefly (<10 seconds) awakens, with eye contact, to voice
-3 Moderate sedation	Any movement (but no eye contact) to voice
-4 Deep sedation	No response to voice, but any movement to physical stimulation
-5 Unarousable	No response to voice or physical stimulation
Procedure	
1. Observe the patient. Is the patient alert and calm? (Score 0). Does the patient have behavior consistent with restlessness or agitation? (Score +1 to +4 according to criteria listed above).	
2. If the patient is not alert, in a loud speaking voice, state the patient's name and direct the patient to open eyes and look at you. Repeat once if necessary. Can prompt the patient to continue looking at you. Patient has eye opening and eye contact is sustained for >10 seconds. (Score -1) Patient has eye opening and eye contact, but this is not sustained for 10 seconds. (Score -2) Patient has any movement in response to voice, excluding eye contact. (Score -3)	
3. If the patient does not respond to voice, physically stimulate him or her by shaking his or her shoulder. If no response to shaking the shoulder, rub the sternum. Patient has any movement to physical stimulation. (Score -4) Patient has no response to voice or physical stimulation. (Score -5)	
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105 to 125. Although not specifically tested in clinical trials, this somewhat more aggressive approach, we

thought, would allow more patients to proceed to the spontaneous breathing trial, thus decreasing weaning time without increasing the risk of failed extubation.

The level of sedation is a component of many weaning tools, including ours. During protocol development, the MRICU staff was testing a new sedation scale, the Richmond Agitation-Sedation Scale (RASS; Table 2). The RASS<sup>15</sup> developed and validated by members of this team is a 10-point scale, from +4 (combative) through 0 (calm, alert) to -5 (unarousable). Patients are assessed at the bedside in 3 simple steps by using discrete criteria, for 30 to 60 seconds. In 202 adult ICU patients, interrater reliability ( $r=0.96$ ) was excellent among 5 physician, nurse, and pharmacist investigators. Interrater reliability ( $r=0.92-0.98$ ) was high for patients from medical, surgical, cardiac surgery, coronary, and neuroscience ICUs, patients receiving and patients not receiving mechanical ventilation, and patients with and without sedative medications.<sup>15</sup> In validity testing, the RASS correlated highly ( $r=0.97$ ) with a visual analogue scale anchored by "combative" and "unresponsive," the Ramsay sedation scale<sup>16</sup> ( $r=-0.85$ ), and the Sedation Agitation Scale<sup>17</sup> ( $r=0.86$ ).<sup>15</sup> After implementation of the RASS in the MRICU, interrater reliability was 0.96 between a nurse investigator and 27 RASS-trained bedside nurses in 101 encounters with patients.<sup>15</sup> In addition, the scale is used as part of a comprehensive confusion assessment method developed and validated in another institution.<sup>18,19</sup> Because a critical part of the weaning protocol is an assessment of sedation, the RASS was included as part of the weaning protocol. During protocol pilot testing, nursing staff voiced concerns that the volume of patients' respiratory secretions was not included as part of the protocol. Because excessive production of secretions may hamper a patient's ability to sustain spontaneous breathing, this item was documented but was not a formal step in the protocol.

The protocol depends primarily on the actions of staff nurses and respiratory therapists, and these team members were key participants in the implementation and continuation of the protocol. Members of these groups both assessed whether patients were ready for a weaning trial by completing screens 1 and 2 (Table 1) and monitoring patients' responses to the trial.

### Protocol Implementation

Extensive education of the unit's critical care staff, including the nurses, respiratory therapists, and physicians, took place before the protocol was implemented. Presentations were given by the ACNP to groups of staff members on several occasions, and lit-

**Table 3** Comparison of weaning outcomes before and after protocol implementation\*

Outcome	Before protocol (14 months of data, n=469)	After protocol (13 months of data, n=459)	p†	First 7 months of protocol (n=250)	Second 6 months of protocol (n=209)
Days of mechanical ventilation	7.00 (1-99, 10.4)	5.59 (1-58, 7.0)	.02	6.0 (1-158, 7.4)	5.09 (1-41, 6.43)
No. of ventilator shifts (8 hours)	20.95 (1-298, 31.2)	16.7 (1-175, 21)	.02	17.9 (1-175, 22.3)	15.3 (1-123, 19.3)
Days in intensive care unit	8.62 (1-117, 11.4)	7.93 (1-59, 8.2)	.29	7.98 (1-59, 8.1)	7.87 (1-149, 8.4)
Total charges for mechanical ventilation, \$	3372 (158-47 231, 5004)	2932 (174-30 450, 3673)	.13	3130 (174-30 450, 3879)	2695 (174-21 772, 3406)

\* All entries are means followed by range and SD in parentheses.

† Significance level of the comparison of values before and after implementation of the protocol.

erature and posters were posted in the critical care area. The MRICU's nursing practice committee met frequently to discuss concerns and areas for improvement. Each patient's bedside nurse coordinated all activities of the protocol. Information related to the progress of protocol implementation and identification of areas for success and areas needing improvement were communicated frequently by charge nurses, in medical team rounds, through posters displayed in the unit, and discussions at staff meetings.

### *Weaning assessments were done every day.*

Once the protocol was implemented, all patients receiving mechanical ventilation were assessed daily by using the screens outlined in the protocol (Table 1). Data for the screens were collected daily at 8 AM by a nurse or a respiratory therapist. After a few months, the collection time was changed to 6 AM because of conflicts with timeliness of completion of early morning tasks. During the first few months of use of the protocol, on the basis of staff comments, changes were made to the documentation sheet to enhance the clarity of the process.

Each patient's progress on the protocol was presented in multidisciplinary rounds that occurred every morning. The results of screens 1 and 2 were reported. Initially, decisions to initiate the spontaneous breathing

trial were made during these rounds; however, as the nursing and respiratory therapy staff became more familiar with the protocol, and ICU physicians were comfortable with the process, the spontaneous breathing trial was often well under way at the time of rounds, further reducing the duration of mechanical ventilation. A senior physician (attending or fellow) made the decision to extubate on the basis of the results of the spontaneous breathing trial.

### **Measuring Protocol Outcomes**

The objective of the weaning protocol was to provide a systematic approach to the weaning process to reduce the durations of mechanical ventilation and stay in the ICU. Initially, we thought that we could collect data about the day-to-day process of protocol implementation, documenting every aspect of the protocol. However, after several months of data collection, and without any additional resources for this project, we realized that even though the protocol was in place and patients were being weaned from mechanical ventilation through use of the process, documentation of each step was difficult. Respiratory therapists and bedside nurses were primarily responsible for the documentation. Although compliance was high for the respiratory therapists, the nurses' compliance level was not adequate. Screens 1 and 2 were often complete, but the outcome of the spontaneous breathing trial and the extubation date often were not recorded on the weaning assessment form. Therefore, to evaluate the outcomes in a more systematic fashion, data were obtained from

the medical center's decision support department. This data provided information about all patients whose hospital bill included a charge for mechanical ventilation and were cared for in the MRICU. Information about the duration of mechanical ventilation (by 8-hour shifts), LOS in the MRICU, and ventilator costs were obtained. For comparison, similar data were obtained for the 14 months before the weaning protocol was implemented.

### *Use of the weaning protocol reduced duration of mechanical ventilation.*

Although this analysis and evaluation procedure did not include controls for extraneous events that may have affected the weaning process in the MRICU, the length of data collection and the sample size should reduce these effects. In addition, no obvious major changes occurred in the weaning processes (new procedures, equipment, or change in attending physicians). However, the protocol progress documentation and data collection times did change during this period. Because this protocol was developed and implemented primarily as a clinical tool, rather than as a rigorous research tool, these intervening variables may have affected the outcomes presented here. In clinical projects, it is often not possible to control for all variables that may affect outcomes. However, protocols intended for clinical use must be practical and efficient as well as responsive to the needs of patients and staff.

The primary purpose for protocol use was realized. Implementation of the protocol significantly reduced the duration of mechanical ventilation as measured by 8-hour shifts and ventilator days (Table 3). Although LOS in the MRICU was not significantly reduced ( $P = .29$ ), a continuing downward trend occurred, from a mean of 8.6 days before the protocol was implemented to 7.9 days during the last 6 months of data collection ( $P = .07$ ).

### **Sustaining Success**

The significant reduction in duration of mechanical ventilation was a beneficial outcome and is similar to the data found in other trials<sup>3,5,7,20</sup> in which a weaning protocol was used. A major challenge in implementing any protocol is the ability to sustain the protocol process. The MRICU has a monthly turnover in house staff, and new interns and residents begin working each year. Therefore, it was especially important to continue education about the weaning process to ensure consistency in use of the protocol. However, a major benefit in this unit is the limited number of

attending physicians (5) who are responsible for the management of all MRICU patients. Implementation of new processes can be more easily communicated and maintained with a small group of providers. The continued success of the protocol over time is evidenced in Table 3 by the continued decreases in duration of mechanical ventilation and LOS in the MRICU.

### *Use of a nurse-directed weaning protocol may increase nurses' knowledge and sense of autonomy.*

Discussions with the MRICU nursing staff clearly indicated that the use of a weaning protocol has created additional benefits. Nurses feel a greater sense of autonomy and responsibility for their patients' care. The protocol has increased their direct involvement in decisions related to patients' care and has provided an additional avenue for communication with the health-care team. Further, through education and use of the protocol, the nurses have gained comprehensive and valuable knowledge of respiratory assessment and mechanics that allows them to actively contribute to good outcomes for patients.

### *Multidisciplinary collaboration is critical to success.*

### **Summary**

The need to provide efficient care requires the collaboration of all disciplines involved in providing patients' care. The weaning protocol we introduced in the MRICU is an excellent example of the benefits of using a collaborative team to identify a best practice and then implement it in a practice setting. Successful implementation of a protocol such as described here requires the full commitment of all members of the healthcare team and can have a significant effect on patients' outcomes.

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