

# Weaning of the Patient with ARDS

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This brief outline will review some of the common causes of weaning failure; methods for assessing readiness for weaning; and common weaning techniques and protocols.

## Assessment of weaning readiness

The ability to separate successfully from mechanical ventilation is dependent upon a host of physiologic factors (Table 1). Central ventilatory drive must be adequate; the patient must be able to maintain a patent airway, if extubation or decannulation is contemplated; and the patient must be able to cough and adequately clear secretions. Airway resistance must be adequately low; airway edema or obstruction can preclude extubation. The work of breathing must be adequately low; decreased lung compliance, increased airway resistance, and hyperinflation impose an increased load upon respiratory muscles. The respiratory muscles themselves must possess sufficient strength and endurance. Even with normal respiratory muscle function, however, abnormal chest wall mechanics, such as severe hyperinflation, abdominal distention, or kyphoscoliosis can place respiratory muscles at a mechanical disadvantage, resulting in fatigue and respiratory failure.

### Table 1: Assessment of weaning readiness

- Resolution of the cause of respiratory failure.
- Cessation of deep sedation and neuromuscular blockade.
- Absence of sepsis.
- Stable cardiovascular status.
- Correction of electrolyte and metabolic disorders.
- Adequate arterial oxygenation (e.g.,  $\text{PaO}_2 > 60$  mm Hg with  $\text{FIO}_2 \leq 0.5$  and  $\text{PEEP} \leq 5$  cm  $\text{H}_2\text{O}$ ).
- Adequate respiratory muscle function.

## Failure to wean

Failure to wean from the mechanical ventilator can be due to many causes (Table 2). Failure to adequately clear tracheobronchial secretions by coughing, and dynamic hyperinflation in patients with COPD or asthma are common causes. Acute congestive

heart failure and myocardial ischemia are common and significant causes of weaning difficulty, but can be difficult to detect. (1-5) Muscle weakness due to acute myopathy or polyneuropathy is also frequent and significant. (1-5) Occult muscle weakness can be due to inadequate rest following exhausting breathing trials. Twenty-four hours of full ventilatory support may be necessary after an exhausting trial. (6) Malnutrition and severe electrolyte imbalance also can contribute to weakness.

**Table 2: Causes of weaning failure**

- Insufficiently treated pulmonary disease.
- Auto-PEEP and hyperinflation.
- Concomitant cardiac disease.
- Nutrition and electrolyte imbalance.
- Inadequate rest following an exhausting spontaneous breathing trial.
- Severe muscle weakness following neuromuscular disease or polyneuropathy of critical illness.

**Weaning parameters**

A relatively predictable series of events usually precedes overt respiratory failure following disconnection of the mechanical ventilator. Respiratory rate increases, tidal volume falls, and the pattern of breathing becomes discoordinate (i.e., respiratory alternans and abdominal paradox occurs). An increase in the PaCO<sub>2</sub> is a late symptom. (7) Patients who fail a trial of spontaneous breathing characteristically develop a pattern of rapid and shallow breathing. (8)

Traditional weaning parameters (See Table 3) are poor predictors of weaning success. A parameter derived from measured respiratory rate and tidal volume, the rapid shallow breathing index (RSBI), has been shown to be predictive of weaning success. (9-13) To calculate this parameter, the patient's respiratory rate and minute ventilation are measured for one minute during spontaneous breathing. The measured respiratory rate is then divided by the tidal volume (expressed in liters). A RSBI  $\leq$  105 is reasonably predictive of weaning success. (9) Women and those intubated with smaller diameter (< 7 mm inner diameter) endotracheal tubes tend to have a higher RBSI. (12) If the patient meets criteria for weaning readiness and has a RSBI < 105, a spontaneous breathing trial can be performed. Prospective controlled studies have shown that about 75% of patients can be extubated if they successfully complete a spontaneous breathing trial. (14,15) The trial can be conducted with the patient breathing spontaneously while attached to the ventilator (CPAP mode), with a low level of pressure support ventilation (5 – 7 cm H<sub>2</sub>O), or disconnected from the ventilator and attached to a T-piece that provides humidity and supplemental oxygen. (16) A 30 minute spontaneous breathing trial is as useful as a longer trial (e.g., 2 hours). (17) The spontaneous breathing trial should be terminated if the patient shows signs of respiratory distress (e.g., respiratory rate > 35/min; SpO<sub>2</sub> < 90%; heart rate > 140/min or 20% change from baseline; systolic blood pressure >180 mm Hg or <90 mm Hg; anxiety; or diaphoresis).

**Table 3: Common Weaning Parameters**

Mechanics
Spontaneous tidal volume and respiratory rate
Vital capacity
Maximal inspiratory pressure
Work-of-breathing
Gas exchange
PaO <sub>2</sub> /FIO <sub>2</sub> , PaO <sub>2</sub> /PAO <sub>2</sub> , P(A-a)O <sub>2</sub>
V <sub>D</sub> /V <sub>T</sub>
Respiratory drive
P <sub>0.1</sub>

**Weaning techniques**

Ventilator weaning is conducted if the patient fails the spontaneous breathing trial. Weaning can be accomplished by gradually reducing the set rate of the ventilator during SIMV (SIMV weaning); gradually reducing the level of pressure with PSV (pressure support weaning); or by providing for periodic trials of spontaneous breathing (T-piece weaning). Various combinations of techniques (SIMV + PSV) and automated “closed-loop” approaches are also possible. Prospective controlled trials have reported the poorest weaning outcomes with SIMV. (14,15) The disadvantage of SIMV may be that little adaptation by the patient’s effort to volume-cycled machine assistance appears to occur on a breath-by-breath basis during IMV. (18) The choice of PSV or T-piece weaning remains a matter of clinician preference. (16) If a particular approach to weaning is not successful, it is prudent to select a different approach. Nevertheless, a standardized approach using specific protocols, compared with nonstandardized physician-directed approaches, appears to wean patients more quickly from mechanical ventilation. (19-23)

Noninvasive mechanical ventilation can be an important adjunct to facilitate weaning in selected patients. In a study by Nava and colleagues, COPD patients, who had been mechanically ventilated for 48 hours and failed a T piece trial, were randomized to weaning by invasive PSV or extubation and face mask PSV. Noninvasive PSV weaning led to reduced weaning time, fewer ICU days, a decreased nosocomial pneumonia rate, and improved 60-day survival. (24)

Protocol-driven approaches to weaning may be more successful than traditional physician-based approaches. Such protocols often can be implemented by nursing or respiratory therapy personnel. (19-21) Ely and coworkers tested large-scale implementation of a therapist-driven weaning protocol. They reported a 97% completion rate and 95% correct interpretation rate of the therapist-driven daily weaning screen and concluded that implementation of such protocols is feasible. (25) In a separate study, Ely and coworkers examined the utility of daily screening for weaning readiness by respiratory therapists. Patients who were judged to be ready received a trial of spontaneous breathing. The physician was notified of the patient’s readiness to wean if the patient successfully completed a spontaneous breathing trial. The intervention resulted in decreased days on the mechanical ventilator, decreased ICU days, and a decreased complication rate. (22) Kollef and colleagues similarly reported that a

protocol-directed approach resulted in weaning patients more quickly than a traditional physician-based approach to weaning. (23)

### **Long-term ventilatory requirements**

Some patients require a prolonged time (weeks or months) to wean. These patients may benefit from care in a specialized long-term ventilator weaning facility. A comprehensive focus on generalized rehabilitation, strength and endurance training, and adequate attention to nutrition may be successful. Due to the nature of some diseases (e.g., amyotrophic lateral sclerosis), however, some patients will not wean from mechanical ventilation. If desirable, mechanical ventilation may be continued in a long-term care facility or at home.

### **Summary**

1. The most accurate “weaning parameter” is the rate:tidal volume index (RSBI).
2. A trial of spontaneous breathing will demonstrate extubation readiness in about 75% of patients.
3. Weaning success is lower with SIMV than with PSV weaning or conducting periodic trials of spontaneous breathing.
4. Protocol-driven approaches to weaning appear equally or more successful than traditional physician-driven protocols.

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