Overview of Weaning from Mechanical Ventilation: Methods and Causes of Weaning Difficulty

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Abstract

Weaning patients from mechanical ventilation (MV) which means transition from mechanical ventilated breathing to spontaneous breathing is considered one of the critical decisions in intensive care unit. Weaning procedures are frequently initiated only when the underlying illness state that required MV has been significantly improved or resolved to the point of being capable of sustaining spontaneous breathing. However, a percent of patients fail and are re-intubated despite fulfillment of all the current weaning criteria and this may be due to the heterogenecity of critically ill patients which impairs the predictive accuracy of the available indices in different patient subgroups. Although rapid and safe discontinuation of MV should be the objective for the majority of patients, both premature and unreasonably delayed extubation still occur, leading to adverse outcomes. Thus, weaning is challenging, represents a large part of the ventilation period and concerns all mechanically ventilated patients surviving their stay. The aim of the present study was to review the methods of Weaning from Mechanical Ventilation and to find a suitable parameter for prediction of failed weaning from mechanical ventilation to prevent hazards of prolonged intubation and ventilation and to improve outcome in these critically ill patients.

Keywords: Mechanical Ventilation; Weaning Difficulty; Critically Ill Patients.

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Introduction

Weaning from mechanical ventilation (MV) could be described as the process of removing ventilator support. Weaning from MV often implies two separate but closely linked views of care, elimination of MV of any artificial airway **(1)**.

Weaning failure is defined as the inability of spontaneous breathing trial (SBT) to work or the need for reintubation within 48 hours of extubation. SBT failure is defined by two types of indicators **(2)**. Objective indicators such as tachypnea, tachycardia, hypertension, hypotension, hypoxemia or acidosis, and arrhythmia. Subjective indicators such as distress or agitation, depressed mental state, diaphoresis, and signs of increased effort **(3,4)** .

SBT failure is typically accompanied by cardiovascular disease or an inability of the respiratory pump to sustain breathing demand. Failure to extubate might be due to the same underlying cause,in addition to, upper airway blockage or copious discharges **(5).**

Weaning needs an adequate gas exchange (defined by the majority of studies as an increase in the arterial oxygen tension/fractional inspired oxygen ratio > 200), an intact sensorium, suitable muscular and neurological function, and stable cardiovascular function. A normal hemoglobin (Hb) level enhances oxygen transport to body cells, and a standard level of blood electrolyte and a status of good nutrition further reduce the risk of fatigue of respiratory muscle during the weaning phase **(6).**

Clinical judgment has been incorporated into this section, as well as objective indicators to assist in the decision making process. Accurate indicators would avoid unnecessary prolongation of MV by assisting in the early identification of weanable individuals **(7).**

Weaning parameters may be classed as those that assess the following indices: oxygenation indices, respiratory muscle strength, respiratory drive, and effort of breathing, as well as composite indices **(8).**

On a theoretically adequate level of pressure support, enhanced work of breathing would very probably be related to patient-specific circumstances (e.g., increased airway difficulty or stiff lungs). For instance, it is reasonable to anticipate that the work of breathing will remain considerable even following extubation, with the possibility of weaning fail **(9).**

Numerous efforts have been made to include many of these characteristics into integrative indices to improve the predictability of weaning outcomes. By combining respiratory rate and tidal volume into an integrative index, the predictive potential of these two indices on their own is greatly increased **(2).**

The f/Vt ratio (respiratory frequency divided by tidal volume), alternatively called the RSBI (rapi44d shallow breathing index), has substantial positive and negative predictive values of 0.79 and 0.95, respectively, with a cut-off value of 105 **(10).**

The Compliance, Rate, Oxygenation, and Pressure (CROP) Index considers not just the respiratory system's requirements, but the respiratory muscles' ability to meet such needs. A CROP value greater than or equal to 13 mL/breath per minute is often associated with effective weaning. CROP index >[Cdyn×MIP×(PaO2/PAO2)]/f.Cdyn> dynamic compliance. MIP > maximal inspiratory pressure (the maximal negative pressure recorded during a 20-s occlusion of the airway. PaO2> Oxygen tension of the arterial blood. PAO2 > Oxygen tension of the alveolar air f > frequency of respiration **(11).**

Methods of Weaning:

Weaning may be achieved in one of two ways: by gradually increasing the duration of impulsive breathing on the endotracheal tube, or by steadily reducing the level of support on IMV, SIMV+PS, or pressure support ventilation (PSV) **(12).**

- **Trials of Spontaneous Breathing (T-Piece weaning):**

A T-piece experiment involves disconnecting the subject from the ventilator, attaching a T-piece to the endotracheal tube, and administering an adequate level of O2 through one of the T-limbs. The individual is urged to breathe on his own for limited periods through the endotracheal tube. This continued duration of breathing is gradually increased in duration until the subject is capable of breathing independently for an extended time without exhibiting distressing symptoms **(13).**

Although the definition of "acceptable duration of time" wasn't established, clinical experience indicates that wean ability occurs once the subject is capable to sustain spontaneous T-piece breathing easily for 1–24 h. Trials ranging within 30 and 120 minutes of spontaneous breathing could be as beneficial in predicting successful weaning . Neither has the optimal time of "rest" on the ventilator been found, although clinical experience shows that a range of 1–3 hours is sufficient. Each day, even one try of spontaneous breathing may be enough . At any point during the trial of spontaneous breathing, if any indicators of cardiorespiratory distress arise, the trial should be stopped promptly **(14).**

- **Synchronized Intermittent Mandatory Ventilation (SIMV) :**

  This is one of the techniques in which the individual and ventilator share the weight of breathing initially. Respiratory workload is gradually transferred to the case. Sufficient breaths are delivered to achieve the appropriate PaCO2 without causing difficulty breathing in the patient. At each level, the required breaths are reduced by 1–3 per minute. A blood gas sample obtained 30 minutes after each drop in IMV frequency enables the PaCO2 and pH to be closely monitored. If the pH remains above 7.35, the required breaths are gradually lowered until the IMV rate reaches zero, with blood gas measurements collected at each stage. After the patient has been able to breathe satisfactorily at this level for 24 hours, extubation is done **(15).**

- **Pressure Support Ventilation (PSV):**

  The PSV mode establishes a predetermined amount of pressure support, which is maintained during the inspiratory breath until the airflow declines to approximately 25% of its maximum range; at this time, the breath is exhaled. This mode gradually decreases the doctor-preset pressure support level until a pressure support level of 3–5 cm H2O, spontaneous breathing occurs without symptoms of discomfort, which is considered to nearly compensate for the resistance of the endotracheal tube and ventilator circuit **(16).**

- **Noninvasive Positive Pressure Ventilation (NIPPV):**

  Not only does NIPPV aid minimize the length of time spent intubated in COPD -patients with acute type II respiratory failure, but it can help increase the rate of weaning. NIPPV involvement in non-hypercapnic respiratory failure weaning is less defined and possibly less significant **(17).**

➢ **Extubation:**

Weaning does not imply extubation. It must be performed only once the participant's capability to keep the airway has been established, which requires an acceptable level of awareness; a Glasgow coma scale (GCS) score of >8 is associated with successful extubation. A healthy cough response is also necessary; Cough strength can be evaluated by spirometry **(18).**

- **Technique of Extubation:**

  The case is placed in a sitting position (Fowler or semi-Fowler). Pre-oxygenation with 100% O2. Suction is applied thoroughly to the mouth and throat. As the cuff is deflated, the tapes locking the ET tube are undone, a fairly large breath is delivered, and the subject is advised to cough vigorously as the tube is removed. Deflate the ET cuff entirely. The tube is quickly removed **(19)**.

After the tube is removed, the subject is made to cough once more. Suction is applied to the mouth and throat once again. O2 is delivered via a facemask. The participant's condition, breathing pattern, vital signs, electrocardiogram, and saturation level of oxygen are all continuously monitored. Numerous secretions in the airway enhance the likelihood of extubation failure. Suctioning is required frequently, many times each couple of hours, indicating that extubation should be postponed. Lastly, laryngeal edema or other upper airway difficulties could hinder effective extubation, and it is important to examine the upper airway's patency prior to removing the endotracheal tube **(15,19)**.

Causes of weaning difficulty:

According to a new classification proposed by the consensus conference, weaning should be categorized into three groups with distinct epidemiological characteristics and clinical outcomes **(Table 1)**. This stratification, though simplistic, distinguishes three types of reasoning and approaches towards patient management **(2)**.

About 30–40 % of patients present as difficult weaning, who require up to three SBTs (or as long as 7 days) to be successfully extubated. The reasons for failed weaning have to be insistently explored and corrected, and the pathophysiology of weaning failure needs to be understood for an optimal management of the patient **(17,20)**.

Table (1): frequent reasons for weaning failure

Simple weaning	Delayed awakening due to accumulation of sedative drugs Lack of screening Excessive level of ventilatory assist making weaning assessment unreliable Lack of systematic discussion during rounds Lack of personnel
Difficult weaning	Accumulation of sedative drugs Fluid overload Left heart failure Respiratory muscle weakness (myopathy) Excessive workload due to infection, secretions, unresolved sepsis, etc.
Prolonged weaning	Severe chronic heart failure Severe chronic respiratory insufficiency Prolonged respiratory muscle weakness (neuromyopathy) Depression Poor sleep quality, severe constipation, persistent sepsis, etc.

- **Central drive:**

Drive to breathe reduced by sedatives, direct insults to the respiratory center , hyperventilation to abnormally low PaCO2 for a particular patient, metabolic alkalosis (commonly exacerbated by hypokalaemia), loss of hypoxic drive (COPD). Clinically patients may fail to demonstrate respiratory distress and will in time develop Type II respiratory failure **(21).**

- **Neuromuscular**

Primary neurological disorders including Guillain–Barre ´ syndrome; Myasthenia Gravis; and Botulism. Critical illness polyneuropathy (more common with steroids and neuromuscular blocking agents). Critical care myopathy/malnutrition. Electrolyte abnormalities such as hypokalaemia, hypophosphataemia, hypomagnesaemia, hypocalcaemia ,and hypothyroidism **(22).**

- **Respiratory parameters:**

Respiratory pump failure is caused by an imbalance between respiratory workload and respiratory capability **(2).**

Increased respiratory load including increased resistance, bronchospasm, and increased or thick secretions **(23).**

Reduced compliance such as pneumonia, pulmonary oedema , intrinsic PEEP, pleural effusions, pneumothorax, and paralytic ileus or abdominal distension **(24).**

Increased ventilation including hypermetabolism due to sepsis, overfeeding, metabolic acidosis, shock ,and pulmonary embolism **(23).**

Therefore, it is necessary to consider ICU regulations regarding sedation, fluid balance, and a methodical screening strategy in order to manage easy and difficult weaning effectively. An individualised approach is also needed to identify and treat failed patients. Extended weaning necessitates a complete strategy.

Conclusion:

Earlier patient weaning from mechanical ventilation is recommended to avoid complications of prolonged mechanical ventilation; however, premature weaning might result in extubation failure which is associated with poor outcomes.

Timing of weaning is crucial. So, it is critical to have accurate parameters that could be used to evaluate the weaning trial's success. Impaired left ventricular systolic and diastolic function was reported to be good predictors of weaning failure.

The following were the most important considerations:

1) Based on the complexity and length of the weaning process, patients should be divided.

2) It is best to think about weaning as soon as feasible.

3) The primary diagnostic procedure used to ascertain whether patients can be effectively extubated is a spontaneous breathing experiment.

4) The first trial should include either low pressure support or T-tube breathing, and it should last for thirty minutes.

5) When a patient fails a trial or trials, pressure support or assist-control ventilation modes should be preferred.

6) Noninvasive breathing methods should not be routinely utilized as a means of treating extubation failure, but they should be taken into consideration for a subset of patients in order to reduce the length of intubation.

Conflict of interest: The authors declare no conflict of interest.

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