Weaning from Mechanical Ventilation: Review Article

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ABSTRACT

Background: Weaning from mechanical ventilation can be defined as the process of abruptly or gradually withdrawing ventilatory support. Recommendations for weaning practice would be based on the findings of multiple well-designed randomized trials conducted over the past decade. In comparison to more progressive removal of ventilatory aid, quick extubation following successful spontaneous breathing trials expedites weaning and minimizes the time of mechanical ventilation (MV). More recently, pressure support ventilation and bi-level positive airway pressure modes have become available. Modern ventilators are increasingly sensitive, allowing easy patient triggering of supported breaths, modes such as tube compensation, and measurement of numerous respiratory parameters. Developments in weaning techniques have paralleled these improvements in ventilator functionality.

Objective: In this review article, the initially required criteria to start and the weaning methods from mechanical ventilation. **Methods:** These databases were searched for articles published in English in 3 databases [PubMed – Google scholar- science direct] and Boolean operators (AND, OR, NOT) had been used such as [Weaning AND Mechanical Ventilation OR Intensive Care Unit] and in peer-reviewed articles between 1992 and 2021. Documents in a language apart from English have been excluded as sources for interpretation were not found. Papers apart from main scientific studies had been excluded: documents unavailable as total written text, conversation, conference abstract papers, and dissertations. **Conclusion:** All cases that received ventilatory assistance should be evaluated daily for weaning suitability. This may include satisfying several preconditions and then undergoing an SBT. If weaning is ineffective, either PSV or daily spontaneous breathing spells of increasing length should be tried.

Keywords: Weaning, Mechanical Ventilation, Intensive Care Unit.

INTRODUCTION

Weaning from mechanical ventilation (MV) could be described as the process of suddenly or regularly removing ventilator support. Weaning from MV often implies 2 separate but closely linked views of care, elimination of MV of any artificial airway [(1)]. The primary challenge is identifying whether a case is prepared to restart ventilatory support. Several studies have mentioned that a direct technique for evaluating the ability to preserve spontaneous breathing is by initiating a trial of unaided breathing. Once a case can sustain breath spontaneously, a 2nd judgment should be created about whether the artificial airway could be withdrawn. This choice is determined based on the case's mental state, methods of protection for the airways, coughing ability, and secretions feature. Extubation is an acceptable operation if the case has an adequate sensorium, complete airway protection devices, and no severe discharges [(2)].

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: 1) objective indicators such as tachypnoea, tachycardia, hypertension, hypotension, hypoxemia or acidosis, and arrhythmia; and 2) subjective indicators such as distress or agitation, depressed mental state, diaphoresis, and signs of increased effort [(3)]. 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, additionally, upper airway blockage or copious discharges [(4)]. Weaning procedures are frequently initiated only when the underlying illness state that necessitated MV has been significantly improved or rectified to the point of being capable of sustaining spontaneous breathing. The inadequate resolution, however, does not preclude effective weaning. Additionally, 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 [(5)].

Weaning Parameters:

Timing of weaning is crucial. So, it is critical to have accurate parameters that could be used to evaluate the weaning trial's success. Clinical judgment has been incorporated into this section, as well as objective indicators to assist in the decision-making process [(1)].

Accurate indicators would avoid unnecessary prolongation of MV by assisting in the early identification of weanable individuals [(6)].

Furthermore, markers can be utilized to detect particular physiological anomalies linked with weaning failures. At the moment, neither a single predictor nor a collection of predictors possesses the needed dependability. Weaning parameters may be classed as those that assess the following indices: oxygenation indices, respiratory muscle strength, endurance, respiratory drive, and effort of breathing, as well as composite indices (Fig.1) [(7)].

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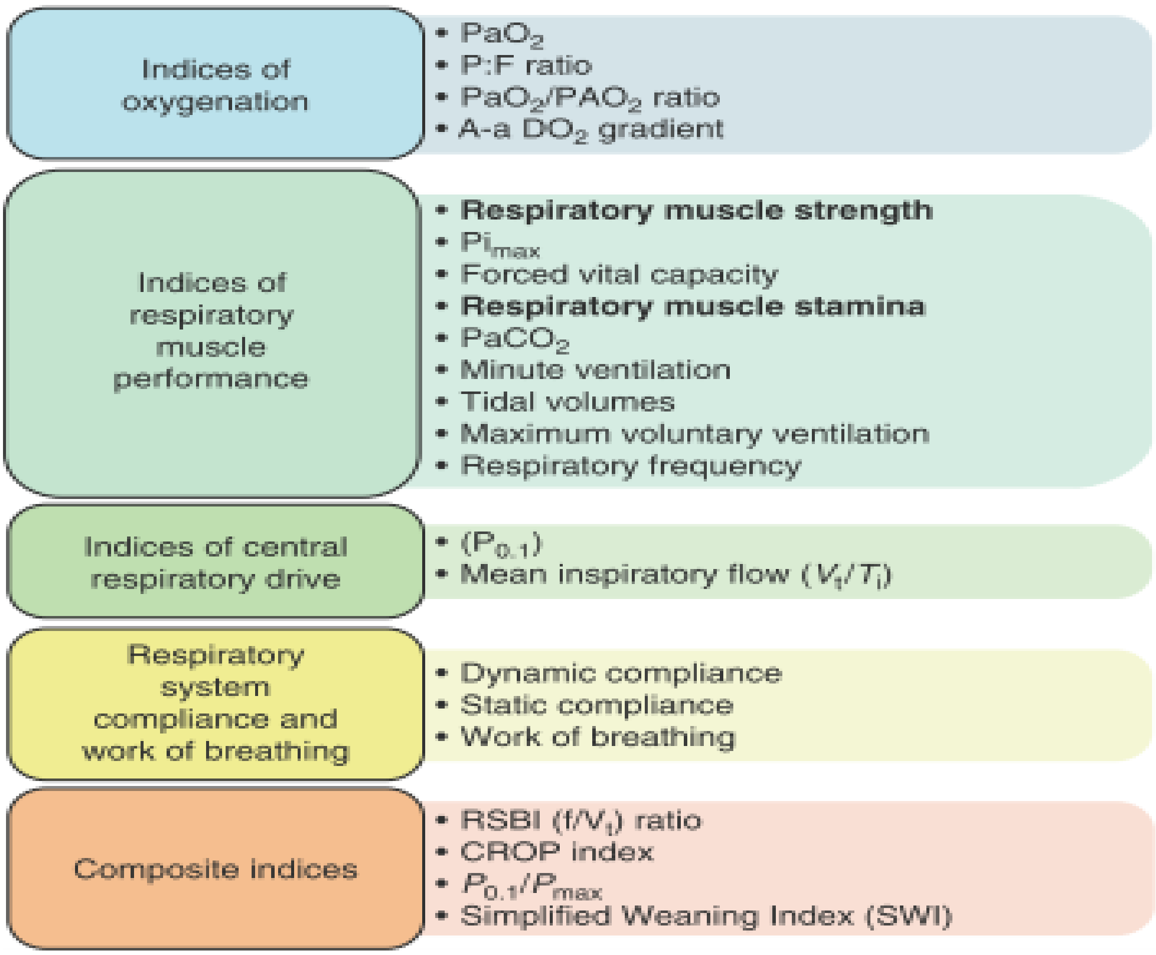

Figure (1): Weaning indices

Table (1): Weaning indices [7]

Indices of oxygenation	
PaO_2/PAO_2 ratio	>0.35
Alveolo-arterial oxygen gradient (A-aD02)	<350 mmHg on FIO_2 1.0
Parameter of oxygenation	Weaning threshold
PaO_2/FIO_2 ratio ("PF" ratio)	>200
Shunt fraction (Qs/Qt ratio)	<0.2 (< 20% shunt)
PaO_2 (on FIO_2 0.5 and PEEP 5 cm H_2O	>60 mmHg
Indices of respiratory muscle strength and endurance	
Respiratory muscle strength	
PI_{max}	< -15 to -30 cm H_2O
Forced VC	>10-15 mL/kg
Minute ventilation (spontaneous)	<10-15 L/min
Respiratory muscle endurance	
$PaCO_2$	<50 rnmHg
Respiratory frequency	≤34 breaths/min or ≥7 breaths/min
Maximum voluntary ventilation	>20 L/min
Tidal volumes	≥6 mL/kg
f/Vt ratio	≤104 breams/min/L
Indices of central respiratory drive	
Mean inspiratory flow (Vt/Ti)	Low
Airway occlusion pressure (P0.1)	≤1.9 cm H_2O
Respiratory system compliance and work of breathing	
Work of breathing	33 J/min or 0.47 J/L
Static compliance	≥34 mL/cm H_2O
Dynamic compliance	≥23 mL/cm H_2O

Oxygenation indices:

The ability to maintain a PaO2 of 55 mmHg while receiving 40% O_2 via the ventilator (with 5cm PEEP) is a critical criterion for MV cessation. Indeed, once off the ventilator, the subject is frequently receiving 50%–60% O_2 via standard oxygen delivery devices, which must place him in the portion at the apex of the oxyhemoglobin dissociation curve and give an extra level of hypoxemia protection [8].

Parameters that Assess Respiratory Muscle Performance:

When the individual entirely exhales to residual volume and then makes a maximal inspiratory effort against an obstructed airway, the PI max (maximum inspiratory pressure) is determined. PI max evaluates not only the diaphragm's strength but also the collective strength of all the inspiratory muscles. A PI max of < -30 cm H2O (the respiratory muscles' ability to generate a negative pressure of at least 30 cm H_2O) is supposed to predict successful weaning [9].

Vital capacity (VC) is an evaluation of the muscular strength of the respiratory system. Since VC assessment is generally unpredictable in predicting weaning outcomes, VC is seldom used as a criterion in evaluating weanability. A VC value of more than ten milliliters per kilogram was proposed to be a predictor of successful weaning (a typical VC value is between 65 and 75 milliliters per kilogram) [10].

Another time-honored but probably erroneous sign of weaning is minute ventilation.

Parameters that assess central respiratory drive

The airway occlusion pressure (P0.1) is evaluated by performing inspiratory effort against an obstructed airway and evaluating the airway pressure 0.1 seconds later. P0.1 is a parameter that indicates the respiratory drive's intensity (typical P0.1 values are 2 cm H2O). Increased levels predict an abnormally high respiratory drive and so preclude weaning success [11].

A downside of P0.1 is that its frequent evaluation has the potential to change respiratory motivation. The mean inspiratory flow (Vt/Ti), which is a ratio of the tidal volume to the inspiratory time, is unaffected by this constraint. However, because Vt/Ti is a measure of activities that occur substantially further from the brainstem than P0.1, it may greatly underestimate the respiratory drive [12].

Respiratory System Compliance and Work of Breathing:

At relaxation, in well individuals, the breathing work per liter is approximately 0.47 J/L; the mean labor of ventilation per minute is 4.33 J/min. Since an extreme work of breathing was connected with successful weaning, a modestly raised work of breathing couldn't be used to predict unsuccess weaning [13].

A portion of the work required to breathe in a person on spontaneous ventilation is due to the inspiratory resistance created by the limited lumen of the endotracheal tube and the long ventilator circuits (the length and diameter of the breathing tubes' luminal lumen are critical factors in determining airway resistance). Extubating a person may eliminate this source of inspiratory difficulty (the endotracheal tube and ventilatory circuits), hence reducing the labor of breath [14].

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 [15].

A noncompliant respiratory system increases the amount of labor required to breathe dramatically. When the volumetric pressure slope is flatter, it takes a large amount of inspiratory effort to fill the lungs. A noncompliant respiratory system may indicate an unresolved pathologic disease in the lung, pleura, or chest wall. Dynamic adherence is typically between 60 and 100 mL/cm H2O. Although weaning characteristics such as C dyn values larger than 22 mL/cm H2O and C stat norms greater than 33 mL/cm H2O are frequently utilized [16, 17].

Composite Indices:

Numerous efforts have been made to include many of these characteristics into integrative indices to improve the predictability of weaning outcomes [18].

By combining respiratory rate and tidal volume into an integrative index, the predictive potential of these two indices on their own is greatly increased. The f/Vt ratio (respiratory frequency divided by tidal volume), alternatively called the RSBI (rapid shallow breathing index), has substantial positive and negative predictive values of 0.79 and 0.95, respectively, with a cut-off value of 105 [19].

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 [20].

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.

The Simplified Weaning Index (SWI) is a quantitative assessment of a patient's respiratory muscle endurance and lung gas exchange efficiency. While the patient is completely ventilated, the steps are done. An SWI value greater than 9 properly predicts successful weaning

93% of the time; a value greater than 11 accurately predicts weaning failure 93% of the time [1].

SWI > [f (PIP−PEEP)/MIP] × [PaCO2/40].

PIP > peak Inspiratory pressure.

PEEP > positive end-expiratory pressure.

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) [21].

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 [22].

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 [1].

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 [23].

At any point during the trial of spontaneous breathing, if any indicators of cardiorespiratory distress arise, the trial should be halted promptly.

Synchronized IMV:

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 [24].

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 [25]. After the patient has been able to breathe satisfactorily at this level for 24 hours, extubation is done.

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 [26]. 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 [14].

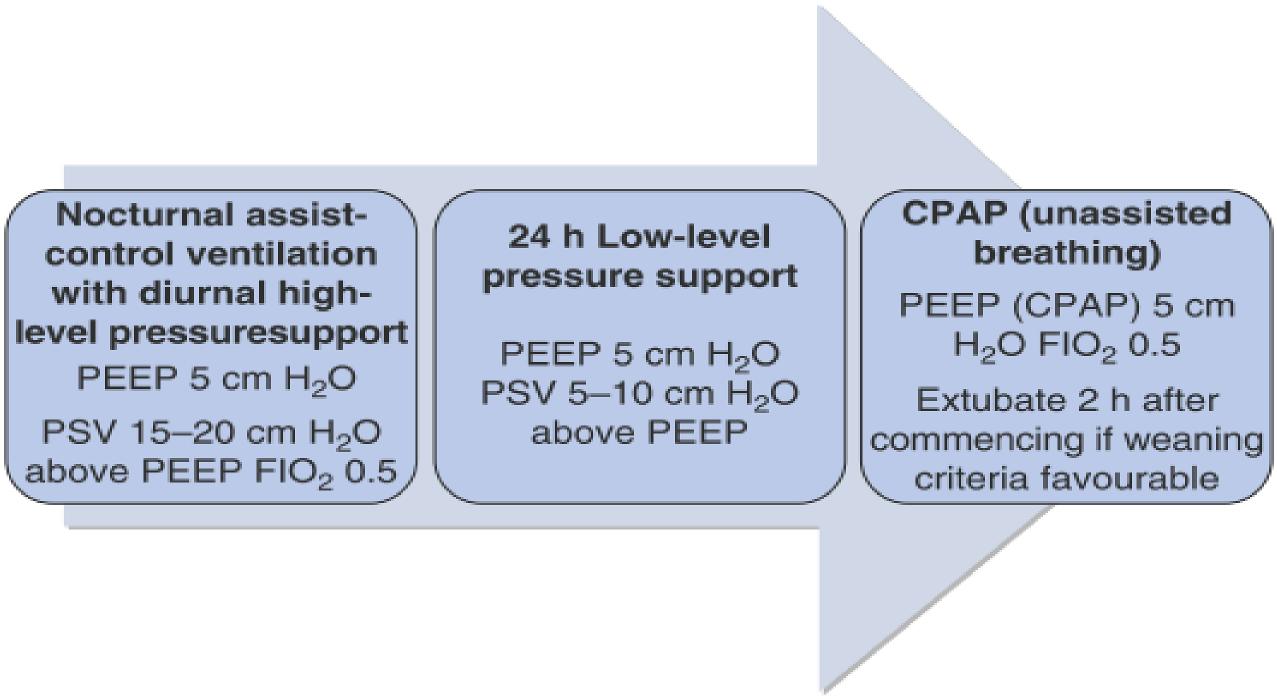

Figure (2). Weaning with Pressure Support [14].

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's involvement in non-hypercapnic respiratory failure weaning is less defined and possibly less significant [27].

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 extubating (28). A healthy cough response is also necessary; Cough strength can be evaluated with an index card or piece of blotting paper, or more formally by spirometry [29].

Technique of Extubation [4]:

(1) The case is placed in a sitting position (Fowler or semi-Fowler). (2) Pre-oxygenation with 100% O_2. (3) Suction is applied thoroughly to the mouth and throat. (4) 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. (5) Deflate the ET cuff entirely. (6) The tube is quickly removed. (7) After the tube is removed, the subject is made to cough once more. (8) Suction is applied to the mouth and throat once again. (9) O_2 is delivered via a facemask. (10) 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 [4]. 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 jeopardize effective extubation, and it is critical to examine the upper airway's patency prior to removing the endotracheal tube [30].

CONCLUSION

All cases who received ventilatory assistance should be evaluated daily for weaning suitability. This may include satisfying several preconditions and then undergoing an SBT. If weaning is ineffective, either PSV or daily spontaneous breathing spells of increasing length should be tried.

A tracheostomy may be beneficial in difficult-to-wean individuals. Over 95% of patients should be able to be weaned in this manner. Each year, a few patients may need a referral to a long-term weaning facility.

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