Weaning from Mechanical Ventilation

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Background

In intubated patients, mechanical ventilation offers essential ventilatory support, while the respiratory system recovers from acute respiratory failure.

Yet, invasive mechanical ventilation is associated with risks and complications that prolong the duration of mechanical ventilation and increase the risk for death.

Safely weaning the patient from the ventilator as soon as possible is paramount.

Weaning process is a continuum lasting from intubation until hospital discharge.
Consequences of inappropriate weaning

**Delayed**
- Airway trauma
- VAP
- Ventilator induced lung injury
- DVT, GI bleed
- Increased sedation

**Premature**
- Respiratory muscle fatigue
- Cardiorespiratory compromise
- Failed extubation
- Loss of airway protection
Where is the main action?
Classification - Weaning Process

Brochard: based on the ability to wean

**Simple weaning**: Patient tolerates first spontaneous breathing trial (SBT) and is successfully extubated (70% of all patients).

**Difficult weaning**: Patient fails to tolerate initial SBT, successful weaning requiring up to three SBTs or up to 7 days from first SBT.

**Prolonged weaning**: Patient fails at least three SBTs or takes more than 7 days after the first SBT.
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<th>Simple weaning</th>
<th>Delayed awakening due to accumulation of sedative drugs</th>
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<td>Lack of screening</td>
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<td>Excessive level of ventilatory assist making weaning assessment unreliable</td>
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<td>Lack of systematic discussion during rounds</td>
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<td>Lack of personnel</td>
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<td>Difficult weaning</td>
<td>Accumulation of sedative drugs</td>
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<td>Fluid overload</td>
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<td>Left heart failure</td>
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<td>Respiratory muscle weakness (myopathy)</td>
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<td>Excessive workload due to infection, secretions, unresolved sepsis, etc.</td>
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<td>Prolonged weaning</td>
<td>Severe chronic heart failure</td>
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<td>Severe chronic respiratory insufficiency</td>
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<td>Prolonged respiratory muscle weakness (neuromyopathy)</td>
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<td>Depression</td>
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<td>Poor sleep quality, severe constipation, persistent sepsis, etc.</td>
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Table 1 Most frequent reasons for weaning failure according to the three groups of the weaning classification: consequences for daily practice
Classification - Weaning

Weaning Success: absence of ventilatory support 48hr following extubation

Weaning Failure:
- Failed SBT
- Reintubation / resumption of ventilatory support following extubation
- Death within 48 h following extubation

Weaning in progress: requiring NIV post extubation
Weaning – Steps

Determine readiness for weaning

Weaning parameters
  Physiological parameters
  Indices

How to wean
  Sedation management
  Mode
  Protocolised

Difficulty in weaning

Tracheostomy
Readiness Testing

The patient’s capacity to breathe spontaneously is often underestimated.

Rapid weaning must be balanced against the risks of premature spontaneous breathing.

Objective assessments are favored because subjective, clinical judgment appears to be relatively inaccurate in assessing readiness.

Nevertheless, 30% of patients never satisfying objective readiness criteria can still be successfully weaned.

Only 5 predictors shown to have good predictive value
Weaning Parameters

### Clinical assessment
- Adequate cough
- Absence of excessive tracheobronchial secretion
- Resolution of disease acute phase for which the patient was intubated
- Clinical stability
  - Stable cardiovascular status (i.e. fe $\leq$ 140 beats·min$^{-1}$, systolic BP 90-160 mmHg, no or minimal vasopressors)
  - Stable metabolic status
- Adequate oxygenation
  - $S_o_2 > 90\%$ on $< F_iO_2$ 0.4 (or $P_aO_2/F_iO_2 > 150$ mmHg)

### Objective measurements
- $f_r$ $\leq$ 35 breaths·min$^{-1}$
- $MIP \leq$ -20--25 cmH$_2$O
- $V_t >$ 5 mL·kg$^{-1}$
- $V_C >$ 10 mL·kg$^{-1}$
- $\#V_t < 105$ breaths·min$^{-1}$·L$^{-1}$
- No significant respiratory acidosis
- Adequate mentation
  - No sedation or adequate mentation on sedation (or stable neurologic patient)

Has the primary pathology resolved???????
Weaning Indices

Negative inspiratory force (maximal inspiratory pressure)

Minute ventilation

Respiratory frequency

Tidal volume

Frequency–tidal volume ratio (f/VT)
  60-105
Steps For Weaning

• Sedation Management

• Modes of weaning
  ✓ Conventional modes
  ✓ Advanced modes
  ✓ SBT – Spontaneous breathing trial

• Protocolised weaning

• Post-extubation care and monitoring
Modes Of Weaning

Conventional modes
- PS ventilation
- SIMV
- t – piece

PSV better than SIMV

Advanced modes
- ATC
- ASV
- PAV
- NAVA

Role of NIV in weaning
Spontaneous Breathing Trial

The best way to determine suitability for discontinuation of mechanical ventilation is to perform a SBT

- T piece trial
- Pressure Support with PEEP
- CPAP
Failure Criteria Of SBT

Weaning failure is defined as either the failure of SBT or the need for reintubation within 48 h following extubation

Clinical assessment and subjective indices
- Agitation and anxiety
- Depressed mental status
- Diaphoresis
- Cyanosis
- Evidence of increasing effort
  - Increased accessory muscle activity
  - Facial signs of distress
- Dyspnoea

Objective measurements
- $P_aO_2 < 50-60$ mmHg on $F_iO_2 > 0.5$ or $S_aO_2 < 90$
- $P_aCO_2 > 50$ mmHg or an increase in $P_aCO_2 > 8$ mmHg
- pH < 7.32 or a decrease in pH > 0.07 pH units
- $f/V_t > 165$ breaths $min^{-1}L^{-1}$
- $f_t > 35$ breaths $min^{-1}$ or increased by ≥ 50%
- $f_c > 140$ beats $min^{-1}$ or increased by ≥ 20%
- Systolic BP > 180 mmHg or increased by ≥ 20%
- Systolic BP < 90 mmHg
- Cardiac arrhythmias
Weaning Failure – Causes

Primary Pathology

- Ventilator dysynchrony
- Increased resistive load of ventilator circuit
- Increased elastic workload (Pneumonia, ARDS, intrinsic PEEP, Amaurosis, abdominal distension)
- Inadequate reversal of paralysis
- Critical illness myopathy, diaphragmatic diaphragm atrophy
- Laryngospasm
- Decreased or suppressed signal conduction
- Increased resistive load of the airways (bronchospasm, secretions, intrinsic PEEP)
- Coronary heart disease, left ventricular dysfunction (systolic and diastolic)
- Endocrinologic

Inadequate reversal of narcotics

Depressed central drive (trauma, metabolic, toxic, infections)
Non Invasive Ventilation As A Weaning Tool

In weaning, NIV has been studied for three different indications, which should be strictly separated.

First, NIV has been used as an alternative weaning modality for patients who are intolerant of the initial weaning trial – **stable COPD patients**

Secondly, NIV has been used as a treatment option for patients who have been extubated but developed ARF within 48 hrs – **Rescue therapy**

Thirdly, NIV has been used as a prophylactic measure after extubation for patients who are at high risk for re-intubation but who did not develop ARF – **COPD patients, Patients with CAD / CHF, Post operative**
Criteria For Extubation Failure

RR > 25 breaths per minute for >2 hours

HR > 140 beats per minute or sustained increase or decrease >20%

Clinical signs of respiratory muscle fatigue or increased work of breathing
  SaO2 < 90%; PaO2 < 80 mmHg on FiO2 > 0.50

Hypercapnia (PaCO2 > 45 mmHg or >20% from pre-extubation), pH <7.33

Worsening CNS status
Contemporary approach

Use of advanced modes

Assessment of fluid balance

Assessment of diaphragmatic function

Assessment of right heart function

Nutritional augmentation
Tricks of the trade

Prepare for weaning at the time of intubation

Choose the biggest possible tube

Avoid overloading the patient with fluids and nutrition

Don’t stress a recovering heart

Do not ignore acid base and electrolyte imbalances

Ask the patient!
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