Weaning The Difficult Patient From Mechanical Ventilation

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Objectives

- Purpose of weaning and extubation
- Rationale of predictive indices in weaning
- Application of weaning parameters
- Impediments to weaning
- Newer weaning strategies
Weaning Definition

• Gradual withdrawal of mechanical support is not always necessary

• Short-term intubation and ventilation for surgical procedures under GA should simply be discontinued when patients have sufficient neurologic function and muscular strength to breathe on their own

Morbidity Associated With Prolonged Intubation

• Vocal cord granulomas
• Ulceration of the vocal cords
• Stenosis of trachea
• Risk factor for nosocomial pneumonia (VAP)
The assessment of weaning proceeds in two phases:

Phase 1: To ensure that certain basic criteria regarding initial reason for mechanical ventilation are satisfied

Phase 2: Determine whether weaning is likely to succeed on the basis of specified criteria

READINESS FOR VENTILATOR WEANING

Major determinants of ability to wean can be classified into three categories:

• Oxygenation
• Ventilatory function
• Mental status / sedation vacation
OXGYGENATION

• Criteria of Adequacy
  \( \text{PaO}_2 > 60 \text{ mmHg on FIO}_2 < 0.35 \) at minimal PEEP,
  \( \frac{\text{PaO}_2}{\text{FIO}_2} > 200 \) (we use 150 at UH)

• Selected causes of failure:
  • Hypoventilation: neurologic injury or drugs
  • V/Q mismatch: dead space, severe CHF, positive fluid balance
  • Disease process not fully resolved

VENTILATION

• Criterion of Adequacy
  \( \text{PaCO}_2 < 50 \text{ mmHg} \) or within 8 mmHg of baseline

• Selected causes of failure
  • \( \downarrow \) respiratory drive: sedation, obesity/hypoventilation syndrome
  • \( \downarrow \) respiratory bellows function: diaphragm weakness, Neuromuscular disease
  • \( \uparrow \) CO\(_2\) production without compensatory \( \uparrow \) in alveolar Ve:
    • fever, hypermetabolism, carbohydrate overfeeding
  • \( \uparrow \) dead space ventilation without compensatory \( \uparrow \) alveolar Ve:
    • PE, bullous emphysema
Mental status

- Criteria of adequacy
  - Awake, alert, cooperative, with intact gag and swallowing
- Selected causes of failure
  - Cerebrovascular accident
  - Sleep deprivation/ICU psychosis
  - Drug therapy
  - Depression
  - Psychological dependency on ventilatory support
  - GCS<8

Assessment of Readiness to Wean

- RR, VT, VE
- ABG
- BP, HR
- NIF
- VC
- RSBI
- P0.1 Value (occlusion pressure)
- Minute ventilation recovery
RSBI

- Rapid Shallow Breathing Index
- One minute test
- Rate/Vt in Liters
  - RR 20 / Vt .400L = 50
  - RR 30 / Vt .150L = 200
- RSBI<100 is Predictive of Weaning Success

Yang & Tobin in 1991 showed that Pts with a RSBI<100 were weaned at a 80% probability. 95%>100 were not ready to be weaned

New Evidence says the RSBI < 65

Occlusion Pressure

- P0.1 characterizes the negative pressure during a short occlusion (.1 seconds) at the start of spontaneous inspiration.
- Occlusion Pressure is a direct measure of a patient's neuromuscular breathing drive.
P0.1 Values

- For healthy lungs and regular breathing P0.1 is 3-4 cmH2O
- High P0.1 signifies a high breathing drive which can only be maintained for a limited amount of time.
- Values over 6cmH2O for a patient with COPD indicate impending exhaustion.

NONRESPIRATORY PARAMETERS AFFECTING ABILITY TO WEAN

- Nutritional status
- Fluid balance
- Metabolic and acid-base derangements
- Cardiac Function
- Renal function
- Pharmacologic therapy
- Neuropsychiatric factors
NUTRITIONAL STATUS

Malnutrition has adverse effects on the respiratory system

- ↓ respiratory muscle strength and function
- ↓ diaphragmatic mass and contractility (VIDD)
- ↓ endurance

NUTRITIONAL STATUS

Over nutrition may impede weaning

- High minute ventilation
  - Produced by excessive Carbohydrate metabolism
  - Other causes of increased CO₂ production: fever, sepsis, shivering, seizures, and inefficient ventilation due to ↑ dead space, PE
ACID-BASE DISTURBANCES

- Acute ventilatory failure in the face of chronic CO₂ retention
  - Presumed normal baseline PaCO₂ of 40 mmHg during vent support --> acute respiratory alkalosis
  - A new compensatory state develops in 3-4 days
  - Kidneys dump the excess HCO₃⁻, but the patient is now unable to be weaned from the ventilator in this new steady state
  - **Treatment**: Allow PaCO₂ to gradually normalize over several days

The Patient with Chronic Obstructive Pulmonary Disease

- Rates of failure to wean as high as 24 %.
- Acid-base imbalance
- Steroids
- Bronchodilator therapy
- Nutrition
- Special consideration auto-PEEP
AUTOPEEP
(Dynamic Hyperinflation, Gas Trapping)

- **Definition**: Incomplete alveolar emptying prior to the next ventilator breath

- Undetectable without maneuver of occluding the expiratory port of the ventilator at end expiration

- **Same** hemodynamic consequences as routine PEEP:
  - ↓ Venous Return
  - ↓ BP

**Auto-PEEP**

- Auto-PEEP is increased when
  - airflow resistance is increased and
  - when exhalation time is decreased

- **Maneuvers to decrease auto-PEEP**
  
  Treat bronchospasm & secretions

  Respiratory rate
  - decrease RR ≤ 16 / min
  - maximize time for exhalation
  - Avoid IR-PCV

  + Increase external PEEP (typically 2-3 above Intrinsic PEEP)
  + Sedation / paralysis
WEANING METHODS

SIMV to T-piece weaning

SIMV to CPAP + PSV weaning

AC ventilation to T-piece

CMV to AC ventilation to T-piece

Newer weaning strategies

T-PIECE WEANING

• Method
  • Disconnect patient from the ventilator allow breathing on a T-piece or CPAP
  • Starting point: 5 min T-piece then 60 min rest
  • Trial duration is increased progressively
  • Rest intervals at least 1-2 hours attempts

• Signs of T-piece weaning failure
  • Elevated HR, BP, and RR
  • Diaphoresis, air hunger, and signs of respiratory muscle fatigue
  • Elevated PCO₂ is a very late sign of decompensation
Interruption Mandatory Ventilation
Weaning

- Spontaneous breathing from a demand system between ventilator breaths while the ventilator provides positive pressure breaths of adjustable size and frequency

- Method
  - Gradual decrease of guaranteed Minute Ventilation (FxVt)
    - Set frequency and size of Vt

Comparison of 4 Weaning Methods

- 546 patients ready for weaning (7.5 vent days)
  - 130 pts. Experienced respiratory distress over 2-hr weaning trial
    - randomly assigned to one of four weaning methods
    - IMV - PSV - Spont Vent > 2x/day - Spont Vent 1x/day
  - Standardized protocols

<table>
<thead>
<tr>
<th>Method</th>
<th>Extubation Time (days)</th>
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<tbody>
<tr>
<td>IMV</td>
<td>5</td>
</tr>
<tr>
<td>PSV</td>
<td>4</td>
</tr>
<tr>
<td>Spont Vent 1x/day</td>
<td>3</td>
</tr>
<tr>
<td>Spont Vent &gt; 2x/day</td>
<td>3</td>
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</tbody>
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Esteban et al NEJM 1995;332:335
Tracheotomy

• Indicated for
  • relief of upper airway obstruction
  • access for pulmonary hygiene
  • control of the airway
  • long-term positive pressure ventilation (beyond 14 days)

• During long-term weaning: a fenestrated tracheotomy tube allows the patient to speak
• Maybe speaking valve

New Strategies for 21\textsuperscript{st} Century

• ATC
• Smart Care
• Adaptive Support Ventilation
• PRVC with Auto-mode
• NAVA- Neurally Adjusted Ventilatory Assist
Why New Modes?

- Decrease ICU days
- Decrease Hospital Length of Stay
- Decrease Cost
- Resource Utilization
- Decrease VAP Rates
- Encourage spontaneous breathing

Automatic Tube Compensation

- Reduces WOB involved in ETT
- Great for weaning
- Doesn’t over shoot to create PS breaths
Adaptive Support Ventilation

- Galileo – Hamilton Medical AG
- Based on ideal body weight, % of minute ventilation desired, maximal inspiratory pressure tolerated.
- Ventilator determines compliance and resistance automatically
- Optimizes inspiratory pressure and respiratory rate based on formula of “Otis”
- Automatically titrates pressure support level to deliver the desired % of minute ventilation
- Therapist reduces the level of % of minute ventilation

ASV (Adaptive Support Ventilation)

- The clinician enters the patient’s IBW, which allows the ventilator’s algorithm to choose a required minute ventilation. The ventilator then delivers 100 mL/min/kg.
- A series of test breaths measures the system C, resistance and auto-PEEP
- If no spontaneous effort occurs, the ventilator determines the appropriate respiratory rate, VT, and pressure limit delivered for the mandatory breaths
- I:E ratio and T of the mandatory breaths are continually being “optimized” by the ventilator to prevent auto-PEEP
- If the patient begins having spontaneous breaths, the number of mandatory breaths decrease and the ventilator switches to PS at the same pressure level
- Pressure limits for both mandatory and spontaneous breaths are always being automatically adjusted to meet the targeted minute ventilation.
ASV (Adaptive Support Ventilation)

- **Indications**
  - Full or partial ventilatory support
  - Patients requiring a lowest possible PIP and a guaranteed $V_T$
  - ALI/ARDS
  - Patient requiring high and/or variable
  - Patients not breathing spontaneously and not triggering the ventilator
  - Patient with the possibility of work land changes (CL and Raw)
  - Facilitates weaning

ASV (Adaptive Support Ventilation)

- **Advantages**
  - Guaranteed VT and Minute ventilation
  - Minimal patient WOB
  - Ventilator adapts to the patient
  - Weaning is done automatically and continuously
  - Variable flow to meet patient demand
  - Decelerating flow waveform for improved gas distribution
  - Breath by breath analysis
ASV (Adaptive Support Ventilation)

- Disadvantages and Risks
  - Inability to recognize and adjust to changes in alveolar VD
  - Possible respiratory muscle atrophy
  - Varying mean airway pressure
  - In patients with COPD, a longer TE may be required
  - A sudden increase in respiratory rate and demand may result in a decrease in ventilator support

Studies supporting ASV

- Randomized controlled study by Sulzer ET AL. in 2001
- Post cardiac surgery (49) patients
- SIMV w/PS versus ASV
- Extubation was shorter with the ASV group 3.2 to 4.1 hours
- Advantage was that patients were switched to PS ventilation quicker than control group
ASV cont’d

- Dongelmans ET. Al 2009
- RCT with 124 patients
- Found that weaning times were similar
- Significant decrease in therapist interaction with ventilator with the ASV group
- Greatly reduces the need for staffing

PRVC with Auto-mode

- Siemens 300A
- Combines VSV and PRVC
- Automatically weans from PC to PS
- Pressure limit increases/decreases based on clinician–set Vt
- If patient becomes apneic switches back to PRVC
PRVC with Auto-mode studies

- Roth et al 2001
- PRVC with auto-mode versus SIMV
- 40 patients
- 136 minutes versus 169 minutes
- Not statically different
- BUT! therapist interaction in weaning process greatly reduced
- Not much else out there

NAVA

- Neurally Adjusted Ventilatory Assist
- Servo 300
- Electrical signal of the diaphragm signals how much PS is delivered to inflate lungs
- Improved synchrony
- Lung protective strategy
- As the patient’s condition improves, Edi amplitude decreases
- Pressure drop is an indicator to consider weaning and extubation
- Not much supporting literature
Smart Care

- Drager Medical XL ventilator
- Adjust PS levels based upon ETCO2 measurements
- Converts from machine breaths to PS breaths automatically
- Decreases vent days
- Decrease ICU days
- Decrease therapist interaction!

Conclusion

- New technology is coming every day
- New technology is only as good as the therapist using it
- New technology decrease staff interaction with the ventilator
- Embrace new technology and understand the ins and outs
References

