Liberating Patients From Mechanical Ventilation

Al Heuer, PhD, MBA, RRT, RPFT, FAARC
Professor-Rutgers University
Co-Owner, A & T Lectures

Learning Objectives

- Review key *terminology*.
- Emphasize the importance of *collaboration*.
- Summarize related research*.*
- Review *Inclusion* and *Exclusion* criteria.
- Summarize how patients should be *prepared & optimized.*
- Review and *debrief some cases*.
- Provide *additional resources*.

Key Terminology

- ***Spontaneous Breathing Trial (SBT):*** Simulate spontaneous breathing for patients with artificial A/Ws.
  - PSV set to overcome resistance
  - Use Tube-Compensation Mode
  - 30 – 120 minutes
- ***Weaning Parameters:*** Metrics used to determine readiness to wean and extubate.
  - Negative Insp. Force (NIF): *patients ability to suck-in*
    - S/B at least -20 to -25 cm H2O
  - Vital Capacity (VC): deep breath in followed by a compete exhalation.
    - S/B a min. 15 mls/ kg or approx. 1.0 liter
- ***Sedation Holiday/Vacation:*** Reduce sedation (often in the AM) to assess ability to wean, follow commands, etc.
  - AKA: Spont. Awakening Trial (SAT)
- ***Rapid Shallow Breathing Index (RSBI):***
  - = Spon. RR / VT in liters
  - S/B < 105

Key Terminology (cont.)

- ***Diaphragmatic Fatigue*** – Imposing excessive WOB while weaning resulting in fatigue.
  - Often takes 24 hrs or more to recover.
- ***Diaphragmatic Atrophy*** – Weakening or respiratory muscles due to lack of use via weaning.
- ***Alveolar De-recruitment*** – May occur when a patient with an artificial A/W is breathing at low tidal volumes and/or low PEEP.
- ***Recruitment Maneuvers (RMs)*** – Using short periods of high PEEP (30 cms for 30 seconds) or other "Open Lung" strategies to treat/prevent atelectasis.
  - Especially important for those weaning via trach collar.
  - Should be used cautiously for hemodynamically unstable patients.
- ***Wean Per Physician Order*** – Weaning a patient outside of the MMC weaning protocol. (e.g., 4 hrs PSV/ 4 hrs on AC).

Rapid Shallow Breathing Index Examples– A Ventilatory Metric

- Example 1: Spon VT: 330 mls, Spon RR: 15
  - RSBI = 15/.330 = 46
  - Interpretation: Compatible with successful weaning
- Example 2: Spon VT: 200 mls, Spon RR: 30
  - RSBI = 30/.200 = 150
  - Interpretation: Incompatible with weaning…
- Example 3: Spon VT: 400 mls, Spon RR: 40
  - RSBI = 40/.400 = 100
  - Interpretation: Insufficient data. Is patient agitated due to weaning and being awake?

Assessing Ventilation (Bedside Mechanics -VC & NIF) -- Another Ventilatory Metric

- **Negative Inspiratory Force (NIF):**
  - Normal -60 to -100 cm H2O
  - Less than -20 to -25 cm H2O suggests insufficient respiratory muscle strength.
  - Rate of decline or improvement are also relevant.
    - A neuromuscular patient whose NIF has decreased from -48 to -29 cm H2O in three days may warrant elective intubation.

- **Vital capacity (VC)**
  - Normal: 65 to 75 mL/kg IBW
  - If intubated: VC equal to or greater than10 to 15 mL/kg indicative of greater success for weaning and extubation.
  - Pre-op: FVC less than 20 mL/kg indicative of higher risk of pulmonary complications and poor success with weaning and extubation.

P/F Ratio—An Oxygenation Metric

- Monitoring adequacy of arterial oxygenation
  - **PaO_2/F_IO_2 ratio**
    - A “normal” P/F ratio breathing room air would be 95/0.21 or about 450
    - American Thoracic Society:
      - Acute Lung Injury (ALI): 200 to 300
      - ARDS: Less than 200
    - Berlin:
      - 200-300 Mild ARDS
      - 100-200 Moderate ARDS
      - Less than100 Severe ARDS
  - Example:
    - A PO2 of 88 torr on 50% = 88/.5 = 176 = Moderate ARDS

Oxygen Index (OI)–Another Oxygenation Metric

(OI) = Mean Airway Pressure (MAP) X FIO2 X 100 / PO2

- Lower OI is better -- Targeted OI less than 20–25
  - OI values less than 5 are considered acceptable
  - Values in the 10 to 20 range indicate impaired oxygenation
  - OI above 25 associated with a severe oxygenation disturbance and poor clinical outcomes
- Unlike P:F Ratio, OI considers patient ***response to both PEEP*** & FIO2
- **PEEP is a major contributor to MAP**

- **Example:**
  - **MAP= 22**
  - **FIO2 = 60%**
  - **PO2 = 72**
  - **22 X .60 X 100 / 72 = 18.3 (Moderately impaired Oxygenation)**

Predictors of Successful Weaning

- Kallet, Zhuo, Yip, et al 2018. Cochrane Systematic Rev.
  - *Findings:* **SBT's combined with conservative sedation** practices were associated with both reduced ventilator days and ICU LOS.

- Burns, Lellouche, Nisenbaum, (2014).
  - *Findings:* **Automated Weaning: Weaning with SmartCare™ significantly decreased weaning time**, ventilator days and ICU stay.

- Baptistella, Sarmento, da Silva (2018) Systematic Review:
  - *Findings: RSBI was the most frequently studied* and an important measurement tool in deciding whether to wean/extubate a patient.

- Kutchak, Rieder, Victorino, (2017)
  - *Findings: Inability to follow commands (hand grasping) independently predict extubation failure* in critically ill neurological patients.

Weaning Protocol Elements

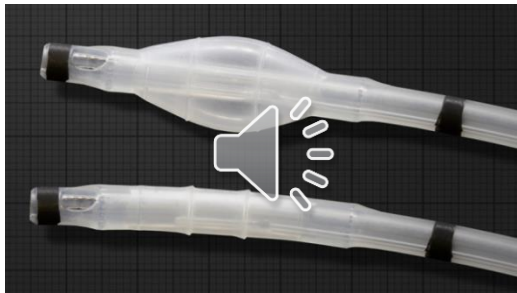
- The patient should be assessed daily for *Readiness to Wean*.
  - SBT with PSV set to overcome resistance: Raw = (Peak AW Pres – Plateau) / Flow in L/sec
  - Alternatively, a mode called *Tube Compensation* (or similar) may be used
  - Recommended Length of Time: 30 – 120 minutes
- Criteria
  1. Ve = 5-12 lpm
  2. Spont VT 5 ml/kg of ideal body weight (IBW): ex. 70 kg IBW X 5 = 350 mls VT
  3. RR < 35
  4. HR< 140
  5. SpO2 >90%
  6. Rapid Shallow Breathing Index (RSBI) <105
  7. Can follow commands (Especially in neuro patients)
- Extubation Criteria (in addition to above)
  1. NIF > -20
  2. Deliberate Cuff Leak > 110-150 mls
- *Weaning on PSV greater than 10 cms for more than 4 hours is discouraged, unless in a long-term ventilator environment (e.g., LTAC)*

“Optimizing” to Facilitate Weaning

- Sedation: Lighten and consider switching to “kinder” form of sedation e.g., Precedex
- Fluid balance
- Proper Nutrition (macro and micro nutrients).
- Permit adequate recovery time from prior failed weaning attempts. (min 24 hours of rest on AC).
- Adjunctive Respiratory Care: Bronchodilators, bronchial hygiene, sx’ing
- Airway optimization: Mucous shavers.
- Adequate staffing/resources.

Endotracheal Tube (ETT) Mucus Shavers

- Evidence has shown that biofilm begins building up in ETT lumen within 24 hours after placement.
- The biofilm reduces interior lumen and contains harmful microbes.
- Pinciroli, et al (2016)
  - ***Findings:*** The ***endOclear mucus shaving device is safe*** and can prevent ETT luminal occlusion.
- Bardes, et al (2017)
  - ***Findings: Comparison of the endOclear® group and controls demonstrated a trend toward a higher pneumonia rate in the former.*** Additionally, the device achieved very small, clinically insignificant, changes in ventilator settings, and no difference was seen in Vent Days.
- Scott, et al (2017)
  - ***Findings:*** ETT scraping can reduce AW resistance but ***did <u>not</u> impact SBT success***.



Categories of Patients in Relation to Weanability

- 1. ***Quick-Wean***=>Extubate — Wake them up, assess and extubate.
  - e.g., patients being *recovered* from OR in ICU
- 2. ***Delayed Quick-Wean*** – Slow to clear sedation…No Spon. Breaths in the morning…Re-Assess/SBT/Wean? in the afternoon.
  - e.g., post complex surgery
- 3. ***Weaning*** but ***extubation contraindicated***.
  - e.g. diaphragmatic atrophy due to extended MV, lack of optimization.
- 4. ***Marginal extubation candidate*** but trach/PEG are immanent.
  - E.g., Repeated resp. failure-Extubate to BiPAP or HFNC.
- 5. ***No Wean--No Reassessment***--Patients who should not be weaned ***nor reassessed*** the same day.
  - e.g., respiratory failure, sepsis, hemodynamic issues, alcohol W/D

Contraindications to Weaning and SBT

- Inadequate Oxygenation and Spontaneous Ventilation
  - PEEP > 10 cm H2O
  - RSBI > 100-105
- Unstable Clinical Status
  - Non-reversal of reason for intubation
  - Hemodynamic instability
  - Significant anemia and/or abnormal blood chemistry
  - Sepsis
  - Head (or other) trauma
- Pharmacologic paralysis
- Immanent major surgery

Many Reasons Why Patients Tolerate Weaning *but Not Extubation*:

- Trauma patients who are stabilized but ***scheduled for surgery immanently***.
- Patients ***on MV for extended time periods***…with diaphragmatic atrophy.
- Patient ***unable to protect airway*** but with favorable RSBI.
  - e.g. vocal cord paralysis, status post stroke.
- Patient with ***insufficient or absent ETT cuff leak***.
- ***Neuromuscular patients*** with marginal weaning parameters.
- ***Supportive Care Issues***: Marginal fluid balance, nutritional concerns…

Patients Who Fail AM SBT and Whose PM SBT is *Not* Warranted

- General: Pt. recently intubated (main cause for intubation not resolved)

- Specific Examples:
  - ***Persistent Respiratory Failure***:
    - Oxygenation Resp. Failure": Pt.s requiring high oxygenation settings, FIO2>60%, Peep> 12.
    - Ventilatory Respiratory Failure: RSBI > 105
  - ***Poor Acid-base status*** critical or not improving (pH , 7.25)
  - ***Hemodynamic instability*** (low BP, unstable HR, arrhythmias)
  - ***Significant anemia and/or abnormal blood chemistry***
  - ***Intentional heavy sedation*** (alcohol/drug withdrawals or seizure protocols)
  - ***Pharmacologically paralyzed*** or recently coming of the paralytics.

Enhancing Extubation Success

- Pre Extubation Assessment
  - Adequate oxygenation and ventilation
  - Ability to Protect airway
  - No absolute contraindications
    - Poor weaning parameters
    - Inadequate cuff leak
    - Poor clinical status (CBC's, fever, CXR, excessive secretions, etc)
    - Can't follow commands nor protect airway
- Pre-Extubation Optimization
  - Reversal of clinical reason for original intubation and mech. vent.
  - Fluid balance
  - Nutrition
- Post Extubation Augmentation
  - Extubate to HFNC
    - Marginal oxygenation
  - Extubate to BiPAP/NIPPV
    - Marginal ventilation

High-Flow Nasal Cannula (HFNC)

Some Evidence:

- Ni, Lou, Yu, BMC Pul. Med (2017).
  - ***Findings:*** After extubation, HFNC is a reliable alternative of NIPPV to *reduce rate of reintubation* compared with conventional O2 therapy.

- Dhillon NK, Smith EJT, Ko A, J Surg. Res (2017)
  - ***Findings:*** Ventilated patients at risk for recurrent respiratory failure have *reduced reintubation rates when extubated to HFNC*.

Non-invasive Positive Pressure Ventilation

- Zhu, Wang, Liu, Jia & Jia, Chim Med J (2013)
  - *Findings:* **NIPPV can reduce the need of re-intubation** and improve clinical outcome as compared with invasive ventilation.
- Bhatti, Ramdass, Cury, et al, Clin Respir J.
  - *Findings:* Clinician dependent factors linked to NIPPV failure.
  - **Inappropriate utilization of NIPPV in respiratory failure is associated with higher mortality.**

Case 1– Interprofessional Collaboration to Get it Started

- 47 YO ♂ post trauma patient with multiple orthopedic injuries is intubated and ventilated on AC mode. All anticipated surgeries have been completed and the patient is now clinically stable. An attempt at a SBT is not successful because the patient is not initiating breaths over the set rate apparently due to heavy sedation. The physicians are not in the unit.
- What steps are the appropriate next steps for the RT and RN?

Case 2- Wean, Don't Extubate

- A 39 YO ♀ post-head trauma patient is recovering from her injuries and during a sedation holiday and SBT. She is now initiating 20 breaths/min at a VT of 330. Her overall clinical status is stable, however she is unable to follow commands.
- What is her RSBI?
- What factors would influence your recommendation regarding weaning & extubation?

Case 3- Wean, Don't Extubate

- A 22 YO ♀ intubated for anaphylaxis. During a sedation holiday and SBT, she is now initiating 15 breaths/min at a VT of 400. Her overall clinical status is stable, and she can follow commands. However, she does not have an ET tube cuff leak.
- What is her RSBI?
- What is your recommendation her care plan and potential extubation?

Case 4- Wean but Extubate to Adjunctive Device?

- A 69 YO ♂ on MV for 10 days for an COPD exacerbation. RSBI during a morning sedation holiday is 102 on + 6 PSV. SPO2 is 94% on FIO2 of 40% and PEEP of +8. The patient has an adequate cuff leak of 150 mls. Clinical status is otherwise stable. ENT is scheduled to assess for tracheostomy over the next 2 days.
- Is this patient potentially a candidate for weaning?
- If they successfully wean all morning on + 8 PSV, should extubation be considered?
- If extubation is considered, are there any special considerations regarding enhancing success?

Case 5 – No Wean in the AM – No PM Weaning Assessment Warranted

- 47 YO ♂ chest trauma patient is mechanically ventilated. CXR reveal bilateral ground glass appearance, PO2 is 65 on 80% and PEEP of 14 (P:F =78) . PAW are 32 cm (low compliance).
- Should this patient be assessed for ability to wean?
- Should they be weaned and why/why not?
- Should they be re-assessed for ability to wean in the afternoon?
- What other therapies should be considered?

Case 6- Excessive Weaning & Diaphragmatic Fatigue

- A patient with marginal weaning parameters (e.g., RSBI =102) has been weaning on + 10 PSV X 9 hours. Over the past 3 hours, his RR has been climbing into the low 30's, HR inc from 105 to 130 and he is diaphoretic, despite sx'ing, bronchodilators and other respiratory interventions.
- Pain and anxiety have been ruled out as the main cause of distress.
- What immediate actions should be taken?
- What are some potential considerations for weaning over the next few days?

Case 7- Trach Collar Wean and Decruitment

- Patient with a spinal injury at C-4 and 5 is intermittently weaning on T/C during the day. Patient has repeatedly had episodes of hypoxemia after 4-6 hours of T/C. CXR shows signs of bi-basilar atelectasis which is unchanged over several days.
- What factors predispose this patient to hypoxemia and atelectasis?
- What recommendations might help this patient's weaning *and* overall respiratory status?

Take Home Messages

- SBT and weaning are ***important tools*** in optimizing vent-patient care.
- However, they involve ***interprofessional collaboration*** & communication.
- SBT & Weaning are ***resource dependent***.
- No single method for weaning and liberation from ventilation is infallible and the ***data are mixed***.
- However, some methods have ***stronger supportive evidence*** than others.
  - SBT Guidelines, RSBI, diaphragmatic issues, de-recruitment considerations.
- Use what evidence we have and stay tuned as more research emerges!

Selected Resources

- Schmidt, Girard, Kress, et al, Official Exec Summary of ATS…Guideline: Liberation from Mechanical Ventilation in Critically Ill Patients, 2017.
- Heuer, AJ. Clinical Assessment in Respiratory Care, ed 9, 2021.
- Kacmarek, Stoller, & Heuer, Egan's Fundamentals of Respiratory Care, ed 12th ed, 2021.
- Kallet, Zhuo, Yip, et al: Cochrane Systematic Rev. Respir Care. Jan;63(1):1-10, 2018.