Respiratory Failure and Mechanical Ventilation

JENNIFER L. HUBBARD, MD, FACS

MAY 21, 2020

Assessment

- Talk to the patient
  - Stridor
  - Hoarseness
  - Can't speak in full sentences
  - Induction of coughing
- Inspection
  - Tachypnea
  - Use of accessory muscles
  - Cyanosis/distress
- Auscultation
  - Absent breath sounds
  - Wheezes
  - Ronchi

Assessment

- Pulse oximetry
  - Normal > 95%
  - COPD patients may "live" low 90s/high 80s
  - Make sure waveform accurate
  - Innaccurate once sats < 80%
- CXR
- ABG
  - ph/pCO2/pO2/HCO3/BE/sat
    - pO2 = dissolved oxygen in blood
    - Delivery of oxygen at tissue level
      - $DO_2 = CO \times [CaO_2 = (1.34 \times Hgb \times SaO_2) + (0.003 \times PaO_2)]$
      - Ergo: sats more reflective of what is happening with oxygen perfusion at tissue level

Example

- 68 y/o M s/p MCC with 6-8 R rib fractures
- O2 sat 90% on room air
- Next step?

Respiratory support/adjuncts

- Atelectasis prevention/treatment
  - Incentive spirometer
  - Flutter valve
  - Ez-pap (PEP)
  - Chest physiotherapy (vest, bed percussion)

Respiratory Support

- Supplemental oxygen
  - Nasal cannula
  - Simple mask
  - Non-rebreather
  - Oxymask

Non-invasive mechanical ventilation

- CPAP (mask or nasal only)
  - Constant pressure (similar to PEEP) increases FRC
  - Settings: pressure and FiO2
- BIPAP (mask or nasal only)
  - Constant pressure increases FRC
  - Additional driving pressure when patient initiates breath (i.e. pressure support)
  - Settings: pressure support, pressure, and FiO2
    - 12/10 on 50%
- AVAPS
  - Tidal volume (Vt), pressure support, constant pressure

Indications for CPAP/BiPAP/AVAPS

- OSA
- Atelectasis and mild respiratory failure in patient with intact sensorium
  - e.g. rib fracture patient
- COPD patients
- DNR/DNI but otherwise full measures
- Generally NOT indicated for post-op patients with respiratory failure, sepsis with respiratory failure, and patients failing extubation

Indications for intubation

- *SOAP*
  - *S*ecretions that are excessive and/or cannot be cleared by the patient
  - *O*xygenation that is inadequate
  - *A*irway compromise or obstruction
    - Altered mental status (GCS ≤ 8)
  - *P*ulmonary function not meeting ventilatory needs
- Impending failure
  - "Guppy breathing," using accessory muscles, severe tachypnea
    - Not sustainable and will lead to fatigue and eventual hypoventilation +/- hypoxemia

Choosing a Mode

- Most surgical patients start off on SIMV or AC
- Adjust as needed based on patient comfort and physiology

Mechanical ventilator modes

- Pressure support (spontaneous)
  - Pressure support, PEEP, FiO2
    - 15/10 on 35%
  - Requires patient to initiate all breaths (no "back-up" rate)
  - Usually used for SBT or patient's needing prolonged weaning

Mechanical ventilator modes: Volume Control

Assist Control (AC)

- Rate
- Tidal Volume (Vt)
- PEEP
- FiO2
- Full tidal volume delivered with each initiated breath
- AC 14 550 8 40%

SIMV

- Rate
- Tidal Volume (Vt)
- PEEP
- Pressure support
- FiO2
- Full tidal volume delivered with only the set rate of breaths.
  - Additional breaths supported with PS, but volume determined by patient effort.
- SIMV 14 550 8 10 40%

Mechanical ventilator modes: Pressure Control

- Plateau pressure or peak pressure used instead of tidal volume
- Decreases barotrauma
- Popularized by ARDSNet studies
- Rate Ppk Peep (+/- PS) FiO2
  - (Can do AC vs SIMV type settings with Pressure instead of Vt)
  - PC 14 35 8 10 35%

Mechanical ventilator modes: Hybrid

- PRVC (Pressure Regulated Volume Control)
  - AKA Dual Mode
  - Gives tidal volume breaths but not allowed to exceed specified pressure
    - Tidal volumes may decrease within a pre-specified range
    - If unable to maintain parameters --> lots of alarms and phone calls from RTs

Additional settings

- I:E ratio
  - Normal respirations about 1:3
  - Increasing inspiration can increase oxygenation by can lead to auto-PEEP and hyperinflation
- Inverse ratio ventilation (IRV) popular 90s & early 2000s
  - Great for oxygenation
  - Severe auto-PEEP
  - Lots of PTX

Traditional Modes: making adjustments

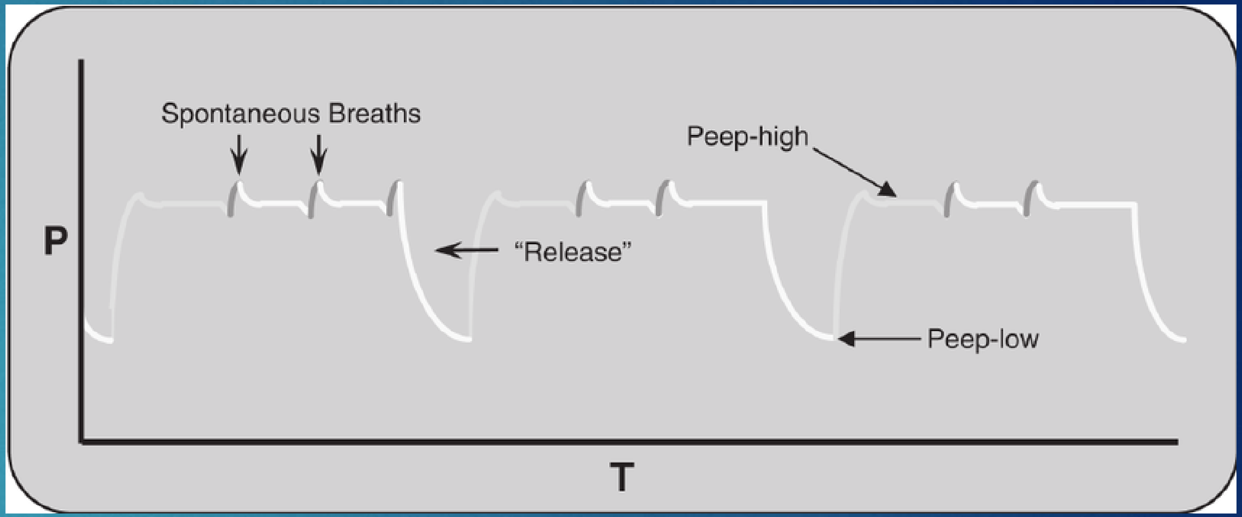
- Starting points
  - Rate 14
  - Vt 5-10 ml/kg
    - 5-7 for ARDS or "at risk"
    - 8-10 less often (spinal cord injuries)
  - Pressure control 18-20 if fairly normal compliance; higher with ARDS/pulmonary edema
  - PEEP 5-8
  - PS 10-12
  - FiO2 100% and wean down based on sats

Traditional Modes: making adjustments

- Oxygenation (Sat, paO2)
  - Adjust PEEP or FiO2
  - FiO2 > 50% --> lung toxicity
- Ventilation (pCO2)
  - Adjust Vt (or P_{peak}) or rate
    - Increased rate or Vt --> decreased pCO2
- Gasping, guppy-breathing; patient-ventilator dysynchrony
  - Increase pressure support
  - Increase PEEP
  - Try a different mode
  - Increase sedation

Mechanical ventilator modes: APRV

- APRV (AKA Bilevel)
  - High constant pressure (P_{high})
  - Short release for expiration (P_{low})
  - Spontaneous breathing superimposed



Mechanical ventilator modes: APRV

- Indications
  - Rescue mode for refractory hypoxemia
  - Patient-ventilator dysynchrony
    - Some patients find it more comfortable as they are able to breathe spontaneously

APRV settings

- P_{high}
  - Depends on level of support needed. Generally < 30
- P_{low}
  - Usually 0 or 3 to start
  - Increase if refractory hypoxemia
- T_{high}
  - Good starting point is 5 seconds
  - Sometimes just give "rate" and RT will calculate T_{high} and T_{low}
- T_{low}
  - Good starting point is 0.5 seconds

Adjusting APRV

- Hypoxemia
  - Increase P_{high}
  - Reduce T_{low}
  - Increase T_{high}
  - Increase P_{low}
- Hypoventilation (Hypercarbia)
  - Decrease sedation to allow more spontaneous ventilation
  - Increase P_{high}
  - T_{high} manipulation (may need to "play with it")
    - Increasing leads to more recruitment
    - Decreasing leads to increase minute ventilation

Mechanical ventilator modes: APRV

- Weaning
  - Drop and stretch
    - Drop P_{high} (usually 2 at a time) and increase T_{high}
  - Can change back to conventional mode when P_{high} is 16-20
  - Can extubate directly from APRV mode

Refractory hypoxemia/ARDS

- ARDS
  - Bilateral infiltrates on chest radiograph
  - PaO2/FiO2 (P:F) ratio ≤200 mmHg,
  - No evidence of left atrial hypertension or a pulmonary capillary pressure <18 mmHg (if measured) to rule out cardiogenic edema
- Acute Lung Injury (ALI)
  - P:F = 201-300 mmHg

Refractory hypoxemia/ARDS

- Vent adjustments
  - High PEEP, low Vt/pressure strategy
- Adjuncts
  - Rotorest (requires specialty bed)
  - Proning (specialty bed or manually)
    - Increases oxygenation
    - No mortality benefit
  - Inhaled prostaglandins
    - Improve oxygenation and decrease pulmonary artery pressures, but new and data lacking

Rescue Modes

- High frequency oscillatory ventilation (HFOV)
  - Increased mortality in ARDS
  - Not recommended except in pediatrics

Rescue Modes

- High frequency percussive ventilation (HFPV), AKA VDR
  - Delivers subphysiologic tidal volumes at high frequencies superimposed on typical ventilator flow
  - Low peak pressures and PEEP with higher mean airway pressure
  - Mobilizes secretions d/t to eddy currents that form around the aliquots of air as the tidal volumes are delivered in a percussive fashion
  - Improved oxygenation with lower peak pressures compared with conventional modes
    - No randomized data to show mortality benefit

Rescue Modes

- ECMO
  - Should not be used as "last ditch" effort (but that's usually how we use it)
  - Hard to know which patients will benefit
  - Best done at ECMO centers (e.g. Legacy Emmanuel)

Practice: What changes should you make?

- SIMV 12 400 10 10 80%
  - ABG: 7.28/50/130/24/-2 on 80%

- Hypercarbia and respiratory acidosis = increase Vt or rate
- Good oxygenation with high FiO2 = decrease FiO2

Practice: What changes should you make?

- AC 18 500 10 60%
  - ABG: 7.49/32/55/16/4

- Decrease rate. Increase PEEP. Consider ARDS adjuncts if clinically worsening.

Practice: What changes should you make?

- Bilevel 24/0 40%
  - ABG: 7.42/38/135/22/1

- Drop P_{high}

Practice: What changes should you make?

- Bilevel 26/0 50%
  - ABG: 7.25/45/60/18/-6

- Correct metabolic acidosis
- Increase P_{high} or P_{low}