Basic Mechanical Ventilation

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Outline

• Basic Science
• Lingo
• Initial Settings
• Common Intern Mistakes
How do we breathe?

- Brainstem control
- Chemoreceptors
- Diaphragm contraction and Chest wall expansion $\rightarrow$ increased intrathoracic volume
- Leads to negative intrathoracic pressure
- Air flows from high to low pressure
- Negative pressure ventilation
The Mechanics of Breathing

- Inhalation: oxygen enters the lungs through the diaphragm.
- Exhalation: carbon dioxide is expelled from the lungs as the space inside the chest decreases.
Why do we breathe?

• Duh
• Oxygenation
• Ventilation – the exchange of CO2
Important Principles

• Ventilation/Perfusion Matching
• Ventilation without Perfusion
  – Dead space ventilation
• Perfusion without ventilation
  – Shunt
• Ideal Body Weight (kg)
  – Males: IBW = 50 kg + 2.3 kg for each inch over 5 feet.
  – Females: IBW = 45.5 kg + 2.3 kg for each inch over 5 feet.
Why do people need ventilators?

- Loss of airway anatomy
  - Edema, direct/indirect trauma, burns, infection
- Loss of protective airway mechanisms
  - Intoxicants, brain injury, strokes
- Inability to oxygenate appropriately
  - Shunt, alveoli filled with stuff
- Inability to ventilate appropriately
- Expected clinical course
Basic Ventilator Lingo

• Control breath
  – Vent initiates the breath

• Assist breath
  – the patient initiates the breath
What can I set?

- Ventilator Target
- Ventilator Mode
- Respiratory Rate
- PEEP
- FiO2
- Flow Rate
- Other stuff… more later
Step 1: What is the target?

- You pick what the ventilator is trying to attain
- If the vent is trying to reach a Volume goal, its called Volume-Targeted
  - AKA volume-cycled, volume-assist, volume-control, volume-limited.
- If the vent is trying to reach a Pressure goal, its called Pressure-Targeted
  - AKA pressure-cycled, pressure-assist, pressure-control, pressure-limited.
- Most adult ICUs use Volume-Targeted and most PICUs use Pressure-Targeted
Volume-Pressure Relationship
Time

Volume

0
Control  Assist  Control

Time
Step 2: How does the vent reach its goal?

- On every single breath?
  - This is Assist/Control (AC)
  - Both Assisted and Control breaths
- Only on the number of breaths that you want?
  - Synchronized Intermittent Mechanical Ventilation (SIMV)
- Both Volume-Targeted and Pressure-Targeted modes can be placed on AC or SIMV
More on AC vs SIMV

- In a chemically paralyzed pt:
  - AC and SIMV will look exactly the same
- In a patient where the patient wants to breath less than the set rate:
  - AC and SIMV will look exactly the same
- In a patient that wants to breath faster than the set rate:
  - AC: every breath will reach the set target
  - SIMV: will only get the set # of breaths
Recap

- Volume-Targeted, AC
- Volume-Targeted, SIMV
- Pressure-Targeted, AC
- Pressure-Targeted, SIMV

- What will you use?
  - Comfort, experience, regional preferences
Anything Else?

- Yes!!
- Pressure Support Ventilation (PSV)
Pressure Support Ventilation (PSV)

- Patient is spontaneously breathing
- The vent augments the patient’s respiratory effort with a “pressure support”
- Tidal Volume is determined by patient’s effort and respiratory system compliance
- Can set a FiO2 and PEEP
- No set respiratory rate
  - Except back-up apnea rate.
- Good choice for those with intact MS with airway issue and able to tolerate ETT, or those with sedatives, intoxicants with a good respiratory effort and expected to improve.
Volume-Targeted, SIMV

- Always add a measure of PSV
- Monitor what kind of tidal volumes the PS breath is generating
That’s it?

- Nope!!!
- Dual-Modes of Ventilation
  - Combine volume and pressure targets.
  - Pressure Regulated Volume Control (PRVC), Auto-Flow, Volume Ventilation Plus (VV+), Adaptive Support Ventilation (ASV), Variable Pressure Control (VPC), Variable Pressure Support (VPS), Volume Assured Pressure Support Ventilation (VAPSV), Pressure Augmentation
There’s More?!?!?

- High Frequency Ventilation
- Airway Pressure Release Ventilation (APRV)
- BiLevel Ventilation
- Proportional Assist Ventilation Plus (PAV+)
- Proportional Pressure Support (PPS)
What do I need to know?

- Difference between Volume-Targeted and Pressure-Targeted
- Difference between AC and SIMV
- What volumes do I want?
- What RR do I want?
- What PEEP do I want?
- What FiO2 do I want?
What Tidal Volume should I start with?

- 8 ml/kg Ideal Body Weight (IBW)
- Almost never above 10 ml/kg IBW
- Note: you’ll want lower tidal volumes in Status Asthmaticus and ARDS/ALI
- In Pressure-Targeted modes you’ll set the Pressure High ($P_{HI}$) aka PIP. Start at 20 cmH2O
  - The tidal volume generated will be determined by the PS and the respiratory system compliance.

...more later
What Respiratory Rate should I start with?

- Most cases about 2/3 of pre-intubation rate
- Higher rates for Sepsis, ARDS, metabolic acidosis
- Cautious use of low rates in acidosis
- Exception: Status Asthmaticus
  - Want lower respiratory rates
- On some machines you set the Inspiratory Time ($T_i$) and Expiratory Time ($T_e$)

... more later
Keep in mind the Minute Ventilation

- Minute Ventilation (L/min) = RR (b/min) x Tidal Volume (liters)
- If you decrease one or both the MV will be lower → hypercapnia
- Tolerated in status asthmaticus and ARDS/ALI
  - Called “permissive hypercapnea”
- Be cautious if you’re starting off with a pH 7.0
What PEEP should I start with?

- Almost always a PEEP of 5
  - Used to keep FRV (functional residual volume)
- Really big adults; PEEP 8
- Adjust up by increments of 2 for marked hypoxia
- PEEP increases intrathoracic pressures and can thus decrease venous return and thus BP
- In Pressure-Targeted modes PEEP is PEEP or Pressure Low ($P_L$)
PEEP Video
What FiO2 Should I start with?

- Always 100%.
- Intubation switches pt from negative pressure ventilation to positive pressure ventilation
  - Changes V/Q unpredictably
- Titrate FiO2 down based on PaO2 from ABG or POx (if good waveform).
What Flow Rate should I set?

• Almost always set at 60 L/min.
• Use higher rates in Asthma or those with air hunger
• Pressure-Targeted modes allow patient to dictate the flow rate that they want
Alarms

• Peak Pressure alarm
  – Resistance to airflow
Increased $P_{\text{peak}}$

Same $P_{\text{plat}}$
Increased $P_{\text{peak}}$

Increased $P_{\text{plat}}$
Sedation & Delirium

- You’ll learn different medications for sedation.
- Opiates (morphine, fentanyl, dilaudid)
- Benzodiazepines (Ativan, Versed)
- Propofol
- Precedex
- Less is sometime more
  - boluses are sometimes better than drips
- A, B, C, D, E
- www.icudelirium.org
Long Term Chemical Paralysis

• Try to avoid it if you can
• Paralysis without sedation = Torture
• If you need it, discuss with fellow or attending
• All one needs in this situation is chemical weakening… usually not full blown paralysis
• Remember if a long acting paralytic is used to intubate the patient, the induction agent may wear out BEFORE the paralytic
Noninvasive Positive Pressure Ventilation

- Multiple Indications
  - Acute exacerbations of COPD (1A)
  - Asthma exacerbations (2B)
  - Cardiogenic Pulmonary Edema (1A)
  - Immunocompromised Patients
  - Hypoxic Respiratory Failure (2B)
  - End of Life

- Relative Contra-indications
NPPV

• Making adjustments
  – Low-High Approach
    • IPAP set at 8-10 cmH2O
      – Raised as tolerated to achieve alleviation of dyspnea, decreased RR, increased tidal volume, and comfort
    • EPAP set at 3-4 cmH20

• Monitoring the patient
  – Close observation required
    • Experienced respiratory therapist helpful
      – Adjust interface and pressures
    – Clinically assess at least every 30 min or less upon initiation
    – Assess patient comfort, air leak, respiratory rate, heart rate, use of accessory muscles, abdominal paradox
Mechanical Ventilation in Asthma

• Early use of NPPV
• Prepare and expect hypotension during intubation
  – IVF bolus, monitor for over-zealous BVM
• Mechanical Ventilation Strategy
  – Permissive Hypercapnia (i.e. prolong I:E)
• Ventilator maneuvers that prolong I:E
  – Low tidal volumes, low respiratory rates, square wave forms, high flow rates.
Mechanical Ventilation in Asthma

- Tidal Volumes: 6-7 ml/kg (IBW)
- Respiratory Rate: 8-10 bpm
- Flow Rate: 80-100 L/min
- Square Wave forms
- SEDATION: propofol, precedex, OPIATES
- Last resort: chemical weakening
- Expect high peak pressures
- Monitor for high plateau pressures
  - Marker of auto-peep
ARDS

- Bilateral, pulmonary infiltrates
- PaO2/FiO2 ratio < 200
- Non-Cardiogenic
- Stiff, non-compliant lungs
ARDS

• Lung Protective Strategy
• Low-Tidal Volumes
  – Start at 8 mL/kg IBW
  – Goal of 6 mL/kg IBW
• Low Plateau Pressures
  – Less than 30
• Permissive hypercapnia
Questions?
Common Intern Mistakes

• Pt was recently intubated, set on SIMV/Vt 500/RR 12/PEEP 5/FiO2 100%, breathing 28 bpm
• Patient looks incredibly uncomfortable. Pox is 93%, ETCO2 is 35
  a) Paralyze the patient
  b) Increase the PEEP
  c) Increase the Vt
  d) Sedate the patient
  e) Add Pressure Support
Discussion

a) Paralyze the patient
   – Don’t do this unless you know what you’re doing

b) Increase the PEEP
   – Oxygenation is OK. Don’t need to do this

c) Increase the Vt
   – Ventilation is OK. Don’t need to do this

d) Sedate the patient
   – Maybe…
e) SIMV with Pressure Support

- Never use SIMV without pressure support
- Remember SIMV only gives you the set RR
- The pt is only getting 12 mechanical breaths
- 16 breaths are pt generated… against all the resistance of the tubing!!!!
- **Torture**
Common Intern Mistakes

• Pt was recently intubated, set on AC/Vt 600/RR 18/PEEP 5/FiO2 100%, breathing 28 bpm
• RT tells you that the ABG: 7.65/12/400/24/98% and asks you what you want done.
  a) Increase the PEEP
  b) Decrease the RR
  c) Increase the Tidal Volume
  d) Give Bicarb
  e) Decrease Tidal Volume
  f) None of the above
Discussion

a) Increase the PEEP
   – Don’t need to, oxygenation is fine

b) Decrease the RR
   – Most common choice. Most common error

c) Increase the Tidal Volume
   – Probably already too high

d) Give Bicarb
   – Pt is already markedly alkalotic

e) Decrease Tidal Volume
   – Maybe. Tidal volume should not be more than 10 cc/kg IBW. Set Vt at 8cc/kg IBW

f) None of the above
   – Maybe. Pt may need sedation/analgesia