Ventilator Management for Status Asthmaticus & Acute Exacerbations of COPD

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COPD is Important!

**Facts:**
- 4th leading cause of death
- Important cause of post-op respiratory failure

**Test Question: True or False?**

“Intubation should be avoided at all costs in patients with severe COPD with acute respiratory failure because they will be stuck on the ventilator”
COPD is Important!

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Test Question: True of False?

“Intubation should be avoided at all costs in patients with severe COPD with acute respiratory failure because they will be stuck on the ventilator”

False!: 80-90% are extubated & survive
Asthma is Also Important!

**Facts:**
- Most common chronic lung disease worldwide
- 11th leading cause of ED visits in US

**Test Question: True or False?**
There’s been minimal advances in ventilator management for asthma, which is why mortality hasn’t changed much in the last 20 years?
Asthma is Also Important!

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Test Question: True or False?
There’s been minimal advances in ventilator management for asthma, which is why mortality hasn’t changed much in the last 20 years?

False! Over past 20 years, ↓Mortality: 30% → 5%; Associated with significant ↓Morbidity
Case: COPD

- 60 yo M heavy smoker p/w diverticulitis, s/p colectomy
  P/w SBO c/b aspiration

- PE: VS 160/80, 120, 20, 100        RA Pox 93%
- Lungs: ↓ BS
- Cor: distant HS
- Abdomen: rigid, tender
- Extremities: cool
Case: COPD

Course:
- Post-laparotomy → ↑SOB, ↑WOB, drowsy
- PE: 170/90, 135, 38   Pox =85%,   wheezing
- ABG: 50% VM:  7.20/85/125
- CXR: hyperinflation without infiltrates

What is your Assessment:

How would you Treat the patient:
Case: COPD

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What is your assessment:
- COPD exacerbation due to aspiration

How would you treat the patient:
- IV Solumedrol, Albuterol and Atrovent Nebs
- Intubate
ICU: Challenging Decisions

- Intubated-> #8 oral ETT ➔ sedated/paralyzed
- Vent: AC 50%, 500 x 16, PEEP 5, PIF 70 (descelerating)
- BP 90/70    HR 120
- PIP = 60 cm H20
- ABG: 7.18/88/60

What would you do next?
1. ↑ RR to 20
2. ↑ TV to 600
3. ↑ FiO2
4. None of the above
ICU Course: Challenging Decisions

Results:
- 7.11 / 98 / 62
- ↓ BP to 80/60 and ↑ HR to 130
- ↑ PIP to 80

What should you do now?
1. ↓ RR
2. ↓ TV
3. ↓ PIF to 50
4. b/l chest tubes
5. Nothing
If you \(\downarrow\) PIF to 50?

- This reduced the PIP
  - But caused more hypotension!
  - Worsened the respiratory acidosis!

- Correct answer is to decrease RR and/or TV back to initial settings
Key Concepts

- Pathophysiology
  - Understand most appropriate ventilator management
  - Understand why the choices made in the case caused seemingly paradoxical effects

- Timing of intubation – when do you pull the trigger?

- Vent settings – how do you avoid complications?

- Weaning – what is the best way?
Dynamic Hyperinflation (DHI)

Underlying Pathophysiology That Explains it All!

DHI is the cause for:
- Respiratory failure
- Barotrauma
- Shock following intubation/MV
- Paradoxical $\uparrow$PaCO$_2$ / pH with $\uparrow$VE (RR or TV)
What is Dynamic Hyperinflation?

- Not enough time to expire → air trapping
- At end-exhalation there’s ↑ lung volume & pressure, similar to when you apply PEEP = AutoPEEP or iPEEP

This drives flow through out exhalation until next breath
Chest X-ray is Characteristic
How Does DHI Cause Acute Respiratory Failure (ARF)?

- Work of Breathing (WOB)
- Neuromuscular Capacity
Respiratory Failure: Why does WOB \( \uparrow \)

\[ \text{Work} = \text{Pressure} \times \text{Volume} \]

\( \uparrow \text{Pressure} \) (to move air and inflate chest):
- \( \uparrow \) Airway Resistance
- \( \uparrow \) Elastic recoil of lung

\( \uparrow \text{Volume} \) (distance chest moves/min) \( \sim \) Min Vent
- \( \uparrow \) Dead space (Vd)
- \( \uparrow \text{VCO}_2 \)
Respiratory Failure:
Why does Neuromuscular Capacity ↓

A flat diaphragm is weaker and ineffective pump
Respiratory Failure Ensues

- $\uparrow$ PaCO$_2$
- $\downarrow$ pH

NM Capacity

WOB
How Does DHI Cause Shock?

**Only after Intubation**

- Spontaneous breathing preserves BP!

- Intubation (sedation/paralysis) → hypotension:
  - Passive inflation on Vent → ↑intrathoracic pressure
    - Compresses heart → ↑CVP → ↓ven return → ↓CO
  - ↓Calf muscle pump → ↓syst $P_{venous}$ → ↓Ven return
  - ↓Catecholamines → ↓systemic $P_{venous}$ → ↓venous return → ↓CO/BP and ↓SVR → ↓BP
How Do You Know if the ↓BP is DHI And Not Tension PTX?

- Apnea trial (30-60 sec)→disconnect ETT
  - DHI→ Hear rush of air from ETT a/w ↑BP
  - Tension PTX- no air rush and no effect on BP

- Immediate Treatment:
  - IVF bolus→↑syst ven pressure→↑Ven Ret /CO
    - Anticipate peri-intubation and fluid load
  - Nebulized bronchodilators to ↓resistance
  - Adjust vent to ↓DHI (stay tuned)→↓CVP→↑VR/CO
Why Does DHI Cause Barotrauma?
-Interstitial and mediastinal air $\rightarrow$ PTX

- TV is added to the trapped gas volume
- $\uparrow$ End-inspired lung volume
- $\uparrow$ Stretch/strain of alveolar tissue $\rightarrow$ alveolar rupture
Why Did the ↑RR cause ↑PaCO₂

\[ V = Q \]
Why Did $\uparrow$RR cause $\uparrow$PaCO$_2$?

$\uparrow$ VE $\rightarrow$ DHI $\rightarrow$ $\uparrow$Lung Volume $\rightarrow$ Occlude capillary blood flow

$\uparrow$V/$\downarrow$Q $\rightarrow$ $\uparrow$dead space $\rightarrow$ $\downarrow$Alveolar Ventilation

Thus, $\uparrow$ RR $\rightarrow$ $\uparrow$PaCO$_2$
Why Does ↓ PIF Cause ↓ BP & Worse Respiratory Acidosis

- Slower inspiratory flow ↓ peak pressure but this prolongs Inspiratory time
- This ↓ expiratory time leaving ↓ time to empty
- Leads to more air trapping, higher iPEEP, $P_{Plat}$
- Higher intra-thoracic pressure
  - Hypotension
  - Worse gas exchange
Summary: Dynamic Hyperinflation Explains the Morbidity/Mortality

Causes:
- Respiratory Failure
- Shock after intubation
- Barotrauma
- May worsen V/Q -↑Vd/Vt and ↑PaCO2

Conclusion:
- To avoid/minimize complications and improve outcomes of patients with airway obstruction, must understand, measure, and manage DHI!!
How Do We Measure DHI?

Historical Note:

30 years ago DHI and AutoPEEP were unknown because it was invisible on the ventilator
AutoPEEP (aka iPEEP) is Occult

Auto PEEP (AP) is trapped distally in lung, not proximal airways; it’s behind the resistance. So baseline pressure not elevated = set PEEP
Physiology of Why it’s Occult....

A. 0 pressure/0 flow at end exhal

B. DHI- drives flow at end exhal but pressure 0- “b/c it’s downstream”

C. Occlude expiratory valve at end exhal, see upstream pressure rise! P = throughout
How to Detect iPEEP: Check Expiratory Flow vs. Time

Zero exp flow at end exhalation indicates equilibration of lung and circuit pressure Thus, no iPEEP
Continuous Flow During Exhalation Suggests iPEEP

The transition from expiration to inspiration occurs without the expiratory flow returning to zero –iPEEP is present.
Can Quantitate iPEEP Using Expiratory Pause Maneuver

Assessing an Equilibrium Point Between Lungs and Circuit

$P_{aw}$ (cmH$_2$O)

- Set PEEP
- Minimum Adequate Time for Maneuver
- Total PEEP

Hit Exp Pause Button
Patient Management
Intubation for MV Associated with Many Complications!
*So Always Consider Use of Non-Invasive Ventilation*
Non-Invasive Ventilation

- Studies show **improved outcomes:**
  - ↓ need for intubation
  - ↓ LOS (2 days)
  - ↓ mortality by 55%

- **Appropriate candidates:** Cooperative, airway protected, and sputum not copious
  - COPD with SOB, tachypnea, Respiratory acidosis
  - Asthma - less data but still worth a trial
  - CHF
  - Hypoxic respiratory failure in immunosuppressed
How To You Use NIPPV?

- Requires ICU transfer

- Start low 8/3-10/5 using PS/CPAP with full FM

- Titrate up gradually → success in 75%

- Failure indicated by worsening symptoms/signs/ABG over 1-2 hrs or no improvement over 4 hrs
Indications for Endotracheal Intubation

- Absolute Indications
  - Cardiac or respiratory arrest
  - Altered Mental Status

- Relative Indications
  - Failure to improve despite Rx
  - Cardiac ischemia, arrhythmias
Intubation: Technique

- **Preparation:**
  - Assume hypovolemia, anticipate hypotension
  - Place ≥ 18 guage IV
  - Pre-emptive IVF boluses – 1-2 liters, vasopressors ready

- **Route: Oral**
  - Avoid nasal route (sinusitis/polyps)
  - Large ETT (≥8)
Which Ventilatory Mode

- Use Volume Cycled since Pressure Cycled modes (PC/PS) may cause wide fluctuations in TV

- AC or SIMV?
  - Doesn’t matter – Since you want to eliminate spontaneous breaths (CMV)
  - SIMV = AC when heavy sedation +/- paralysis is used
How do you Monitor DHI?

- PIP
- Plateau press
- iPEEP
Should We Use The PIP?

- **PIP**: Measured in proximal airway, not alveoli
  - Reflects pressure dissipated across the resistance
  - Pressure much lower in the alveoli
  - Doesn’t correlate well w/ the amount of DHI
  - No correlation w/ risk of barotrauma or hypotension

- Conclusion: Ignore the PIP (and certainly don’t make vent changes to reduce it)
Use the **Plateau Pressure** to Assess Degree of/Manage DHI?

- Reflects max alveolar stretch/risk of barotrauma

- Most intuitive and practical

- Identical conceptually to using Pplat for ARDS

- Data: Goal- targeted Plat < 30 cm H$_2$O
What To Do When $P_{plat} > 30 \text{ cm H}_2\text{O}$ or There Are Adverse Effects of DHI?
Manage the 3 Determinants of DHI

The volume of gas trapped per breath (DHI) depends on the amount inspired (TV), time available to expire (Te), and degree of obstruction to exhalation (Expiratory Resistance)!

- Tidal Volume
- Expiratory Time (*note: not I:E ratio*)
- Expiratory Resistance
Management of DHI

- ↓ **Airway resistance** – order meds (BD and steroids) and wait;
  
  Nothing more you can do.

- ↓ **Tidal Volume** – Set low (8 ml/kg) and leave

- ↑ **Expiratory Time** - Two interventions
  - ↑ Inspiratory flow and leave
  - ↓ RR**** and adjust based on Pplat, BP, pH
↑Peak Inspiratory Flow Rate

But must ignore the rise in Peak Pressure!!

- Use ~ 60-80 l/min
- Use Square Wave – shorter iTime
- This will ↓iPEEP/Plat pressure
- But ↑PIP occurs (ignore!!)
- Never ↓PIF b/c the PIP is high
RR Setting: Primary Management

- Start at 10-12 (VE < 10 l/min)

- If Plat is high, lower RR

- Can continue to lower until goal achieved
  - Limited by \( \uparrow \text{PCO}_2/ \downarrow \text{pH} \)
If you **↓**RR to **↓**DHI, What Should You do if This Causes Worsening Resp Acidosis?

1. Abandon strategy - go back up on RR
2. Leave it be – take a “chill pill”
3. Buffer pH with NaHCO3
4. Pray
Recommendations: Permissive Hypercapnia (PHC)

- High PCO2 is safe, providing pH is OK
- PHC alone for pH > 7.15
- Consider IV NaHCO3 for pH < 7.1-7.15
- Sedation +/- paralysis (< 24 hrs safe)
- Contraindications:
  - Increase ICP
  - Severe metabolic acidosis, pregnancy, pHTN
Initial Ventilator Settings

- FiO2: 1.0
- Mode: AC VC
- MV: < 10 L/min
- Tidal Volume: ~8 ml/kg
- Rate: 10-14
- Flow Rate: 60-80 L/min
- Flow profile: Square
- PEEP: 0
Algorithm Approach to Vent Mgmt

Vt ~ 6-8 ml/kg
RR = 12-14
PIF = 80 square
PEEP = 0
Plateau Pressure < 30

Hemodynamics
- IVF for Shock
- If persists, ↓ Plat press goal

yes
pH > 7.15?

no
↓Ve until Plat ≤ 30

yes
HCO₃ Infusion

no
Maintain settings

Maintain settings

pH < 7.15?

↓Ve until Plat = 30

pH > 7.15?

yes

no

Maintain settings
When to Consider for an SBT?

When the obstruction resolves....

How to recognize:

- ↓PIP, Plat, iPEEP
- Expiratory flow vs. time display
- ↓Inspiratory resistance (Pip-Plat narrows)
Ventilator Liberation

- Mean duration of MV:
  - Asthma
    - 40% < 1 day, 70% < 2 days, 85% < 5 days
  - COPD ~ 3-5 days
- Method:
  - Spontaneous breathing trials
  - Consider NIV for COPD pt’s who fail SBT’s
- Post-extubation: observe in ICU for 24 hrs
Summary

- DHI is the key problem in asthma/COPD

- After BD/steroids, assess response to Rx; intubate only if ΔMS or treatment/NIV failure

- Use NIV in all cases; if no contraindications

- IVF load pre/post-intubation to avoid/treat shock

- Monitor iPEEP, $P_{Plat}$, Resistance ABG’s daily
Summary

- Treat DHI if $P_{plat} > 30$ or hemodynamically unstable
  - Use ACVC 100% with 8 ml/kg TV, RR 10-14, Insp flow rates ~ 80 l/m in square wave, O PEEP

- Adjust RR down if need to avoid risks – as judged by $P_{plat}$, pH, hemodynamics
  - If pH then drops < 7.15 consider NaHCO3

- Judicious IVF (LR preferred) to improve venous return
Questions???

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