

# Common Ventilator Management Issues

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You have just admitted a 28 year-old male with an asthma exacerbation. He was intubated in the ED for labored breathing and his initial vitals after intubation were fine.

He's now hypotensive with BP 82/50, HR 130, RR 32. He looks uncomfortable and his breath sounds are diminished.  
Vent settings include AC, Vt 500, RR 12, 100% FiO2, 5 PEEP  
Peak pressures = 50, Plateau pressures = 32, Auto-PEEP = 15

What is the most likely cause for his hypotension?

- A. Tension pneumothorax
- B. Hypovolemia
- C. Auto-PEEP with breath stacking
- D. Septic shock

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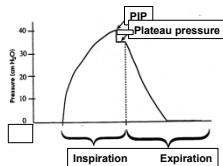
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## Peak Inspiratory Pressure

- Maximum airway pressure measured - almost always occurs at the end of inspiration
- "Dynamic" - measured during flow
- Increases with flow rates, airway resistance, patient- ventilator dyssynchrony



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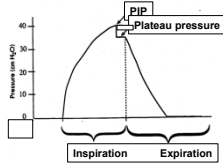
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## Inspiratory Plateau Pressure

- Airway pressure measured at end of inspiration with no gas flow present (during breath hold)
- Estimates alveolar pressure at end-inspiration
- Indirect indicator of alveolar distension



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## Inspiratory Plateau Pressure

- Increased with:
  - States that decrease lung compliance
  - ARDS, pulmonary fibrosis, obesity, large pleural effusions, abdominal compartment syndrome
- High inspiratory plateau pressure can lead to:
  - Barotrauma, volutrauma
    - pneumothorax at IPP > 30 cm H<sub>2</sub>O
  - Impaired venous return to the right heart
  - Decreased cardiac output

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## Inspiratory Plateau Pressure (IPP)

Methods to decrease IPP:

1. Correct underlying states if present
  - Drain effusions, tap ascites, etc
2. Decrease PEEP
3. Decrease tidal volume

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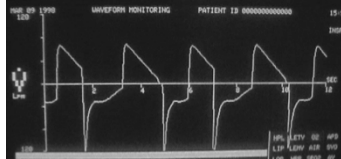
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### Auto-PEEP

- Auto-PEEP is the pressure in the airways at end expiration
- Can be measured on most ventilators
- Increases peak, plateau, and mean airway pressures
- Potential harmful physiologic effects



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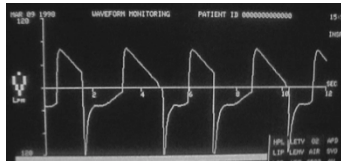
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### Auto-PEEP

- Reduce auto-PEEP by shortening inspiratory time
  - Decrease respiratory rate
  - Decrease tidal volume
  - Increase gas flow rate



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Peak pressures = 50, Plateau pressures = 32, auto-PEEP = 15

What is the most likely cause for his hypotension?

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- C. Auto-PEEP with breath stacking
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Case 2  
Continued

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A 28 year-old male with an asthma exacerbation has just been admitted to the ICU. He is on mechanical ventilation and is hypotensive. He is uncomfortable with a RR of 34. You diagnose breath stacking with auto-PEEP = 15 cm H<sub>2</sub>O.

Vent settings include AC, Vt 600, RR 16, 100% FiO<sub>2</sub>, 5 PEEP  
Peak pressures = 50, Plateau pressures = 35, Insp time = 1sec

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Vent settings include AC, Vt 600, RR 16, 100% FiO<sub>2</sub>, 5 PEEP  
Peak pressures = 50, Plateau pressures = 35, Insp time = 1sec

What is the next best step to reduce auto-PEEP?

- A. Reduce ventilator rate to 12
- B. Increase inspiratory time to 2 seconds
- C. Reduce tidal volume to 400 cc
- D. Give sedation / analgesia to reduce patients respiratory rate
- E. C and D

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*Inspiratory Time: Expiratory Time (I:E ratio)*

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- Spontaneous breathing I:E = 1:2
- Determinants of inspiratory time
  - Tidal volume
  - Gas flow rate
  - Respiratory rate
  - Inspiratory pause
- Expiratory time passively determined

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*Inspiratory Time: Expiratory Time  
Examples*

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- Vent 1
  - Assist control, Vt 600, RR 10
  - Insp time = 1 second
  - Exp time = ?

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*Inspiratory Time: Expiratory Time  
Examples*

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- Vent 1
  - Assist control, Vt 600, RR 10
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*Inspiratory Time: Expiratory Time  
Examples*

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- Vent 1
  - Assist control, Vt 600, RR 10
  - Insp time = 1 second
  - Exp time = 5 seconds
- Vent 2
  - Assist control, Vt 600, RR 20
  - Insp time = 1 second
  - Exp time = ?

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*Inspiratory Time: Expiratory Time  
Examples*

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- Vent 1
  - Assist control, Vt 600, RR 10
  - Insp time = 1 second
  - Exp time = 5 seconds
- Vent 2
  - Assist control, Vt 600, RR 20
  - Insp time = 1 second
  - Exp time = 2 seconds

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*I:E Ratio During Mechanical Ventilation*

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- Problems can arise when the expiratory time is too short to permit full exhalation
  - Breath stacking
  - Auto-PEEP
- Increased intrathoracic pressure can result in:
  - Decreased venous return
  - Decreased cardiac output
  - Tachycardia, hypotension, hypoxemia
- The way to fix auto-PEEP is to allow the lungs to fully empty

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*Return to the case*

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- Vent: AC, Vt 600, RR 16, 100% FiO<sub>2</sub>, 5 PEEP, Insp time = 1 sec
- Peak pressure 50 cm H<sub>2</sub>O, IPP 35 cm H<sub>2</sub>O; auto-PEEP 15
- Total rate 30 breaths/min
- I:E ratio = 1:1
  
- pH 7.20, PaCO<sub>2</sub> 60 torr, PaO<sub>2</sub> 215 torr, SpO<sub>2</sub> 100%
- BP 90/60 mm Hg, heart rate 130–140 beats/min

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*Return to the case*

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- Total rate 30 breaths/min
- I:E ratio = 1:1
  
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*Analysis*

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- Hypercapnia
- High peak airway pressure
- Wide peak-plateau pressure difference
- High auto-PEEP
- High minute ventilation, increased PaCO<sub>2</sub>
- Hypotension and tachycardia (from auto-PEEP)

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### How to Fix the Vent

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- The patient has breath stacking and Auto-PEEP
- We need to increase his expiratory time
  - Decrease respiratory rate
    - .
    - .
- Need to decrease inspiratory tidal volume
- Give bronchodilators
- These interventions will increase expiratory time from 1 second to 5.5 seconds

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### How to Fix the Vent

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- The patient has breath stacking and Auto-PEEP
- We need to increase his expiratory time
  - Decrease respiratory rate
    - .
    - .
  - Increase inspiratory flow rate (decrease insp time to 0.5 seconds)
- Need to decrease inspiratory tidal volume
- Give bronchodilators
- These interventions will increase expiratory time from 1 second to 5.5 seconds

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### How to Fix the Vent to Improve Auto-PEEP

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- The patient has breath stacking and Auto-PEEP
- We need to increase his expiratory time
  - Decrease respiratory rate
    - Add sedatives
    - Reduce ventilator rate from 16 to 10
  - Increase inspiratory flow rate (decrease insp time to 0.5 seconds)
- Need to decrease inspiratory tidal volume
- Give bronchodilators
- These interventions will increase expiratory time from 1 second to 5.5 seconds

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A 28 year-old male with an asthma exacerbation has just been admitted to the ICU. He is on mechanical ventilation and is hypotensive. He is uncomfortable with a RR of 34. You believe that he has breath stacking with auto-PEEP.

Vent settings include AC, Vt 600, RR 16, 100% FIO<sub>2</sub>, 5 PEEP  
Peak pressures = 50, Plateau pressures = 35, Insp time = 1sec

What is the next best step to reduce auto-PEEP?

- A. Reduce ventilator rate to 12
- B. Increase inspiratory time to 2 seconds
- C. Reduce tidal volume to 400 cc
- D. Give sedation / analgesia to reduce patients respiratory rate
- E. C and D

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### Case 3

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A 42-yr old female is admitted after a drug overdose complicated by emesis and aspiration. Intubation, mechanical ventilation, and neuromuscular blockade are initiated in the emergency department:

AC, Vt 680, RR 10, FIO<sub>2</sub> 100%, PEEP 5. She weighs 68kg  
Vent mechanics include: Ppk 52, IPP 48, Auto-PEEP 0, SpO<sub>2</sub> 86%  
ABG pH 7.38, PaCO<sub>2</sub> 36, PaO<sub>2</sub> 54, SpO<sub>2</sub> 86%

What is the next best step to optimize the vent?

- A. Increase PEEP to 10
- B. Reduce tidal volume to 400 cc (6cc/kg)
- C. Increase respiratory rate
- D. All of the above

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### *Analysis of Ventilator-Patient Interaction*

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- High inspiratory plateau pressure
  - IPP 48 cm H<sub>2</sub>O
- Hypoxemia despite FIO<sub>2</sub> at 1.0
  - SpO<sub>2</sub> 86%, P<sub>a</sub>O<sub>2</sub> 54 torr
- Adequate ventilation
  - pH 7.38, PaCO<sub>2</sub> 36 torr
- Sedation/neuromuscular blockade

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### *Fixing the PaO<sub>2</sub>*

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- Hypoxemia despite FIO<sub>2</sub> at 1.0
  - SpO<sub>2</sub> 86%, P<sub>a</sub>O<sub>2</sub> 54 torr
  - Vent = AC Vt 680, RR 10, FIO<sub>2</sub> 100%, 5 PEEP
- Solution = ?
- Consequences = ?

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### *Fixing the PaO<sub>2</sub>*

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- Hypoxemia despite FIO<sub>2</sub> at 1.0
  - SpO<sub>2</sub> 86%, P<sub>a</sub>O<sub>2</sub> 54 torr
  - Vent = AC Vt 680, RR 10, FIO<sub>2</sub> 100%, 5 PEEP
- Solution = Increase PEEP
- Consequences = Increased airway pressures

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### *Fixing the Plateau Pressure*

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- IPP = 48 cm H<sub>2</sub>O (Peak = 52)
  - Vent = AC Vt 680, RR 10, FIO<sub>2</sub> 100%, 5 PEEP
- Solution = ?

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### *Fixing the Plateau Pressure*

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- IPP = 48 cm H<sub>2</sub>O (Peak = 52)
  - Vent = AC Vt 680, RR 10, FIO<sub>2</sub> 100%, 5 PEEP
- Solution = Decrease Vt
  - Goal = 6 cc/kg IBW (~ 360 cc)
- Consequences = ?

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### *Fixing the Plateau Pressure*

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- IPP = 48 cm H<sub>2</sub>O (Peak = 52)
  - Vent = AC Vt 680, RR 10, FIO<sub>2</sub> 100%, 5 PEEP
- Solution = Decrease Vt
  - Goal = 6 cc/kg IBW (~ 360 cc)
- Consequences = drop in minute ventilation
  - Initial MV = 680 x 10 = 6.8 L
  - After change = 360 x 10 = 3.6 L
  - PaCO<sub>2</sub> will rise, pH will fall

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### *Fixing the Plateau Pressure*

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- IPP = 48 cm H<sub>2</sub>O (Peak = 52)
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  - PaCO<sub>2</sub> will rise, pH will fall
  - Need to increase the respiratory rate

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### *Patient J.T. - Fixing the IPP*

- IPP = 48 cm H<sub>2</sub>O (Peak = 52)
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- Solution = Decrease Vt
  - Goal = 6 cc/kg IBW (~ 360 cc)
- Consequences = drop in minute ventilation
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  - After change = .360 x 10 = 3.6 L
  - Need to increase respiratory rate

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### *Acute Lung Injury - Summary*

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- Decreased lung compliance results in high airway pressures
- Low tidal volume often needed
- Maintain IPP  $\leq$  30 cm H<sub>2</sub>O
- PEEP to improve oxygenation

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