

Basic Mechanical Ventilation

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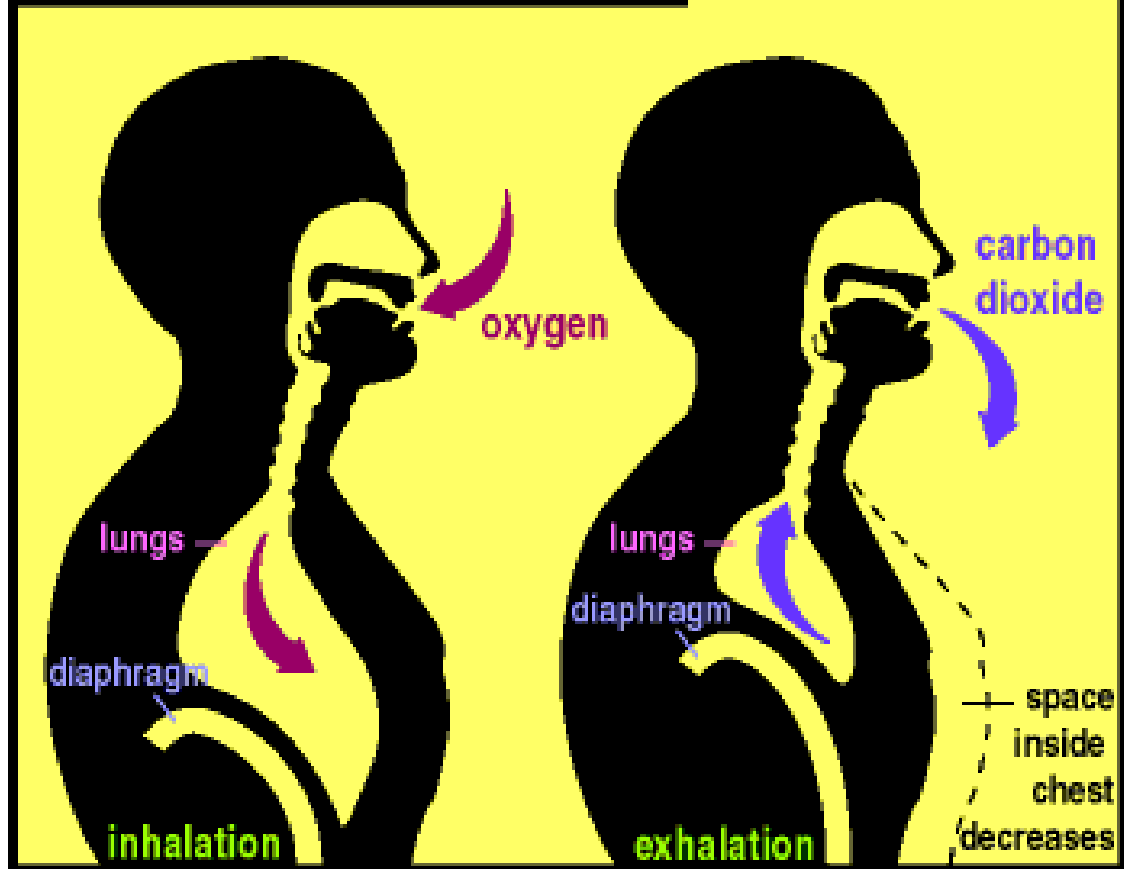
Outline

- Basic Science
- Lingo
- Initial Settings
- Common Intern Mistakes

How do we breath?

- Brainstem control
- Chemoreceptors
- Diaphragm contraction and Chest wall expansion → increased intrathoracic volume
- Leads to negative intrathoracic pressure
- Air flows from high to low pressure
- Negative pressure ventilation

The Mechanics of Breathing



Why do we breath?

- 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: $IBW = 50 \text{ kg} + 2.3 \text{ kg for each inch over 5 feet.}$
 - Females: $IBW = 45.5 \text{ kg} + 2.3 \text{ kg for each inch over 5 feet.}$

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



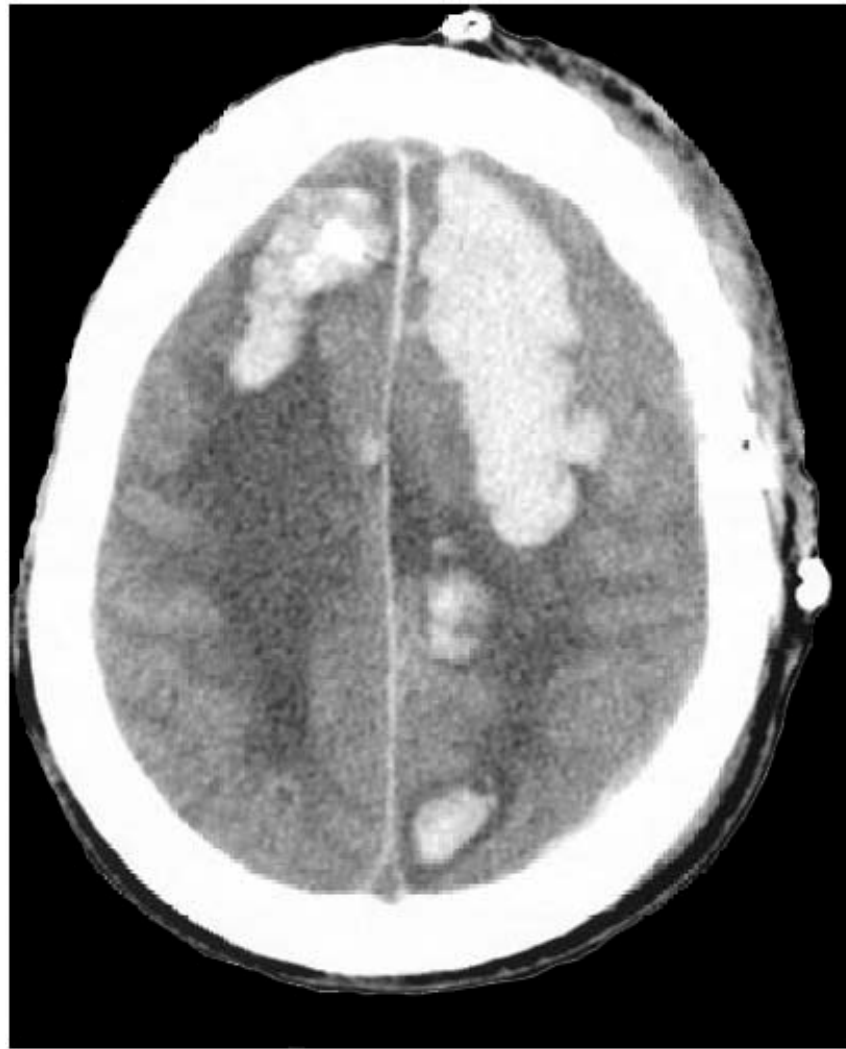
Courtesy P. DeBlieux, MD

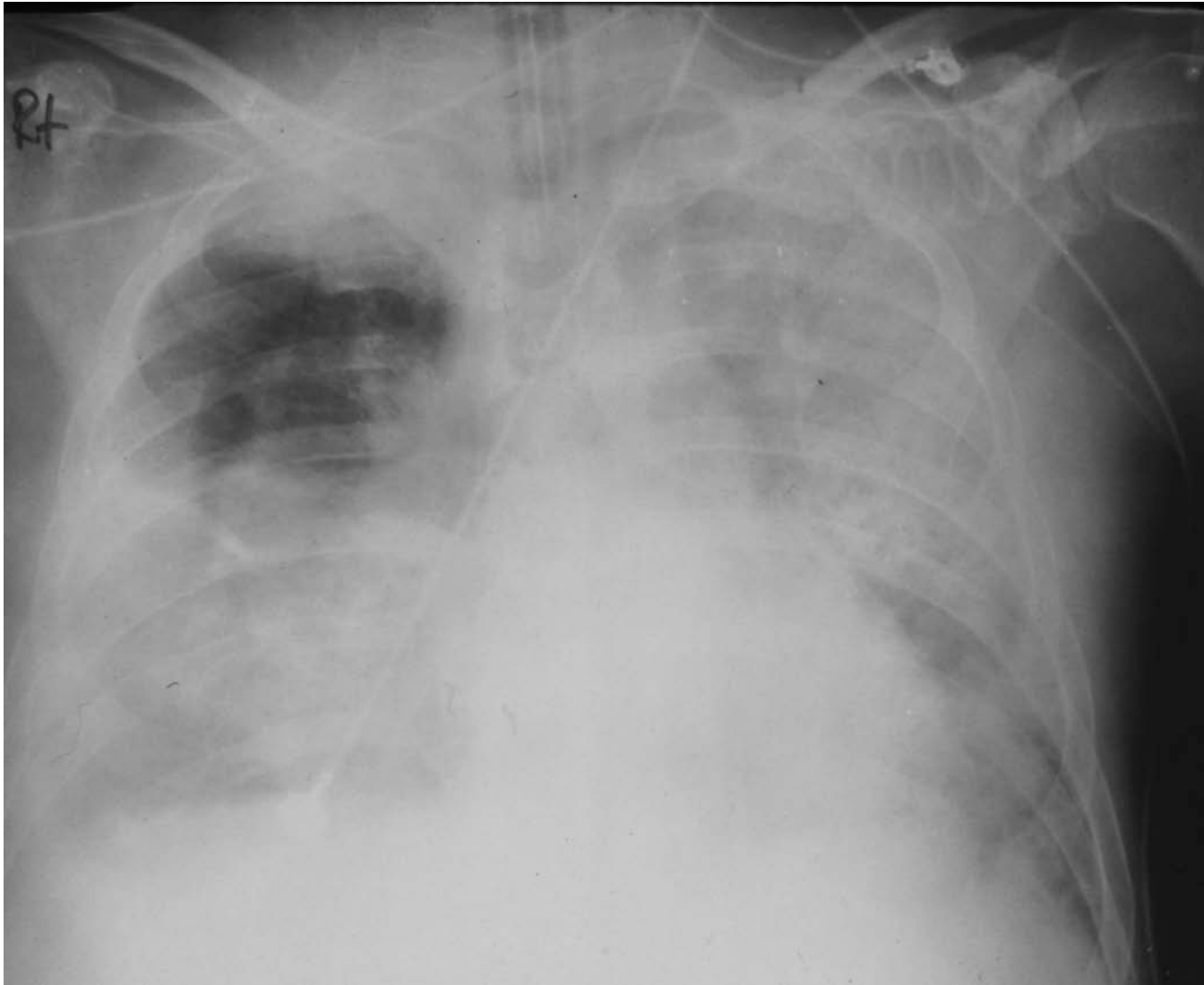


Courtesy P. DeBlieux, MD



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Basic Ventilator Lingo

- Control breath
 - Vent initiates the breath
- Assist breath
 - the patient initiates the breath

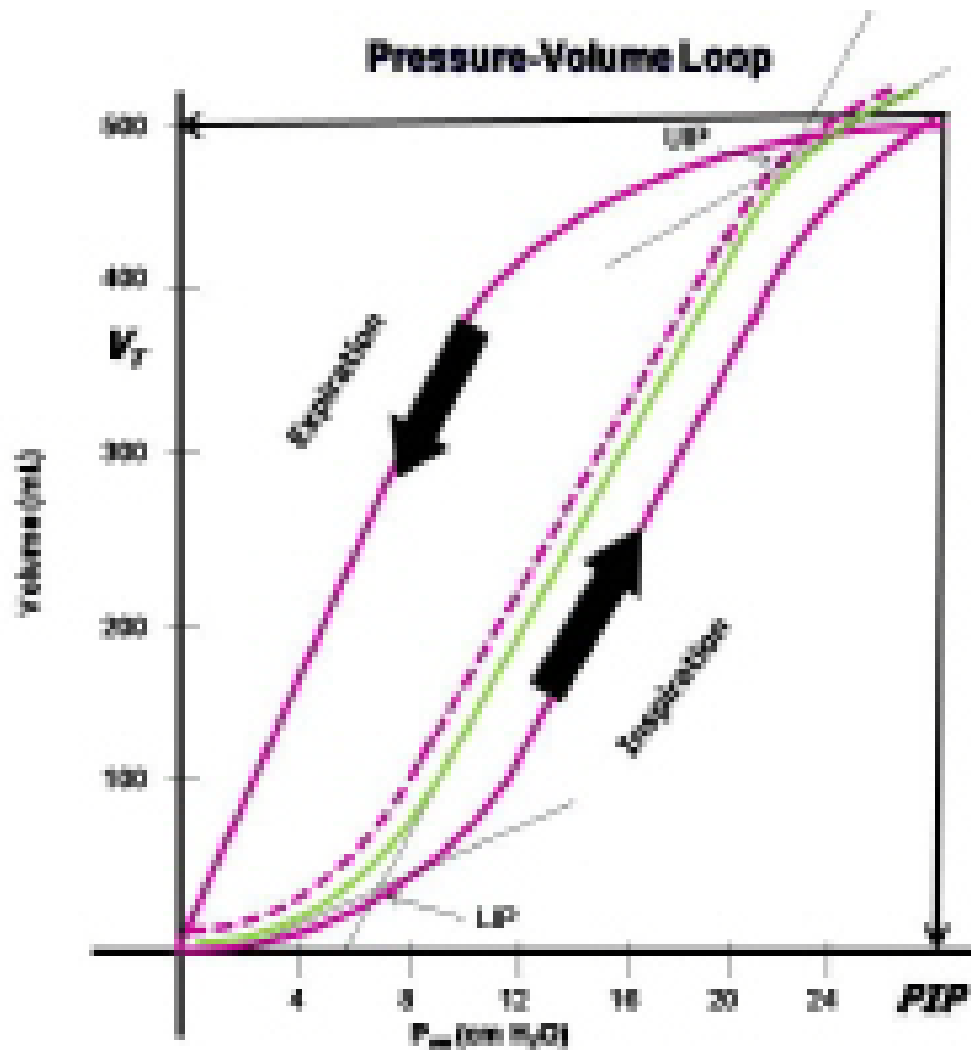
What can I set?

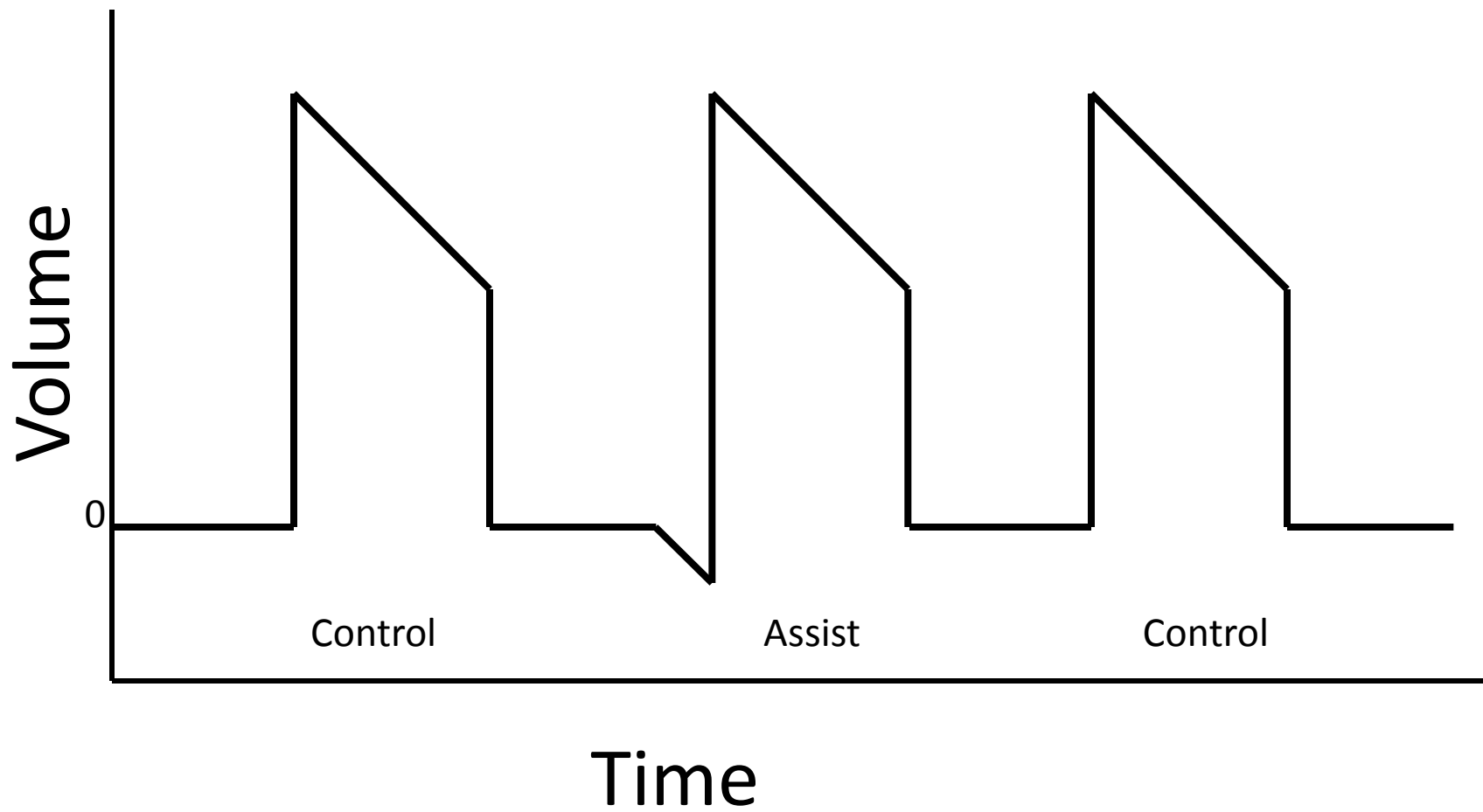
- Ventilator Target
- Ventilator Mode
- Respiratory Rate
- PEEP
- FiO₂
- Flow Rate
- Other stuff... more later

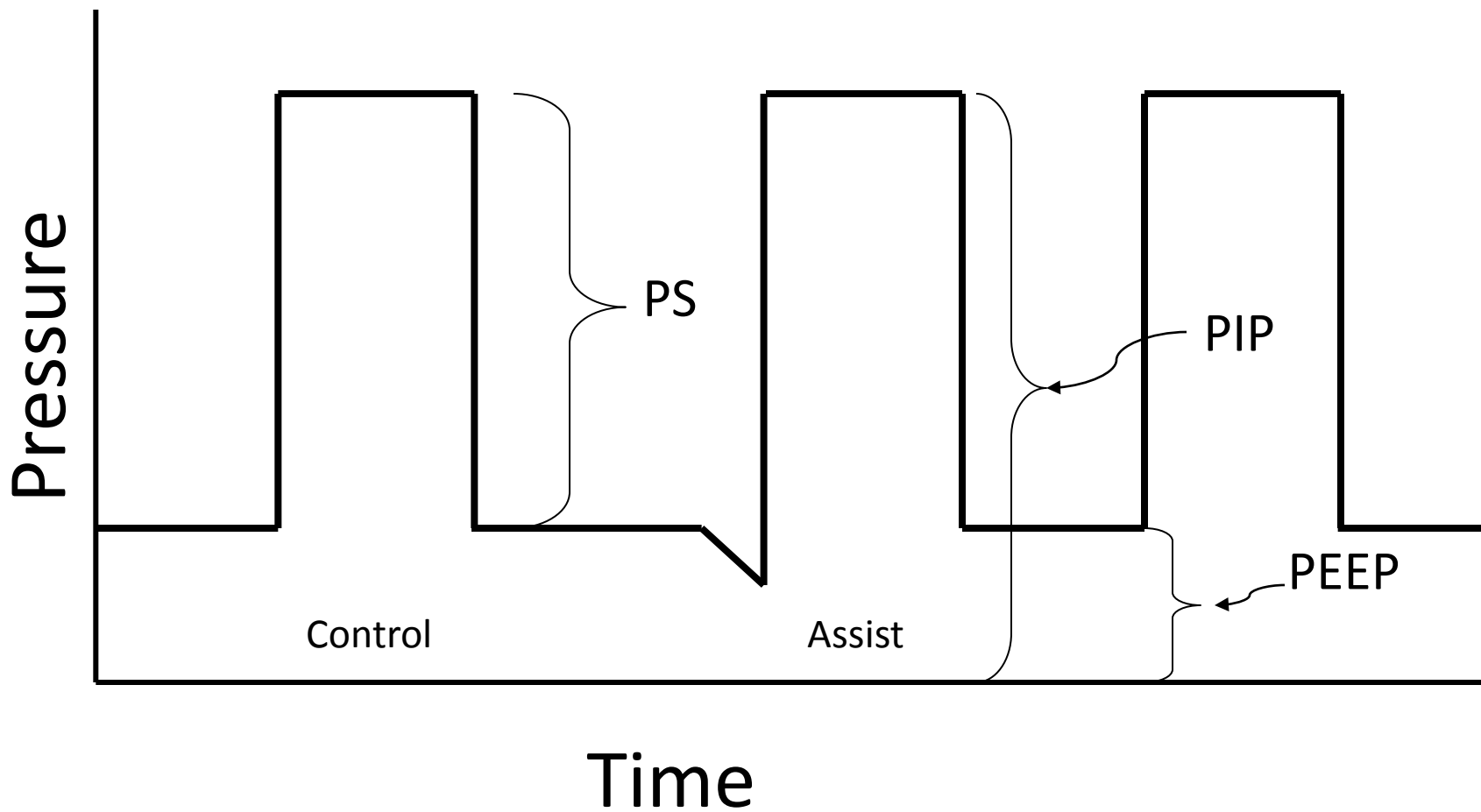
Step 1: What is the target?

- 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





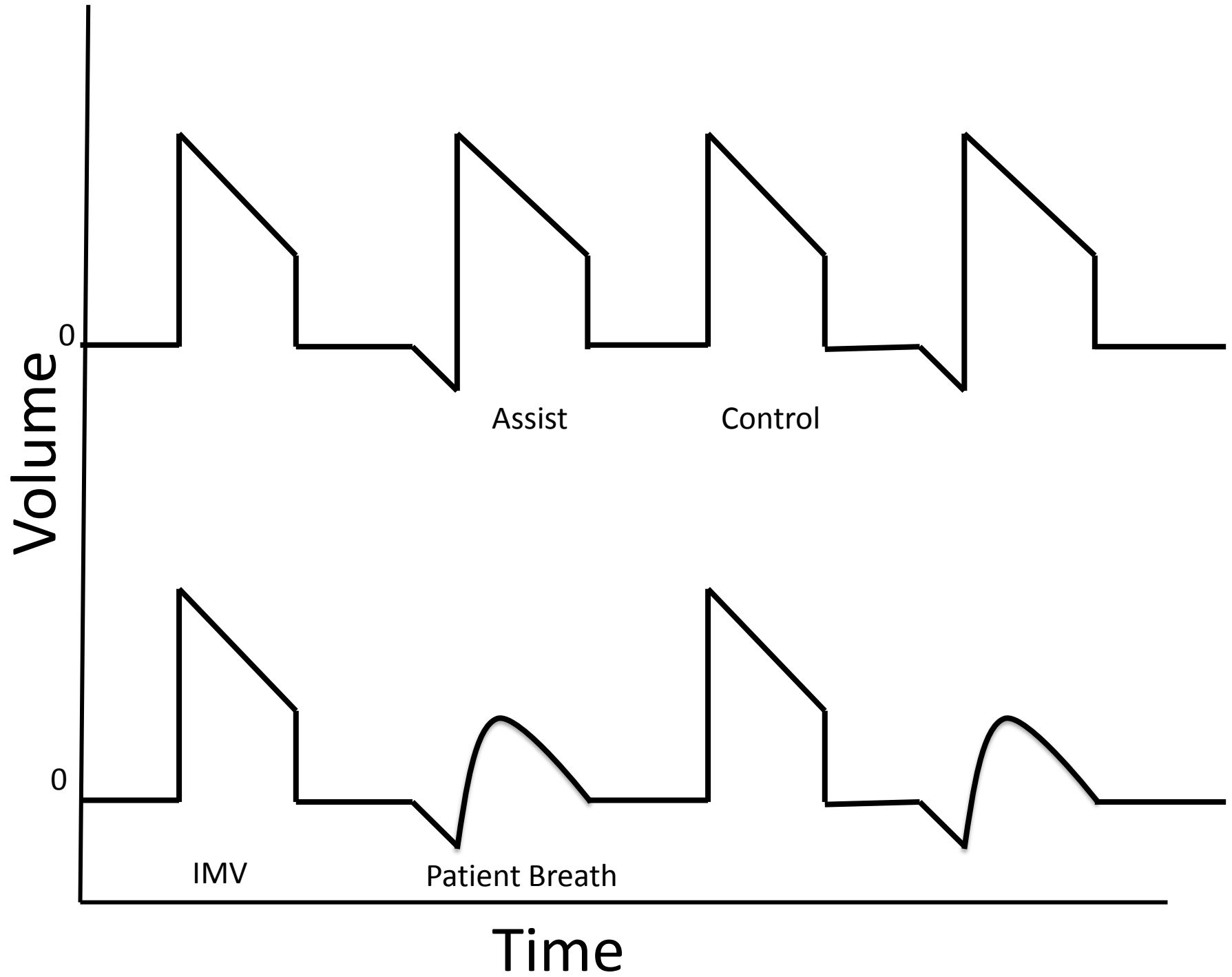


Step 2: How does the vent reach it's goal?

- 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_H) 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?

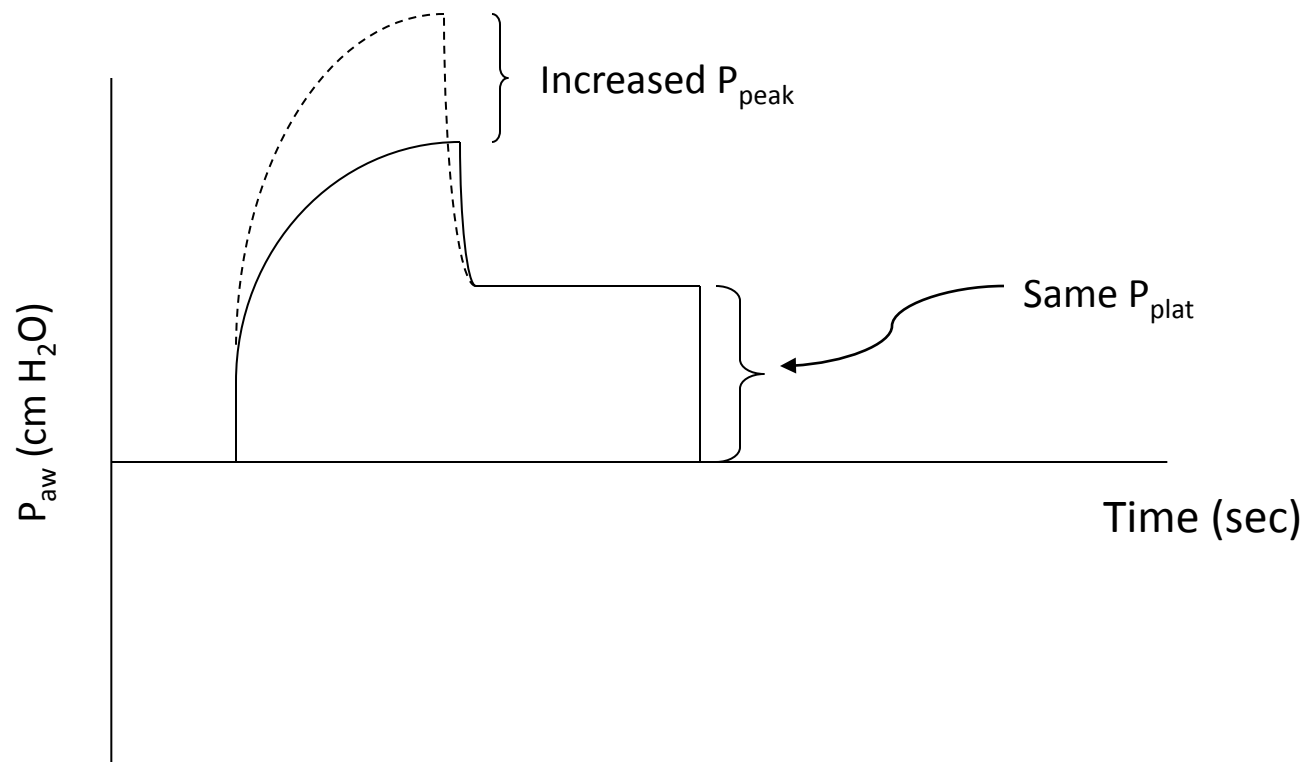
- Always 100%.
- Intubation switches pt from negative pressure ventilation to positive pressure ventilation
 - Changes V/Q unpredictably
- Titrate FiO₂ down based on PaO₂ from ABG or PO_x (if good waveform).

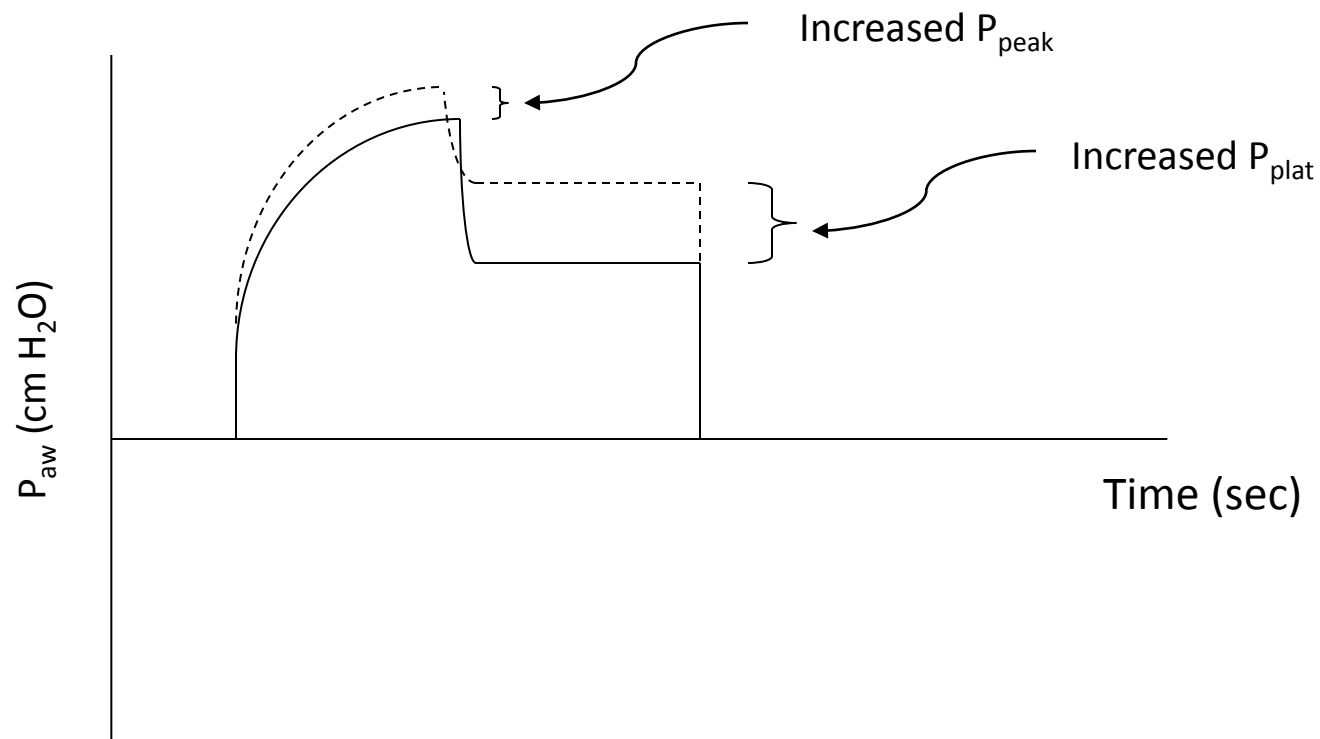
What Flow Rate should I set?

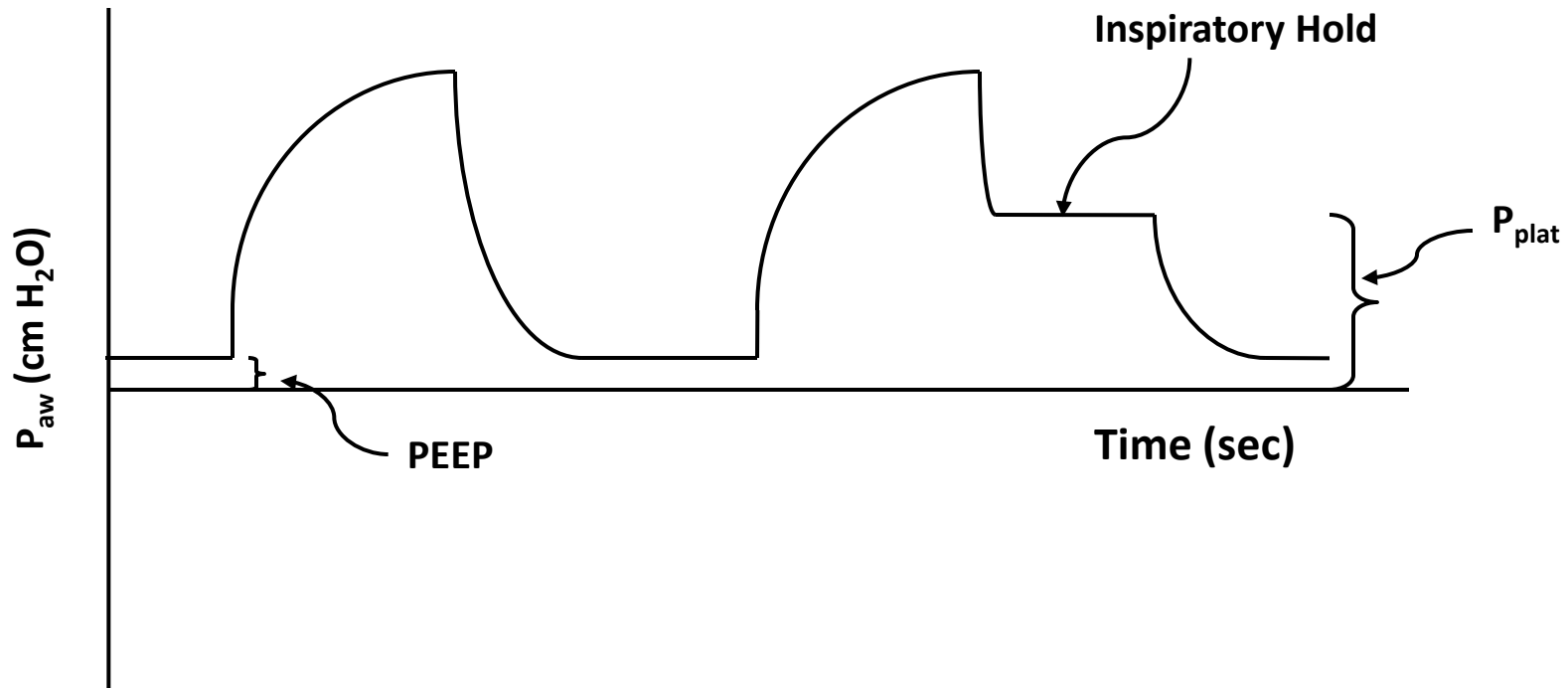
- Almost always set at 60 L/min.
- Use higher rates in Asthma or those with air hunger
- Pressure-Targeted modes allow patient to dictate the flow rate that they want

Alarms

- Peak Pressure alarm
 - Resistance to airflow







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 cmH₂O
- 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.

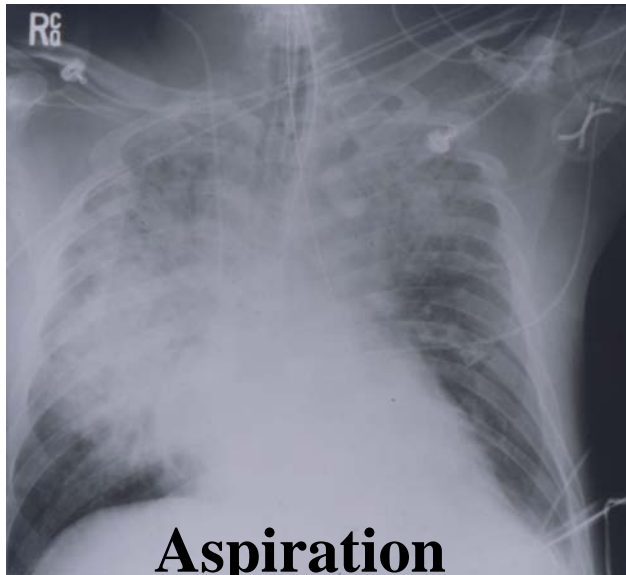
Mechanical Ventilation in Asthma

- 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
- $\text{PaO}_2/\text{FiO}_2$ ratio < 200
- Non-Cardiogenic
- Stiff, non-compliant lungs

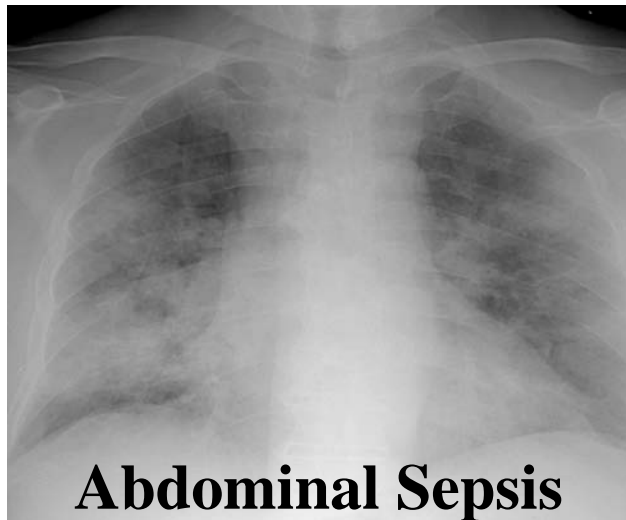
ARDS



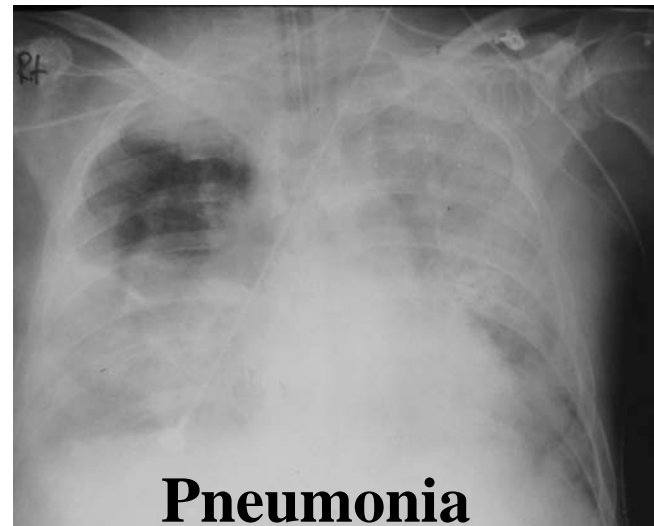
Aspiration



Major Trauma



Abdominal Sepsis



Pneumonia

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 V_t

- 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 V_t at 8cc/kg IBW
- f) None of the above
 - Maybe. Pt may need sedation/analgesia