CRITCARE BITES

STATUS ASTHMATICUS

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SICM
Society of Intensive Care Medicine
SINGAPORE

MAD FOR MEDICINE

PATHOPHYSIOLOGY

- Acute severe asthma exacerbation characterized by markedly increased airway resistance
- Dynamic hyperinflation occurs when reduction in expiratory flow leads to incomplete exhalation of delivered tidal volume
- Air that is left behind exerts a positive pressure, known as auto-PEEP
- Deleterious effects
  - Hypotension
  - Barotrauma

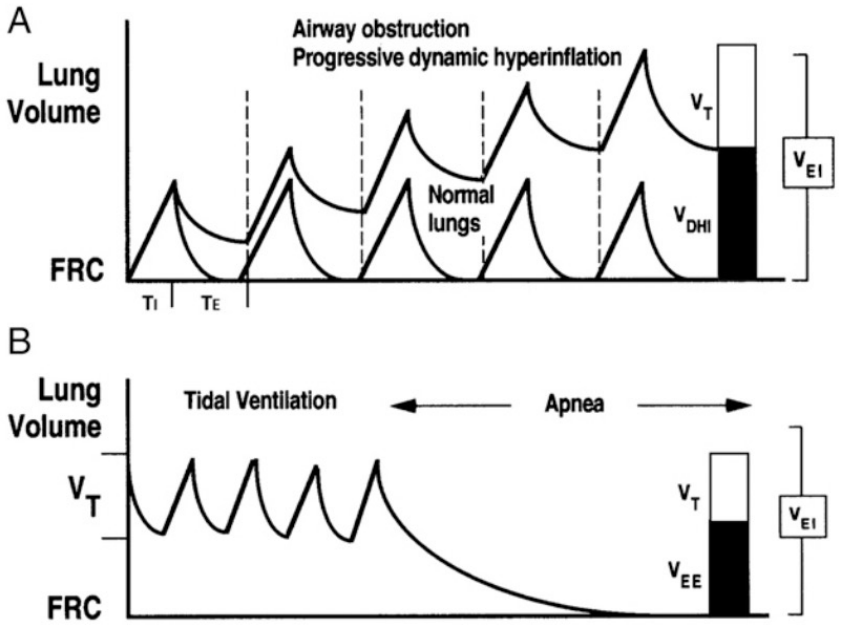


Figure 2 – *A, Dynamic hyperinflation. B, Measurement of V_{EI} and V_{EE} by use of a prolonged apnea. V_{EE} and V_{DHI} are equivalent. FRC = functional residual capacity; T_E = expiratory time; T_I = inspiratory time; V_{DHI} = volume (above FRC) caused by dynamic hyperinflation; V_{EE} = volume (above FRC) at end expiration; V_{EI} = volume (above FRC) at end inspiration; V_T = tidal volume. (Reprinted with permission from Tuxen and Lane.[15])*

SEVERITY STRATIFICATION

MODERATE ASTHMA

- increasing symptoms
- PEF >50-75% best or predicted
- no features of acute severe asthma

ACUTE SEVERE ASTHMA

Any one of:

- PEF 33-50% best or predicted
- respiratory rate ≥25/min
- heart rate ≥110/min
- inability to complete sentences in one breath

LIFE-THREATENING ASTHMA

In a patient with severe asthma any one of:

- PEF <33% best or predicted
- SpO_2 <92%
- PaO_2 <8 kPa
- normal $PaCO_2$ (4.6-6.0 kPa)
- silent chest
- cyanosis
- poor respiratory effort
- arrhythmia
- exhaustion, altered conscious level
- hypotension

Most asthma patients should have a low pCO2 from hyperventilation Normal pCO2 is a sign of impending respiratory failure

NEAR-FATAL ASTHMA

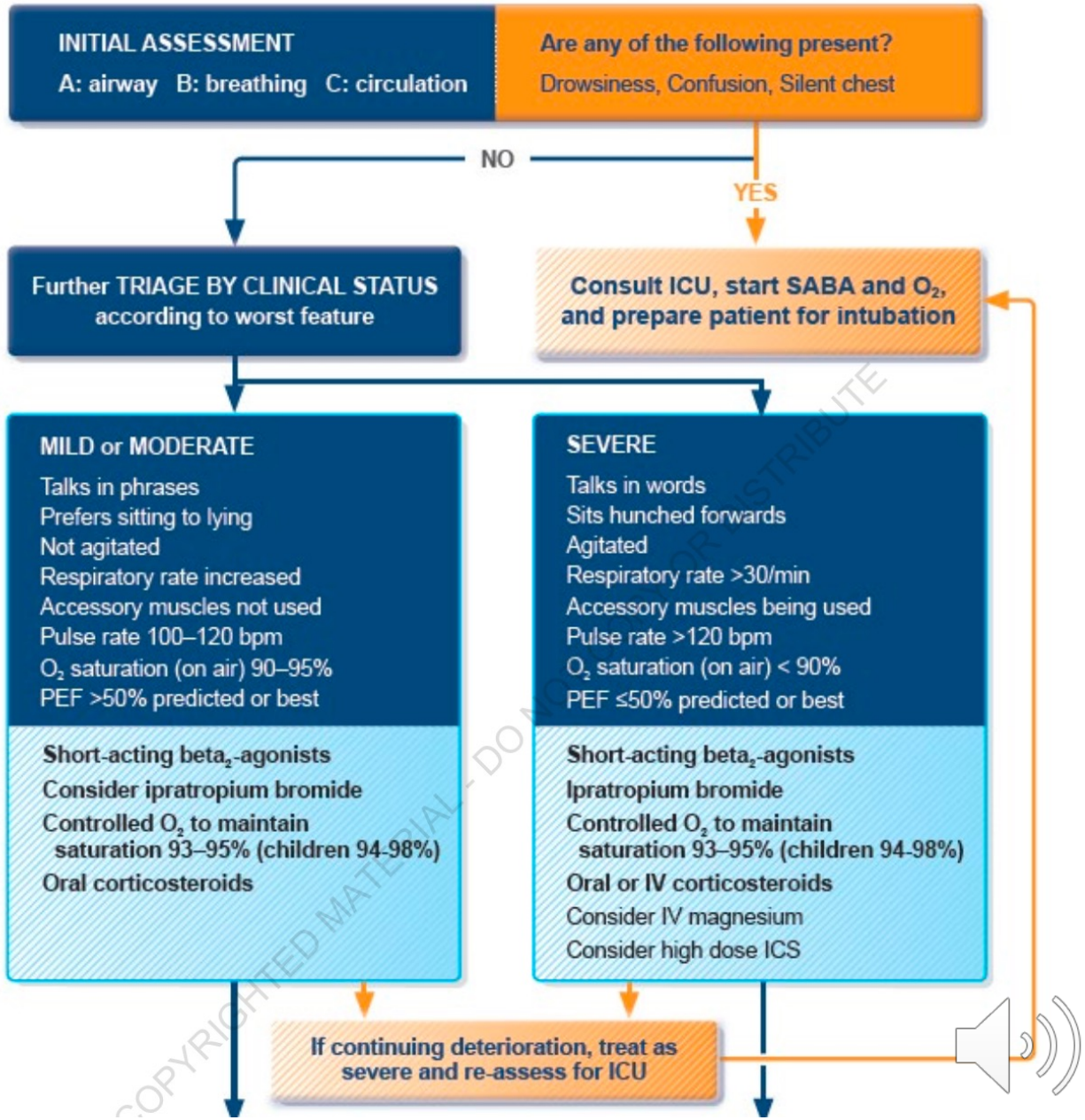
Raised $PaCO_2$ and/or requiring mechanical ventilation with raised inflation pressures

BTS 2016 asthma guidelines

INITIAL TREATMENT

- Nebs back to back every 15 minutes
- IV hydrocortisone 200mg once then 100mg 8H
- IV MgSO4 2g (≈ 8mmol)
- Empiric antibiotics for concomitant pneumonia if present
- **Frequent re-assessment** of patient's response

Box 4-4. Management of asthma exacerbations in acute care facility, e.g. emergency department



GINA 2022

NIV?

- **Controversial**
- Evidence is lacking, only 1 major RCT looking at severe asthma (Soroksky, Chest 2003)
  - 15 assigned to BiPAP and 15 to conventional therapy
  - BiPAP improved lung function tests and reduced hospitalization
  - Is it really a severe asthma attack if the patient can be discharged home?
- Should not delay intubation if employed
- Initiate in ICU setting with close monitoring

A Pilot Prospective, Randomized, Placebo-Controlled Trial of Bilevel Positive Airway Pressure in Acute Asthmatic Attack*

Arie Soroksky, MD; David Stav, MD; and Isaac Shpirer, MD

INDICATIONS FOR INTUBATION

Clinical

1. Cardiac arrest
2. Respiratory arrest or profound bradypnea, silent chest
3. Physical exhaustion
4. Altered sensorium: lethargy/ agitation that interferes with O2 delivery or treatment

Arterial blood gas

1. pH <7.2
2. PaCO2 ↑ >5mmHg or >55-70mmHg
3. PaO2 <60mmHg on 100% O2

Clinical judgment > numbers

- Respiratory distress, RR >40
- Complications: barotrauma
- Unresolving lactic acidosis

INTUBATION TECHNIQUE

- Rapid sequence intubation
- Large size ETT if possible (size 8.0)
  - Minimizes additional airway resistance
  - Facilitates secretion removal and bronchoscopy if needed (mucus plugging common)
- Pre-medication: IV Fentanyl 2-3mcg/kg to attenuate laryngospasm
- Induction agents: IV Ketamine 1-2mg/kg, IV Propofol 2mg/kg (bronchodilatory)
- Paralytic agents: Rocuronium 0.6-1.2mg/kg (avoids histamine release)
  - Succinylcholine theoretically can cause histamine release, but has been safely used
- Post-intubation: controlled hypoventilation during bagging

POST-INTUBATION HYPOTENSION

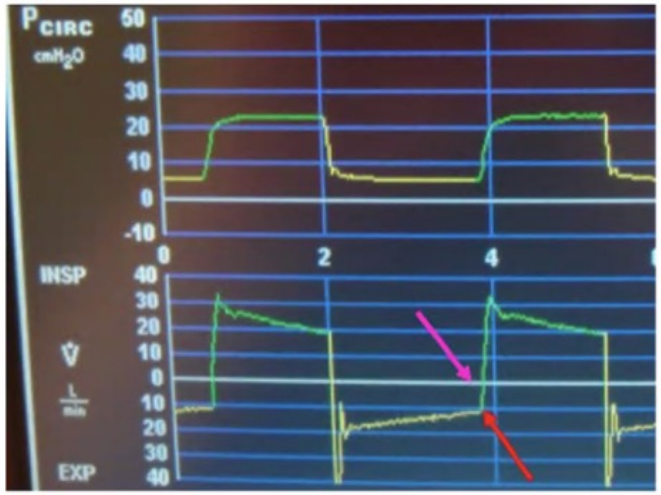
Causes

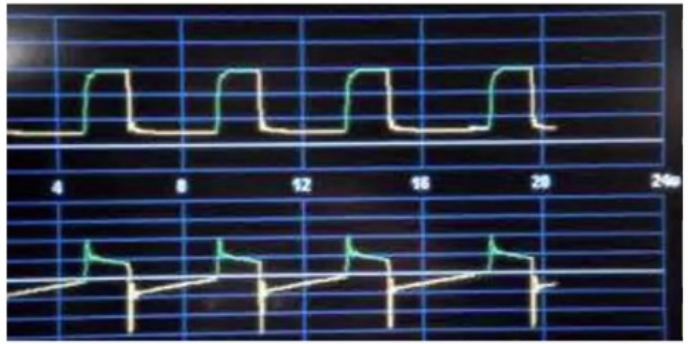
- **Dynamic hyperinflation** leading to reduced cardiac filling from high intrathoracic pressures
- **Tension PTX**/ pneumomediastinum
- RSI drugs
- Concurrent sepsis/pneumonia
- Hypovolemia from intercurrent illness
- Cardiac event

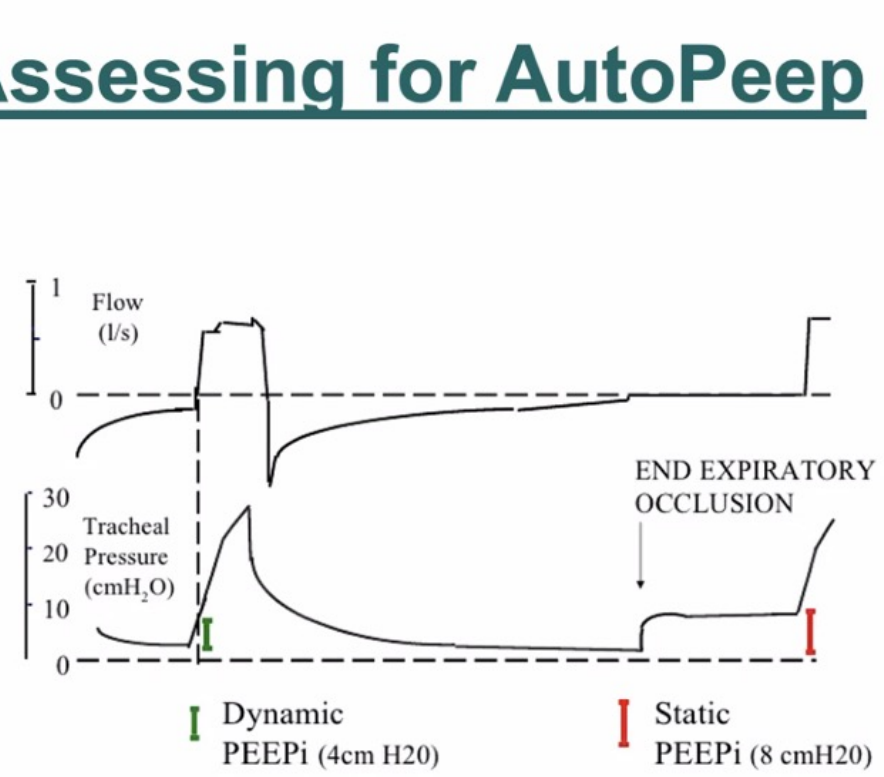
Management

- Fluid resuscitation: 30ml/kg crystalloids
- Clinical examination looking for evidence of PTX, check for auto-PEEP
- Vasopressors: Phenylephrine boluses, NorA
- POCUS, CXR, ECG
- Decrease PEEP/ rate of ventilation if being ventilated or bagged
- Disconnect circuit if necessary

DETECTING AUTO-PEEP





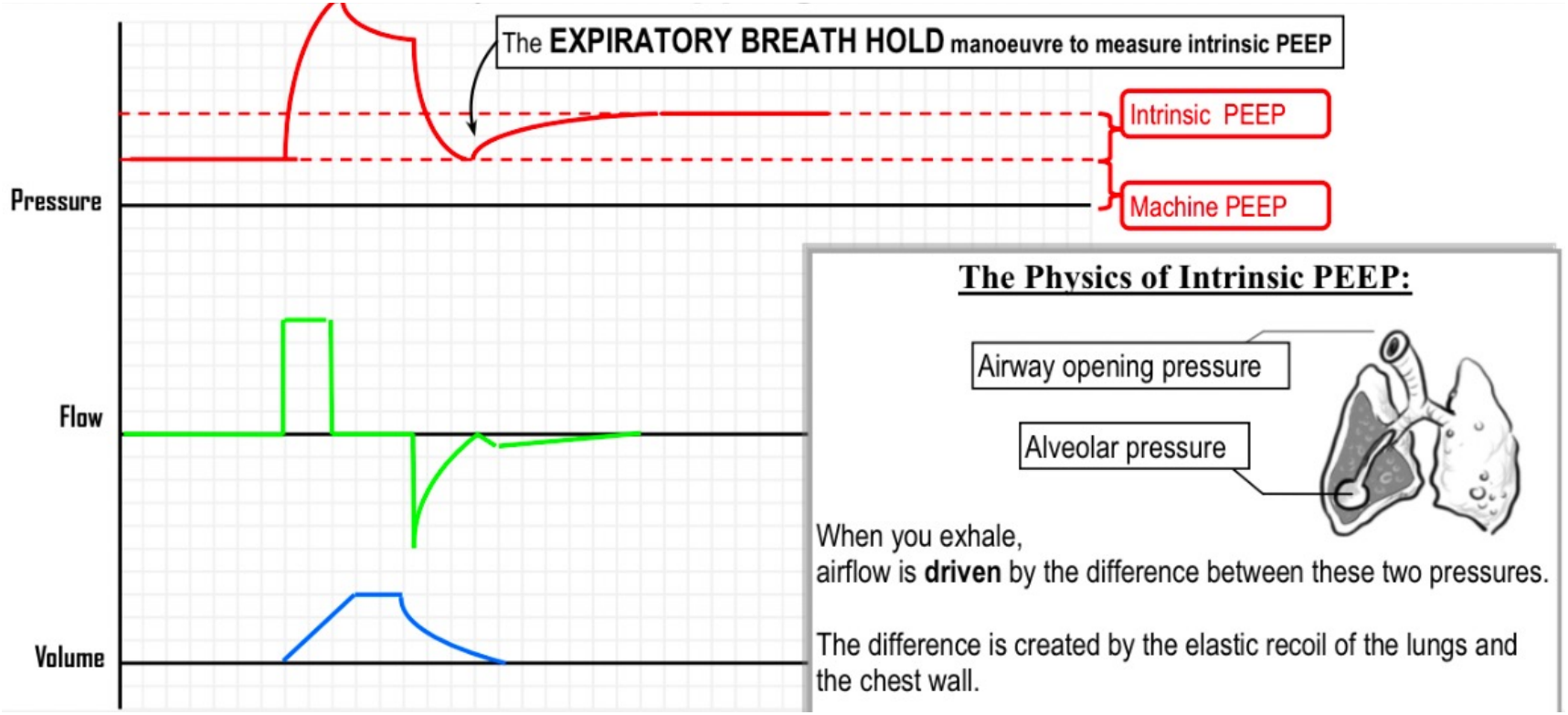


1) Failure of the expiratory flow waveform to return to baseline

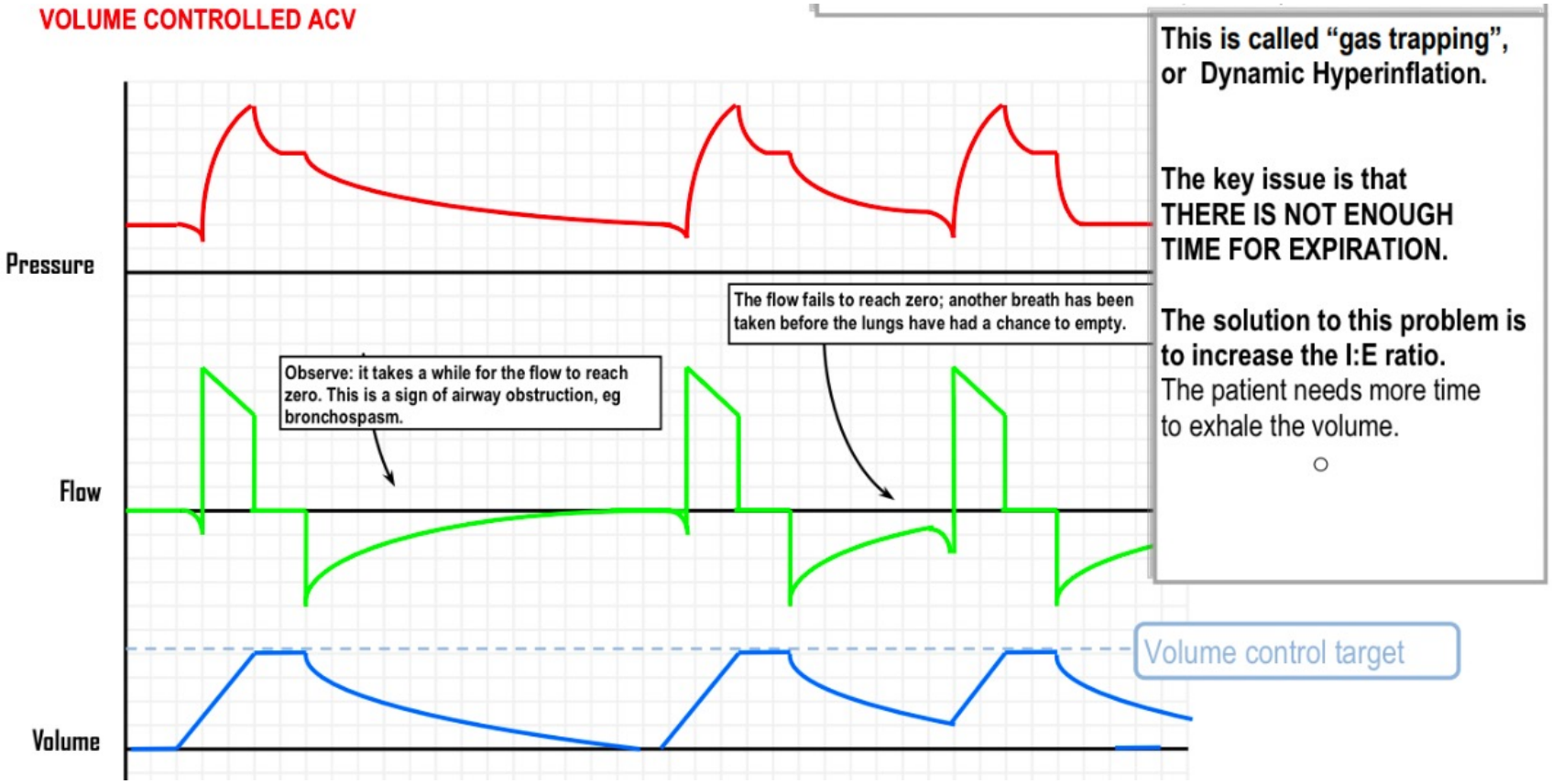
2) Expiratory hold

3) Increasing Pplat

EXPIRATORY HOLD MANEOUVRE



DYNAMIC HYPERINFLATION



GOALS OF MECHANICAL VENTILATION

Severe hyperinflation may result from breath stacking

Patients are at risk for barotrauma and hypotension

Controlled hypoventilation to minimize airway pressure and barotrauma

Accept hypercapnia to allow adequate time for expiration

SEDATION STRATEGY

- **Adequate sedation**
  - Reduce O2 consumption and CO2 production from work of breathing
  - Ensure patient-ventilator synchrony, prevent rapid RR which may cause auto-PEEP
  - Usual agents: Propofol, Fentanyl; add Midazolam if required
- **Neuromuscular blockade**
  - Rocuronium preferred over Atracurium (histamine release)
  - Target BIS 40-60
  - TOF: aim 1-2 out of 4 or titrate infusion to achieve ventilator synchrony

VENTILATORY STRATEGY

- **ACVC**: ✓precise control of VT, peak inspiratory pressure alarms for safety
- **Low tidal volume:** 6-8ml/kg ideal body weight
- **Low RR:** 10-12 breaths/min
  - Effect of RR is more pronounced in increasing expiratory time than altering I:E ratio
- **Increase inspiratory flow** (at least 60L/min) to achieve **I:E ratio of 1:4-5**

- Titrate FiO2 to target SpO2

APPLIED PEEP

- Excessive PEEP is not recommended in sedated and paralyzed patients
- PEEP selected is between 0 and 5cmH2O
- Sticky airways theory: PEEP maybe beneficial as it splints small airways open (overcomes dynamic airflow obstruction) allowing for easier release of air from the alveoli
- If intrinsic PEEP is reduced with applied PEEP, it implies that airway recruitment has occurred

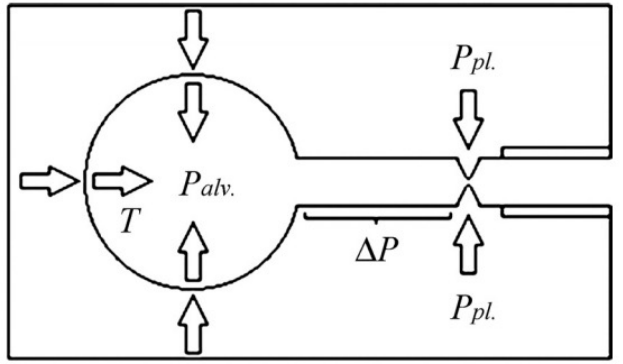


Image: Adv Physiol Educ 37: 266–267, 2013;

BRONCHODILATORS

- MDI puffs
  - ATS: 6-8 puffs of Salbutamol or Berodual MDI into ventilator circuit, timed with inspiration
  - Clinical practice: 20 puffs Berodual/ Salbutamol q2-4h
- Nebs via Aerogen attachment
  - Total volume of liquid to nebulize is 6ml
  - Usually salbutamol 4ml: ipratropium 2ml
- Continue IV hydrocortisone 100mg 8h

Aerogen® Solo

RESCUE MEASURES

- Ketamine infusion: 0.15-2.5mg/kg/h
  - Duration of infusion ranges from 1h to 5 days
  - Data mixed
- Inhaled anaesthetic agents: Sevoflurane using Anaconda device
  - Case reports, case series
  - Contraindications: pregnant, hypotension/ shock, raised ICP, history of malignant hyperthermia
- IM/ SC adrenaline 1:1000 0.3ml q20min x3 (0.3-0.5mg) or IV 3-5ml of 1:10,000 adrenaline
  - Controversial: no significant difference compared to β_2-agonists (Baggott et al)
  - Not recommended by GINA
- Disconnect from the ventilator and manually compress chest
- Bronchoscopy for airway toileting (if mucus plugs)
- ECMO or ECCO2R as salvage

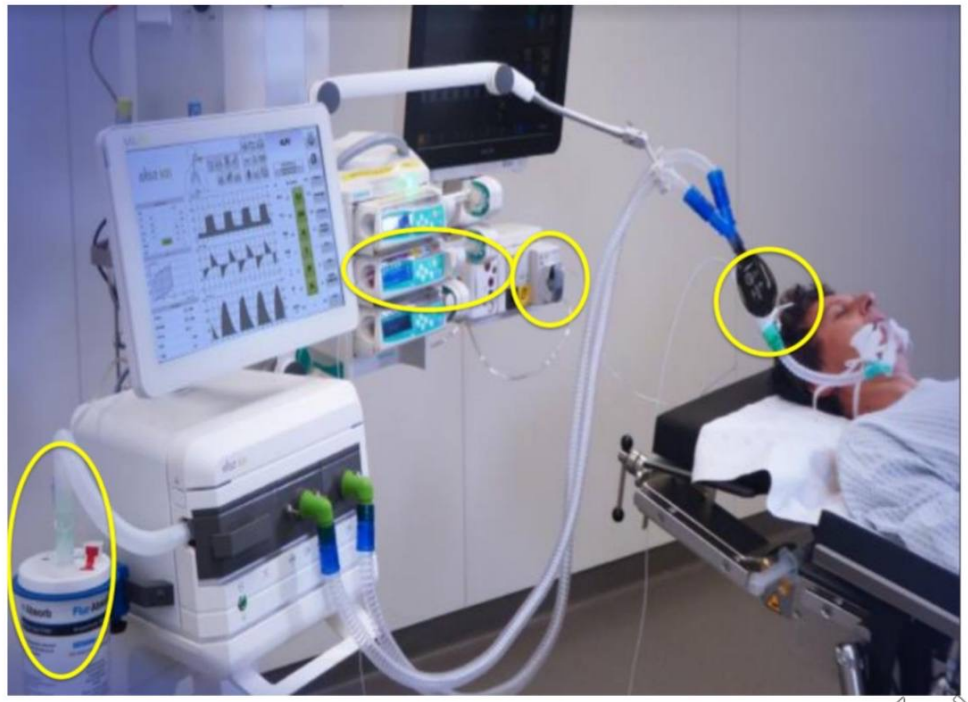
ANACONDA

- Inspiratory flow usually set at 40-60L/min
- Automatic tube compensation is turned off

- Anaconda device is attached between in-line suction and ventilator circuit

- Massimo monitor can be used to measure ETSevo
  - Aiming for 0.5-1.5% on gas monitor
  - Titrate to bronchospasm, dynamic hyperinflation and hemodynamics

- Scavenging/ waste gas disposal must be set up



COMPLICATIONS

- Complications are rare when Pplat is <30cmH2O and auto-PEEP <15cmH2O
- Scenarios that may arise
  - Hypotension
  - Peak pressure alarm
  - Worsening hypoxemia
  - Cardiac arrest
  - Tension pneumothorax

COMPLICATIONS: HYPOTENSION

- Consider **Pneumothorax** first as this requires emergent intervention
- Hypovolemia – give fluids first
- Measure auto-PEEP and Pplat, apply PEEP reduction measures
  - Trial of apnea or hypopnea to decrease intrathoracic pressure
- Evaluate for other causes
  - 4 classes of shock - hypovolemic, distributive, cardiogenic, obstructive

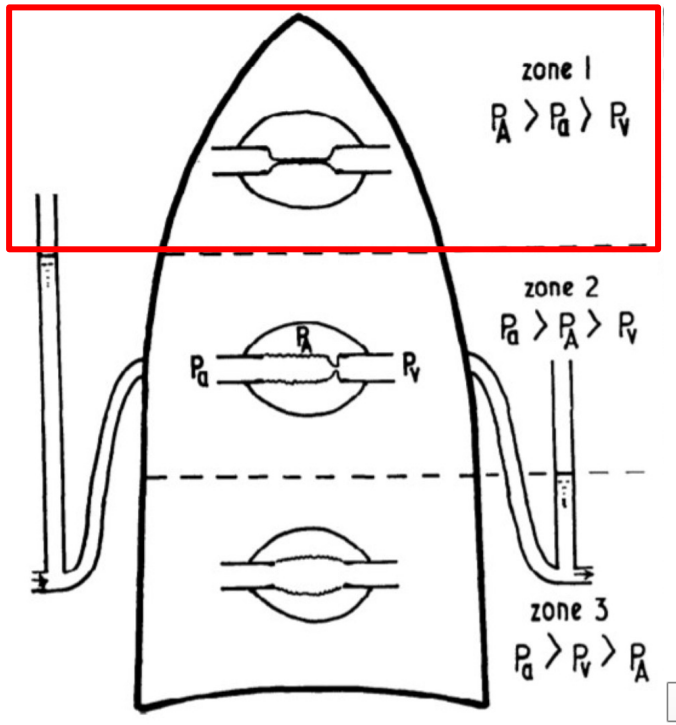
COMPLICATIONS: PEAK PRESSURE ALARM

- Usually when **peak inspiratory pressure exceeds 40 cmH2O**
- Check ventilator circuit and ETT for any kinks
- Attempt to pass in-line suction through and suction to check patency
- Auscultate for unequal breath sounds, wheeze, crepitations
- Differentiate between increased Resistance versus Compliance
- Check plateau pressure
  - If Ppeak - Pplat difference is large (>5 cmH2O) = increased airway resistance
    - ETT obstruction
    - Bronchospasm
    - *Will often need to increase Ppeak alarm limit if main problem is thought to be increased resistance in status asthmaticus*
  - If Ppeak - Pplat is small = decreased lung compliance
    - **Lung collapse**, **PTX**, pneumonia, ARDs, pulmonary edema, raised IAP

COMPLICATIONS: PEAK PRESSURE ALARM

- If pressures are excessive, may need to disconnect from the ventilator to allow for passive exhalation +/- manual chest compression
- Bagging can be done intermittently
  - PaCO2 will be high due to increased dead space (Zone 1)
  - Avoid the temptation to bag excessively fast and hard

$$V_E = V_A + \uparrow V_D$$

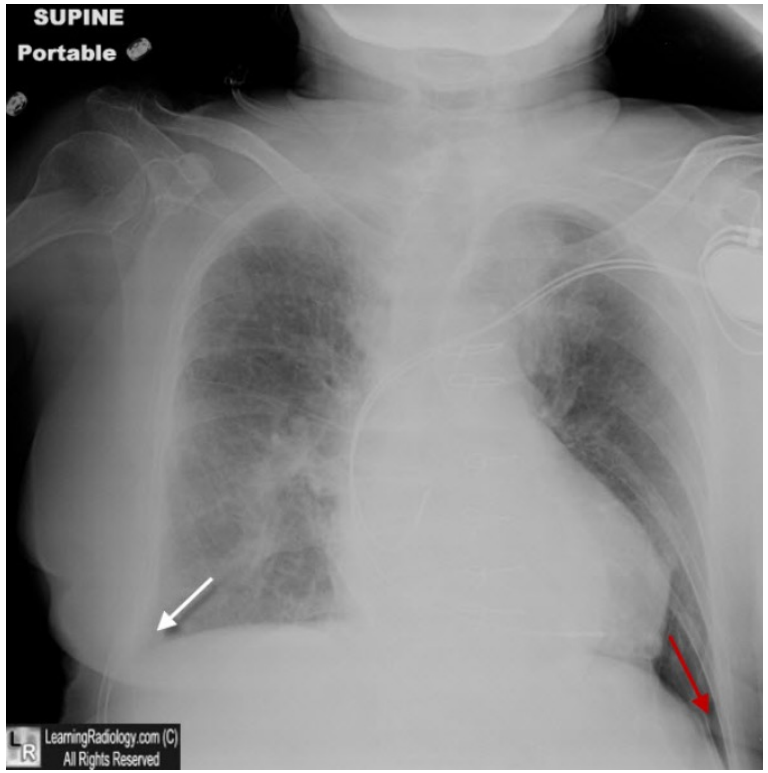


COMPLICATIONS: HYPOXEMIA

- **Pneumothorax**
- **Lung collapse from mucus plugging**
- **Progressive bronchospasm**
- Pneumonia, developing ARDs
- Endotracheal tube displacement/ blockage/ leakage
- Right mainstem intubation
- Aspiration
- Raised IAP decreasing respiratory system compliance

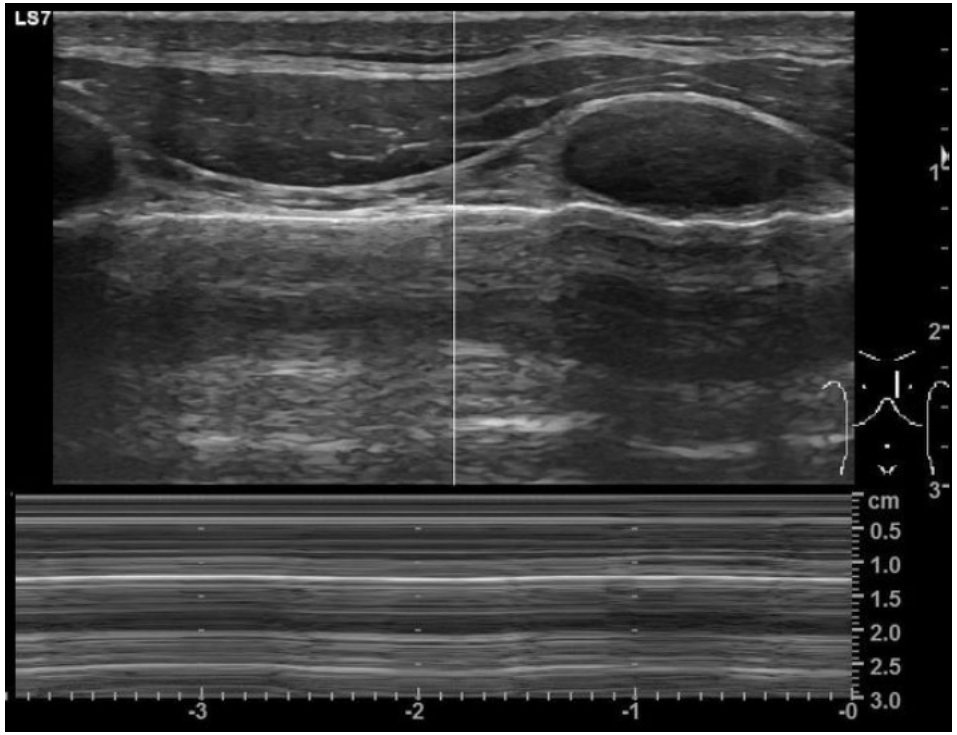
COMPLICATIONS: PNEUMOTHORAX

- Pneumothorax may not be apparent in a patient who is mechanically ventilated and supine
- Deep sulcus sign (red arrow)
- Management
  - Needle decompression in 2nd intercostal space if tension pneumothorax
  - Large bore chest tube insertion (24-28Fr)



COMPLICATIONS: PNEUMOTHORAX

- Ultrasound
  - Lung point
  - Absence of lung pulse
  - Stratosphere sign



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COMPLICATIONS: CARDIAC ARREST

Causes

- Critical lung hyperinflation
  - Decreased preload to RV
  - Increased pericardial pressure causing tamponade physiology
  - Increasing total pulmonary vascular resistance and RV strain
- Tension pneumothorax
- Trial of apnea or hypopnea for no more than 30-60 seconds or circuit disconnection + external chest compressions, volume challenge and adrenaline
- Other 5Hs and 5Ts

WEANING: PEEP SELECTION

- Waterfall theory
- Top of the waterfall = intrinsic PEEP
- Bottom of waterfall = external PEEP
- If extrinsic PEEP < iPEEP, extrinsic PEEP will not worsen iPEEP

- Set extrinsic PEEP to 70-80% of iPEEP

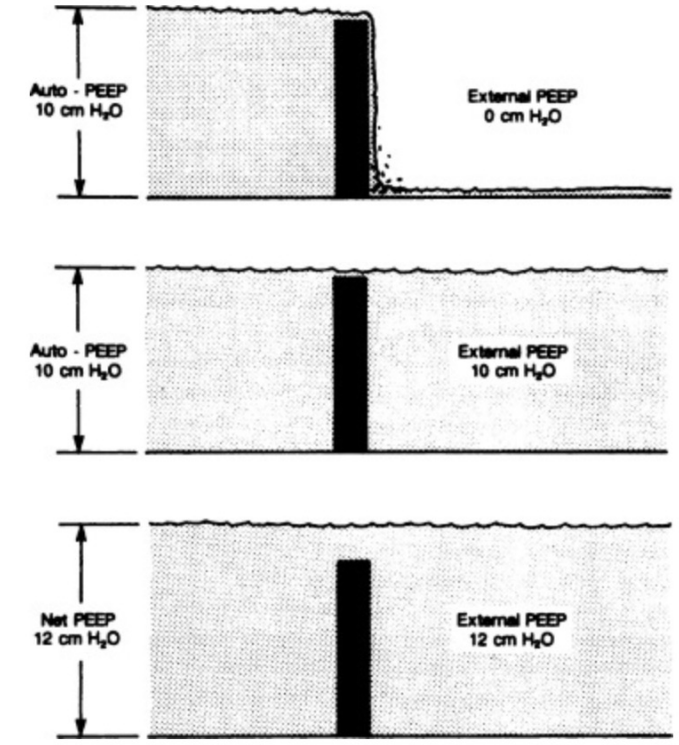
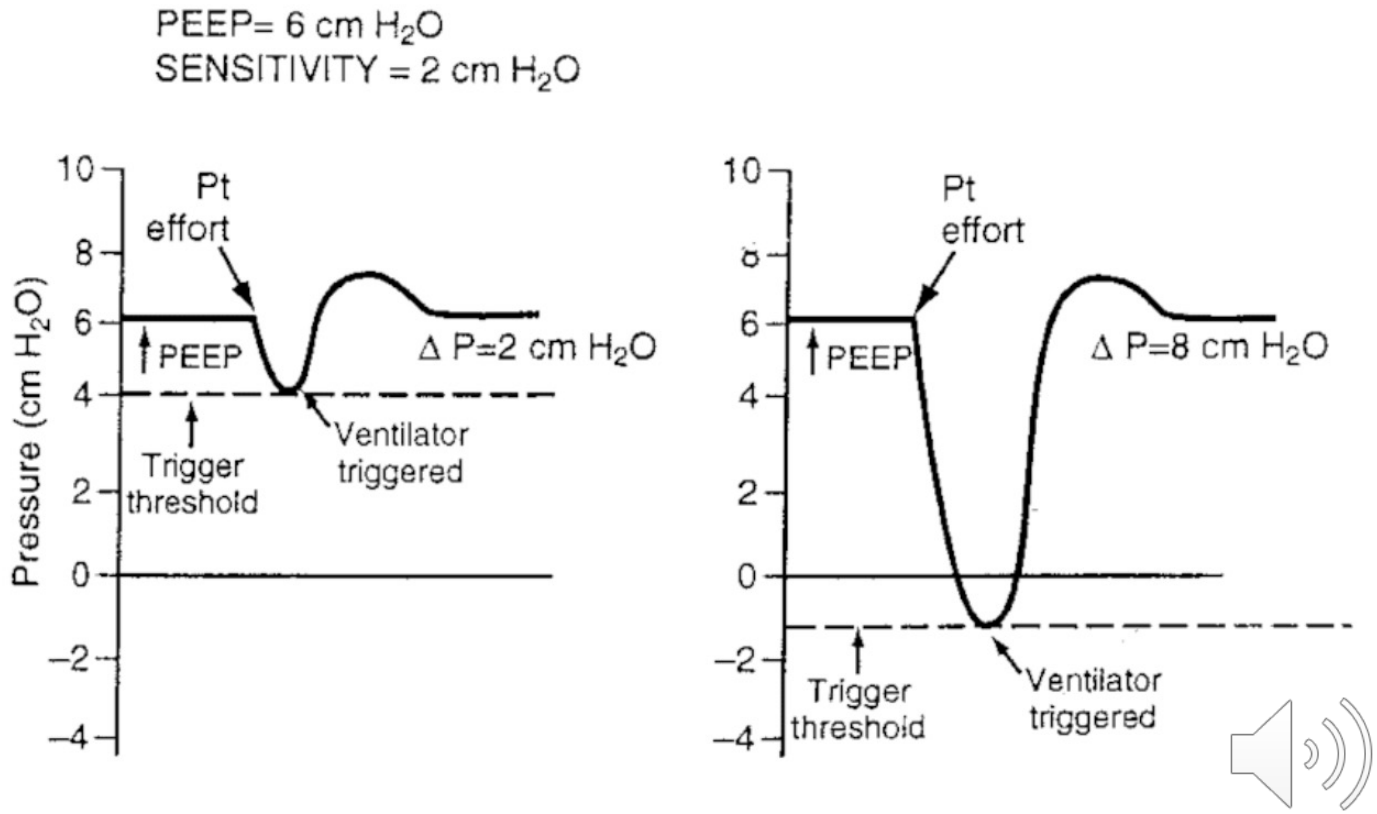


Figure 1 The analogy of a waterfall over a dam (indicated by the solid bloc

Chest. 1989 Sep;96(3):449-51.

WEANING: PEEP SELECTION

- Reduces work of breathing
- Reduces the pressure gradient needed to trigger a breath
- Only applies to spontaneously breathing patients



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