

Auto-PEEP- How to recognize and treat during anesthesia/surgery

Dr. Venugopal Reddy. MD, EDIC, FCARCSI

Associate Professor of anesthesiology and CCM

Divisional Director of CCM and Director of surgical ICU

Department of Anesthesia and CCM

Penn State Medical College

Pennsylvania, Hershey, U.S.A

History

- A 55-year old smoker and a known case of COPD was brought to emergency room with history of severe abdominal pain
- **Past History:** Known smoker for the last 25 years smokes 1-2 packs per day

Medical: H/O hypertension, acid reflux

Medication: Fluticasone, Salbutamol, Ipratropium, Metoprolol, PPI and antacids

Case Report of COPD Continued

Respiratory: Prolonged expiratory phase, fine rhonchi

CVS: HR =128/min, BP 134/68 mm Hg, RRR, Loud P2

CT abdomen: free air under the diaphragm.

Blood Gas Analysis

Normal range

pH	7.25	(7.35-7.45)
PaCO ₂	49 mm Hg	(35-45 mm Hg)
PaO ₂	70 mm Hg	> 90 mm Hg
HCO ₃	32 mmol/L	24-26 mmol/L
BE	- 5.5 mmol/L	0-3 mmol/L
O ₂ Sat	95% on 40% O ₂	Lactate 4.2 mmol/L

Anesthetic management

- General anesthesia with intubation
- Arterial and central venous cannulation
- Fluid: Lactated Ringers
- Mechanical ventilation: Volume Control
 - VT 550 mL, RR = 14/min, I:E ratio = 1: 2.0
 - PAWP 32 cm H₂O, PEEP = 7 cm H₂O
 - FiO₂ = 0.5, O₂ Sat 94%

□ 15 minutes later



Blood pressure (76/44 mmHg)

O₂ saturation (85%)

decrease in the minute volume

- Increase in the airway pressure 39 cm H₂O

□ Alarms ***

- Peak airway pressure
- low minute volume
- Low oxygen saturation
- Low Blood pressure

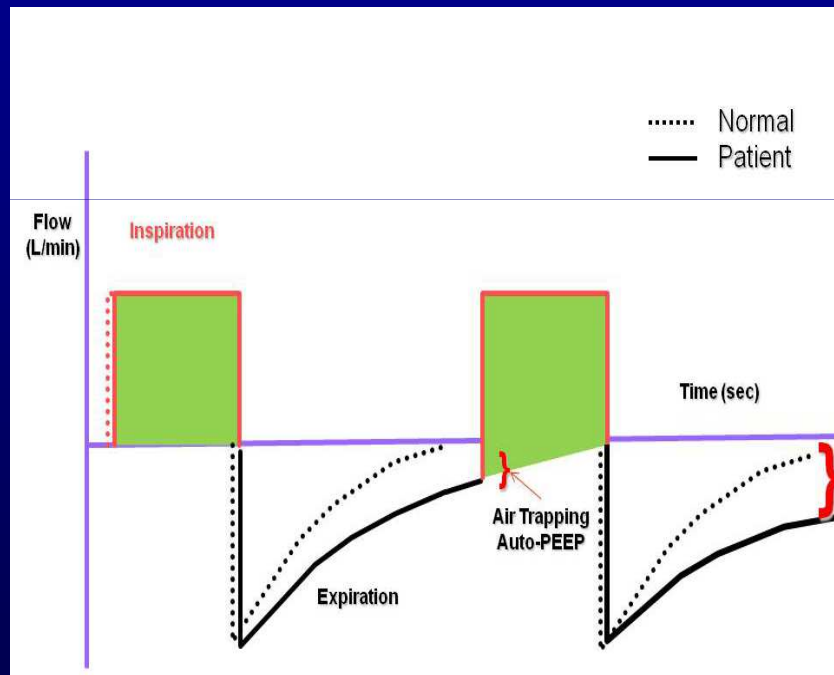
Differential Diagnosis

- Hypotension
- low minute volume
- increased airway pressure?
- Could it be due to one single problem ?

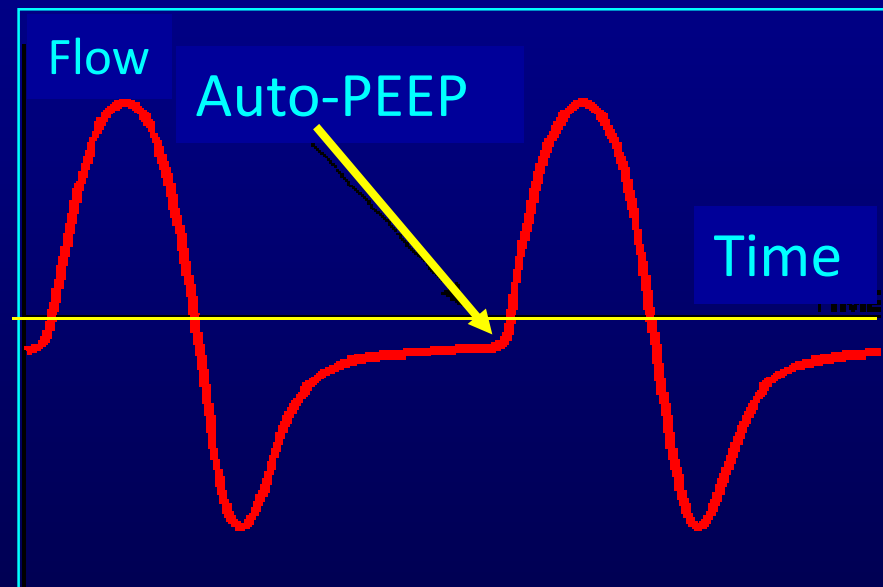
Auto-PEEP ?

Auto-PEEP during ventilation

Volume control mode



Pressure Control Mode



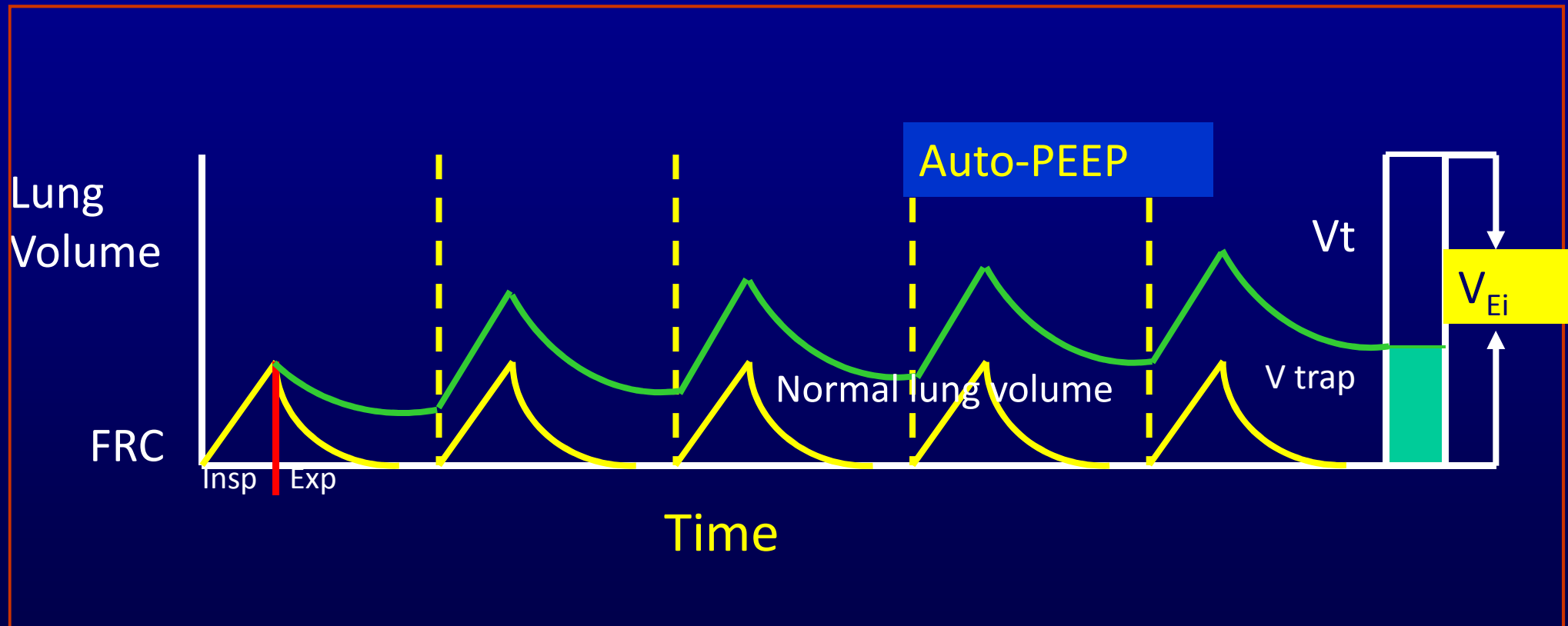
Definition of auto-PEEP

Definition: “Auto-PEEP is defined as the positive alveolar pressure at the end of exhalation during mechanical ventilation”

Auto-PEEP occurs in ventilated patients whenever the inspiratory cycle begins before expiratory flow finishes.

Intrinsic PEEP, dynamic hyperinflation, occult PEEP, endogenous PEEP, or inadvertent PEEP.

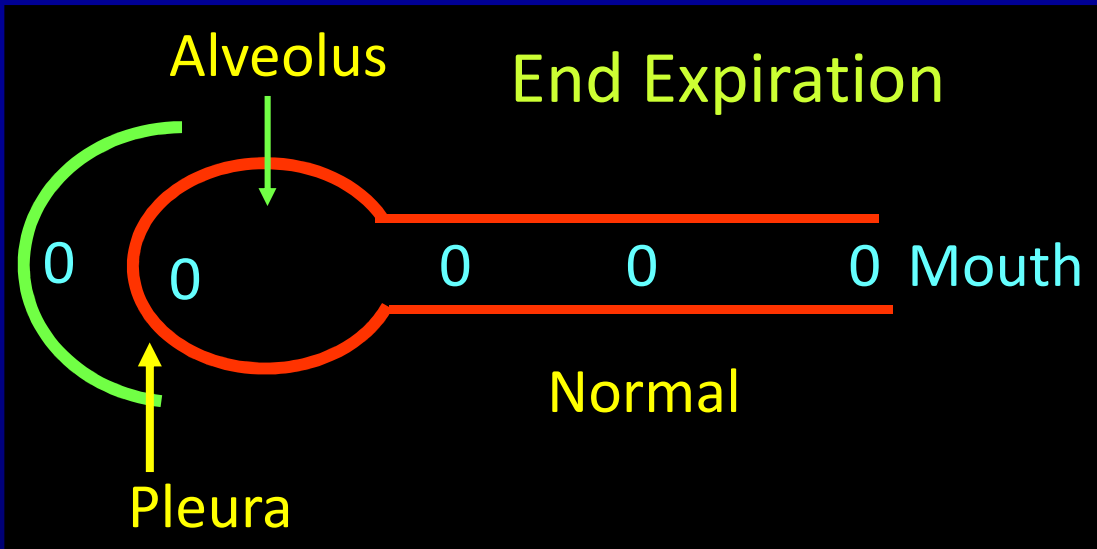
Auto-PEEP during mechanical ventilation



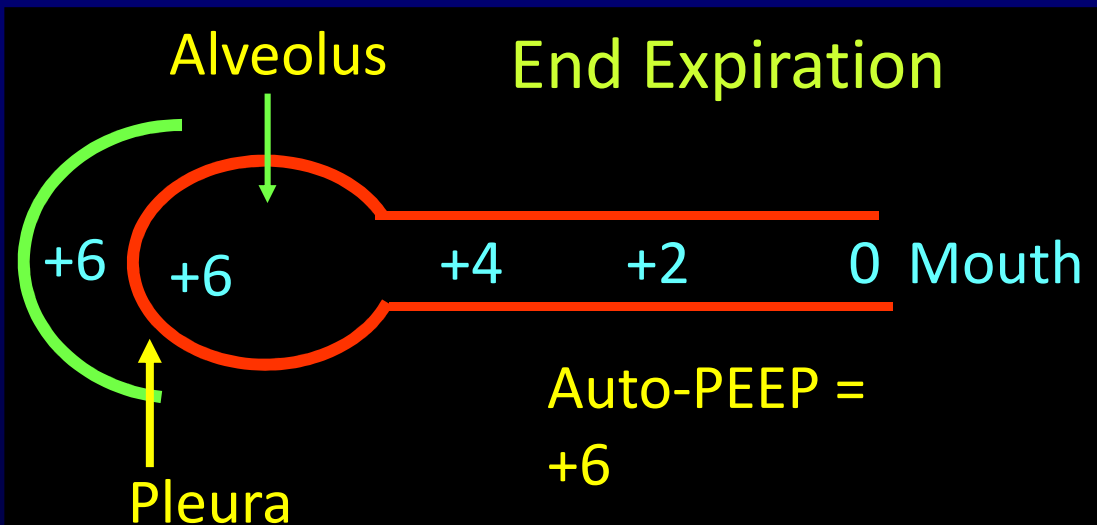
When to expect Auto-PEEP during surgery

- COPD
- Asthma
- Severe bronchospasm
- Inverse ratio ventilation
- ARDS (airway resistance)

Physiology of Auto-PEEP



End-expiration: Normal pressure in pleura, alveoli and airways. During end-expiration there is "no-flow". Pressure in the alveoli = pressure at the mouth



Auto-PEEP = Pleural and alveolar pressures remain +ve at end-expiration compared to mouth pressures. To initiate a breath patient needs to generate pleural pressure of -7 cm H₂O

Ventilatory Effects of auto-PEEP

□ Pressure control mode

- Hypoventilation

➤ Volume control mode

- peak airway pressure

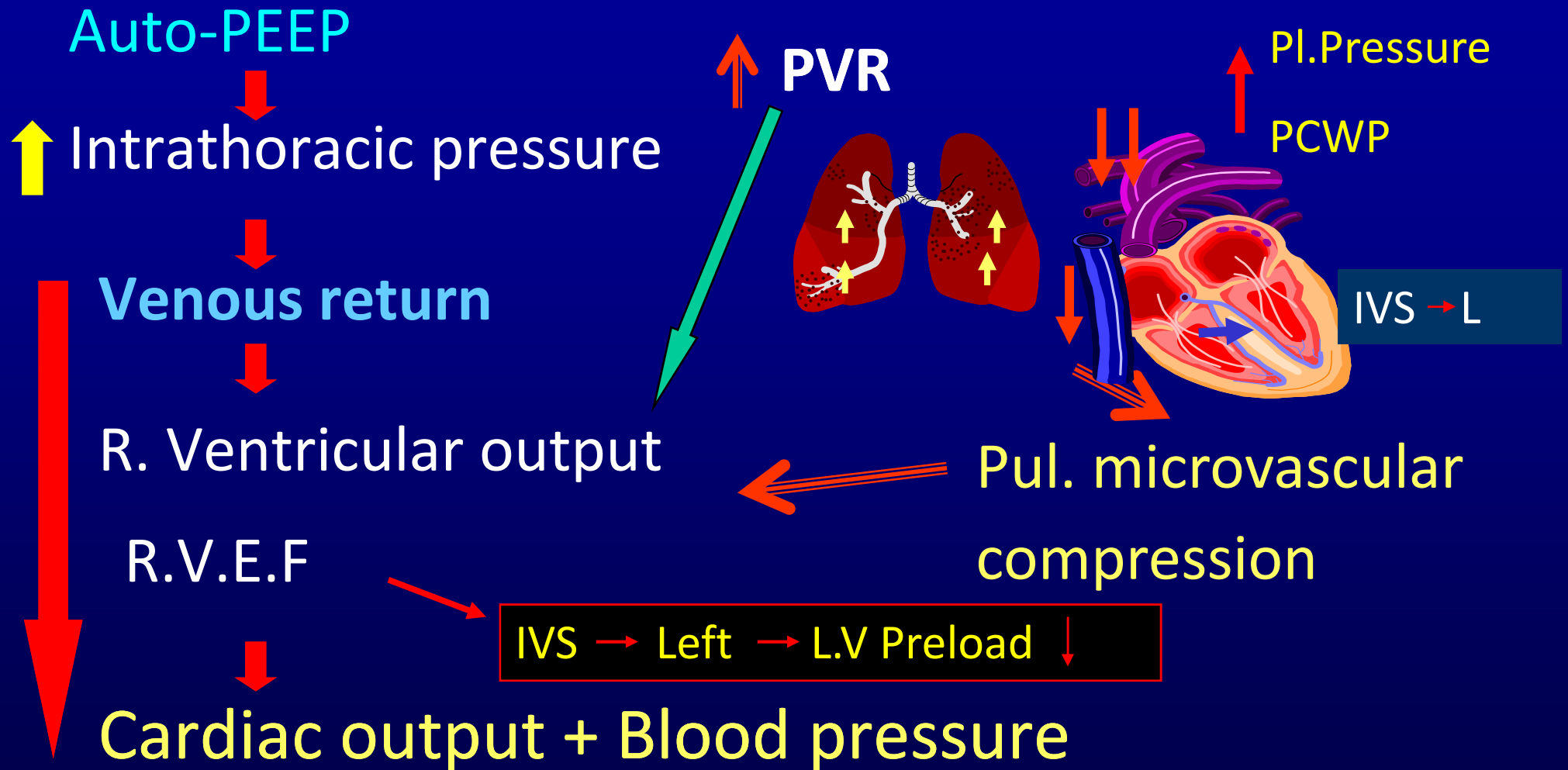
- peak airway pressure

- **Alarm** low tidal volume

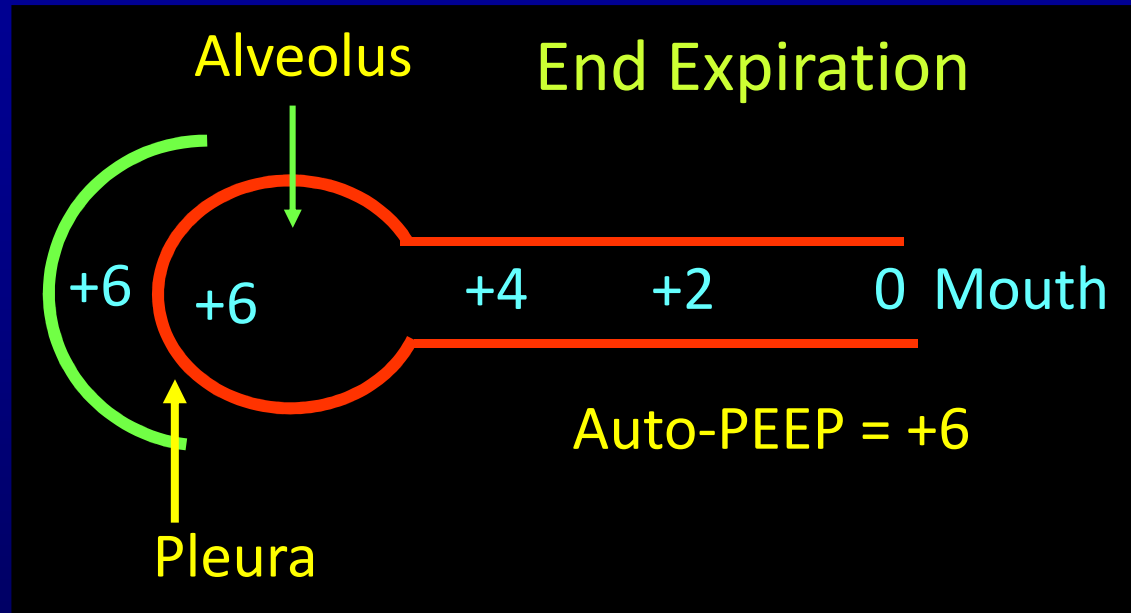
- high PEEP alarm

□ Pulse oximetry: low Oxygen saturation

Effect of Auto-PEEP on heart



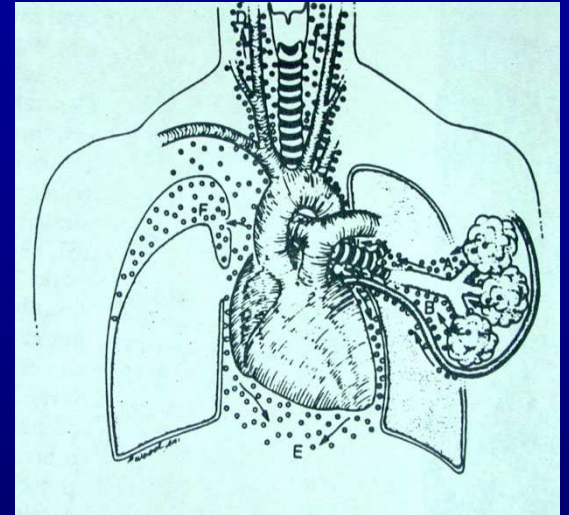
Factors that determine Auto-PEEP



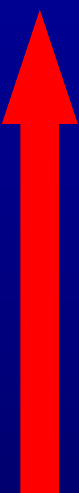
- ✓ Tidal volume (V_T)
- ✓ Time available for expiration (t_e)
- ✓ Severity of airflow obstruction

Adverse effects of Auto-PEEP

- 1) Increased work of breathing.
- 2) Difficulty in triggering the ventilator
- 3) Increase dead space
- 4) Respiratory muscle weakness.
- 5) **Barotrauma**: Pneumothorax, pneumomediastinum, Pneumopericardium, Surgical Emphysema
- 6) Hypotension: VC and PC ventilations
- 7) Hypoventilation: PC ventilation
- 8) Inaccuracies in C.V parameters (CO, PAP)



Recognition of Auto-PEEP

1. patient effort
 2. peak airway pressure (VC mode)
 3. plateau pressure
 4. chest wall girth
 5. Reduction in V_T during PC ventilation
 6. Failure of Ppeak to change with the application of PEEP_e
 7. X-ray chest : hyperinflation
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Measurement of Auto-PEEP

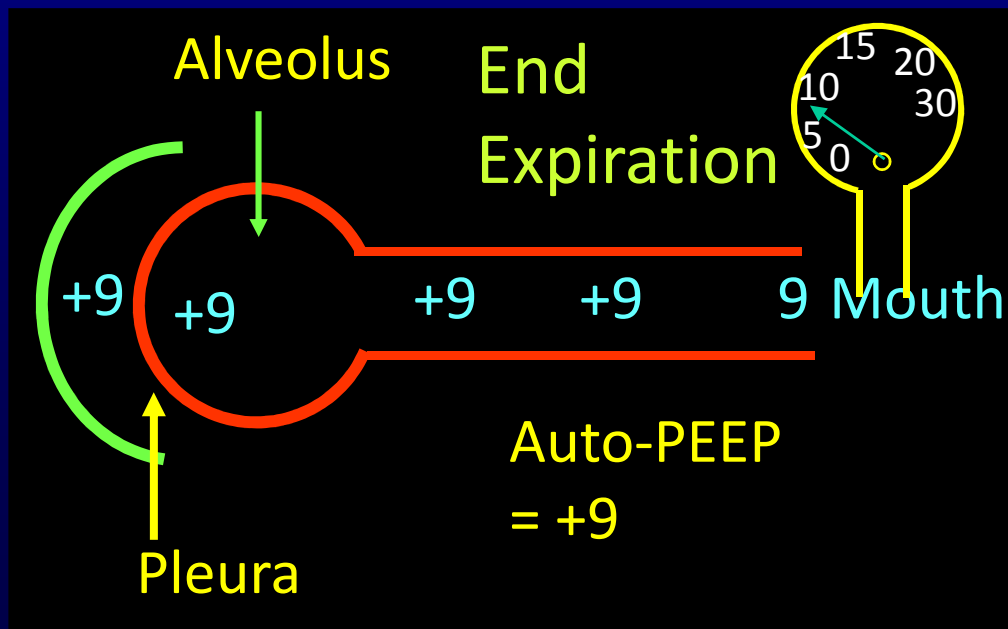
- ❑ Spontaneous breathing: Difficulty in measuring Auto-PEEP, since patient actively uses abdominal expiratory muscles

- ❑ At the end of expiratory pause
 - Pharmacological paralysis +
 - A period of apnoea (40-60 sec)

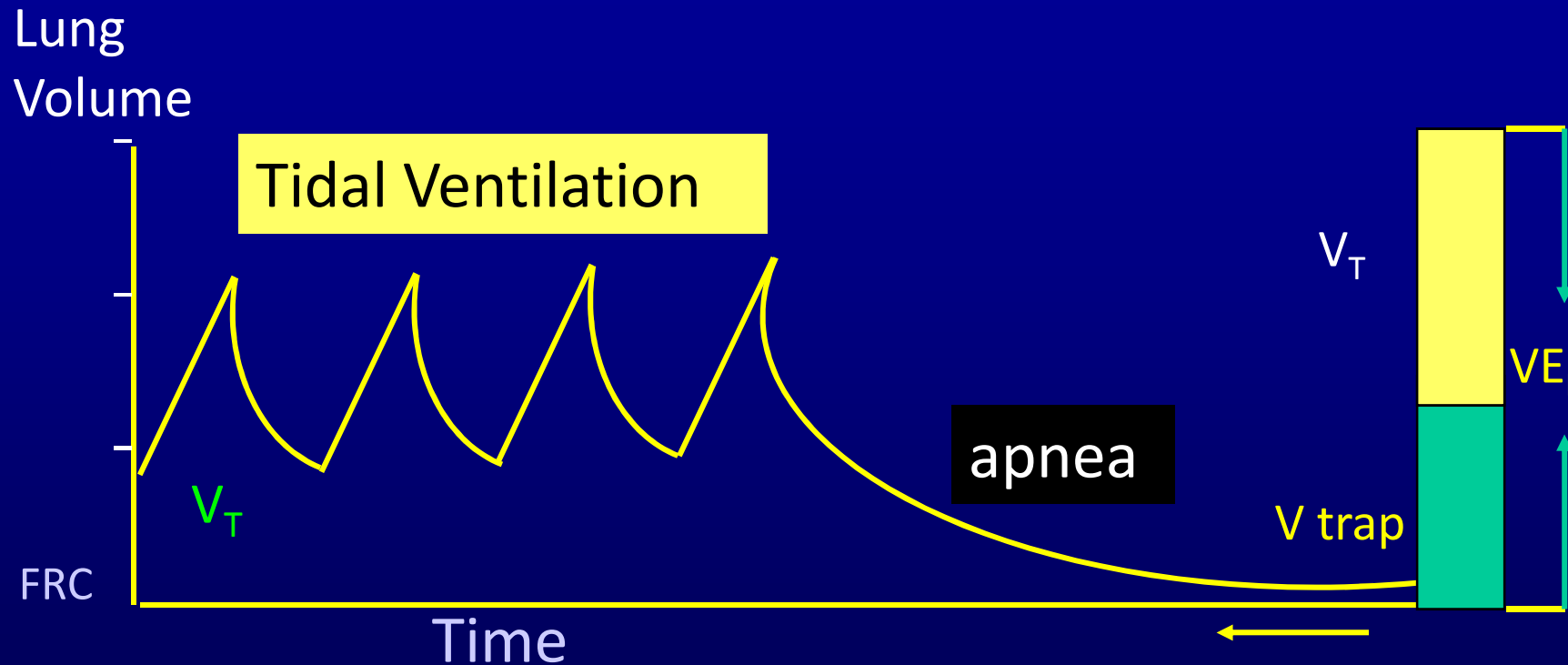
- ❑ Oesophageal balloon technique

Measurement of Auto-PEEP

- ❑ Manual end-expiratory occlusion pressure
- ❑ Activating an end-expiratory pause button.
- ❑ Occlusion should be sufficiently long



Measurement of Auto-PEEP and End expired lung volume



Apnea should be long enough for all the expiratory gas flow to cease

Measurement of Auto-PEEP

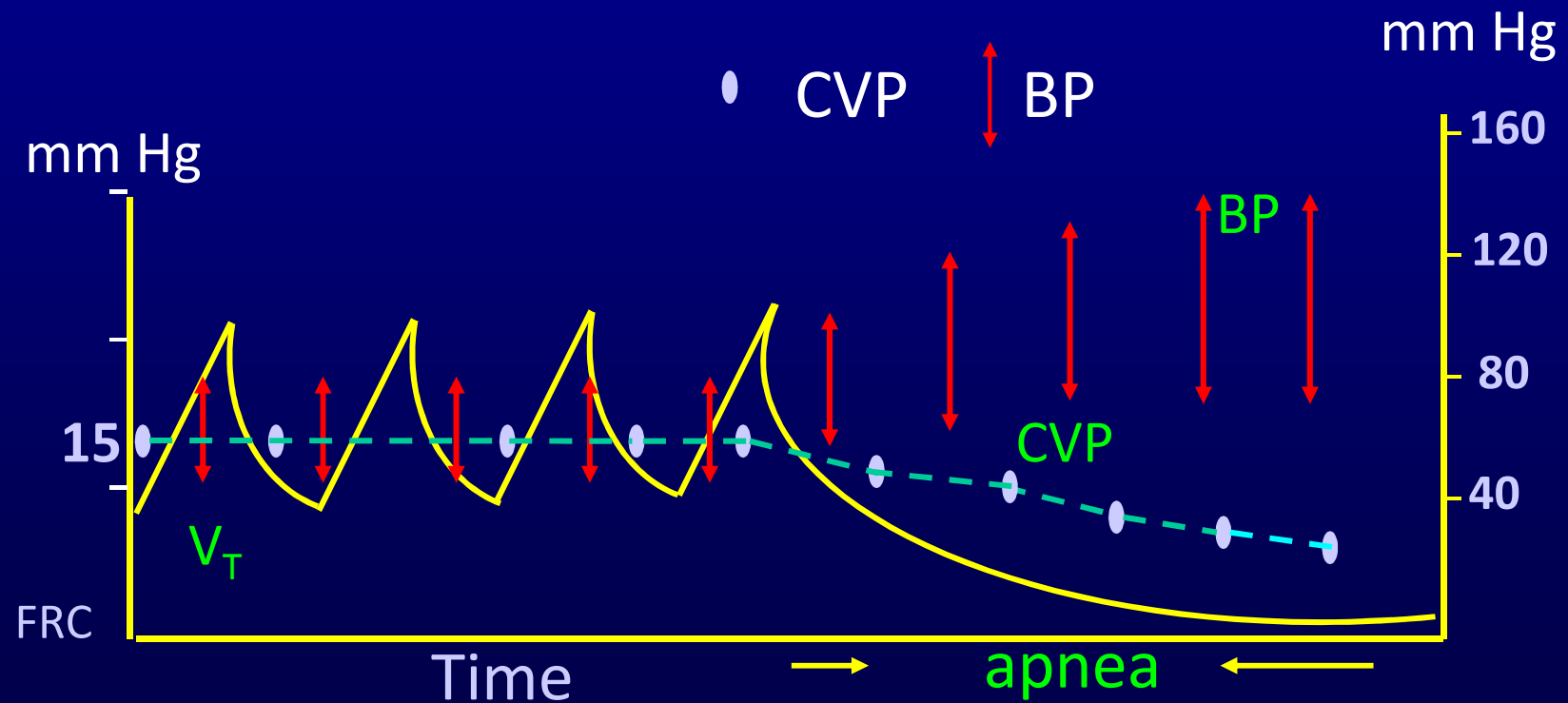
□ Oesophageal balloon technique



Graph of flows and pressures. **V** = flow; **V_T** = tidal volume; **PAW** = airway pressure; and **PES** = oesophageal (pleural) pressure. With **auto-PEEP**, the patient must generate pleural pressures to initiate inspiration. Here, the pleural pressure (as measured by oesophageal pressure) must be -15 cm water (arrow) before inspiratory airflow begins.

Auto-PEEP and hypotension

apnea test to diagnose hypotension secondary to Auto-PEEP



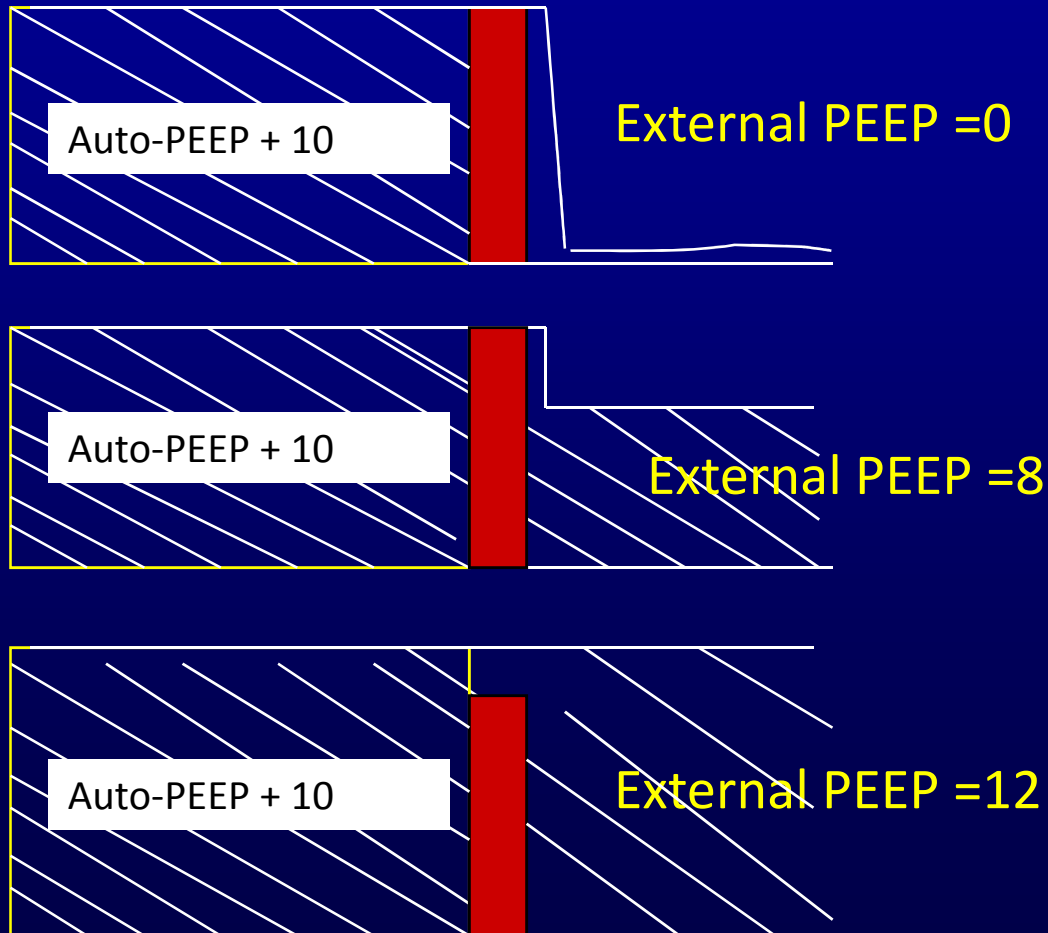
Strategies to minimize auto-PEEP

1. Provide external PEEP during spontaneous breathing
2. Increase the time for expiration
3. Decrease expiratory flow resistance
4. Decrease CO₂ production
5. Avoid excessive “manual bagging”

External PEEP during spontaneous breathing

Tobin: PEEP, auto-peep, and waterfalls.

Chest 1989; 96:449-51



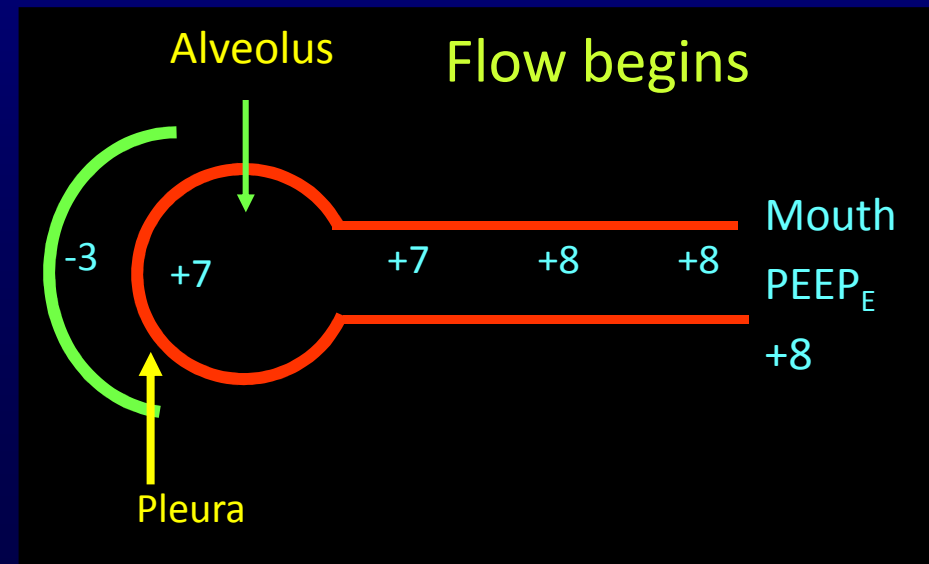
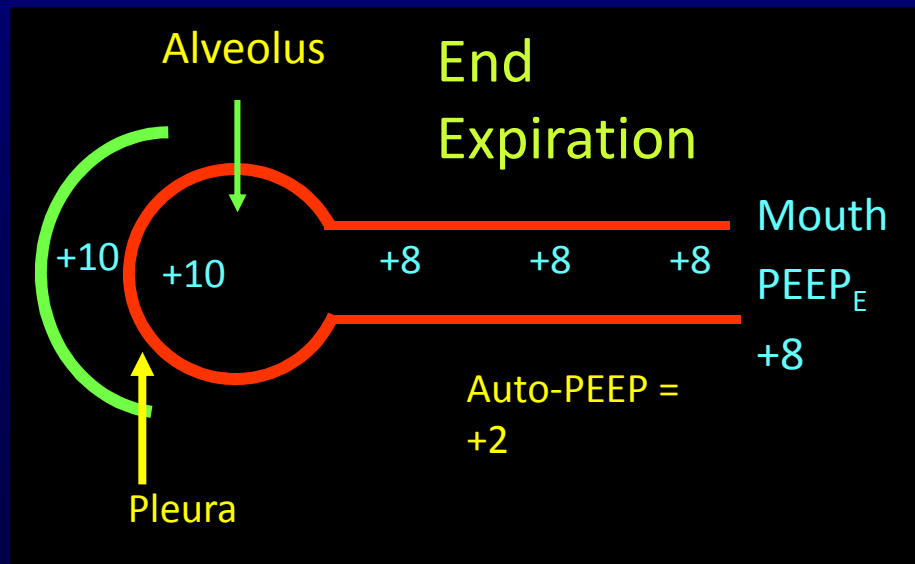
Strategies to minimize auto-PEEP

End expiration alveolar pressure = 10 cm H₂O

Provide external PEEP < or = auto-peep

Applying extrinsic PEEP = 8 cm H₂O

patient generates -2 or -3 cm H₂O to begin inspiration.



Strategies to minimize Auto-PEEP

□ Increase the time for Expiration

Minimize volume of the lung at the end of inspiration (VE_i) above FRC = V_T + trapped gas

- high inspiratory flow rate (V_1)
- decrease inspiratory time
- low V_T
- low respiratory rate

$$TLV_{E1} = V_{E1} + FRC$$

TLV_{E1} = Correlates with hypotension and barotrauma

Any Questions ?