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Mechanical Ventilation

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Indications for Mechanical Ventilation

1 – airway instability

2 – primary respiratory failure

Indications

- Airway instability necessitating endotracheal intubation
  - Operation
  - Brain trauma
  - Intoxication
- Primary respiratory failure
  - acute respiratory distress syndrome (ARDS)
  - Trauma
  - cardiogenic pulmonary edema
  - exacerbation of chronic obstructive pulmonary disease (COPD)

Ventilator Mode Phase Variables

1. Trigger
2. Limit
3. Cycle

a) When is inspiration ended
b) When is inspiration started
c) What parameter can not be exceeded

Trigger

- Pressure, volume, flow or time when inspiration is started

Cycle

- Pressure, volume, flow or time when inspiration is ended

Limit

- A maximum pressure, volume or flow which will not be exceeded during inspiration and is different from the cycle variable
- Therefore, cannot be time limited because time would be the cycle variable

Some more definitions

- Mandatory – the ventilator determines either the start or end of inspiration

- Spontaneous – the patient determines both the start and end of inspiration

So what confuses you about mechanical ventilation?

Which Ventilator Mode am I describing?

Part 1

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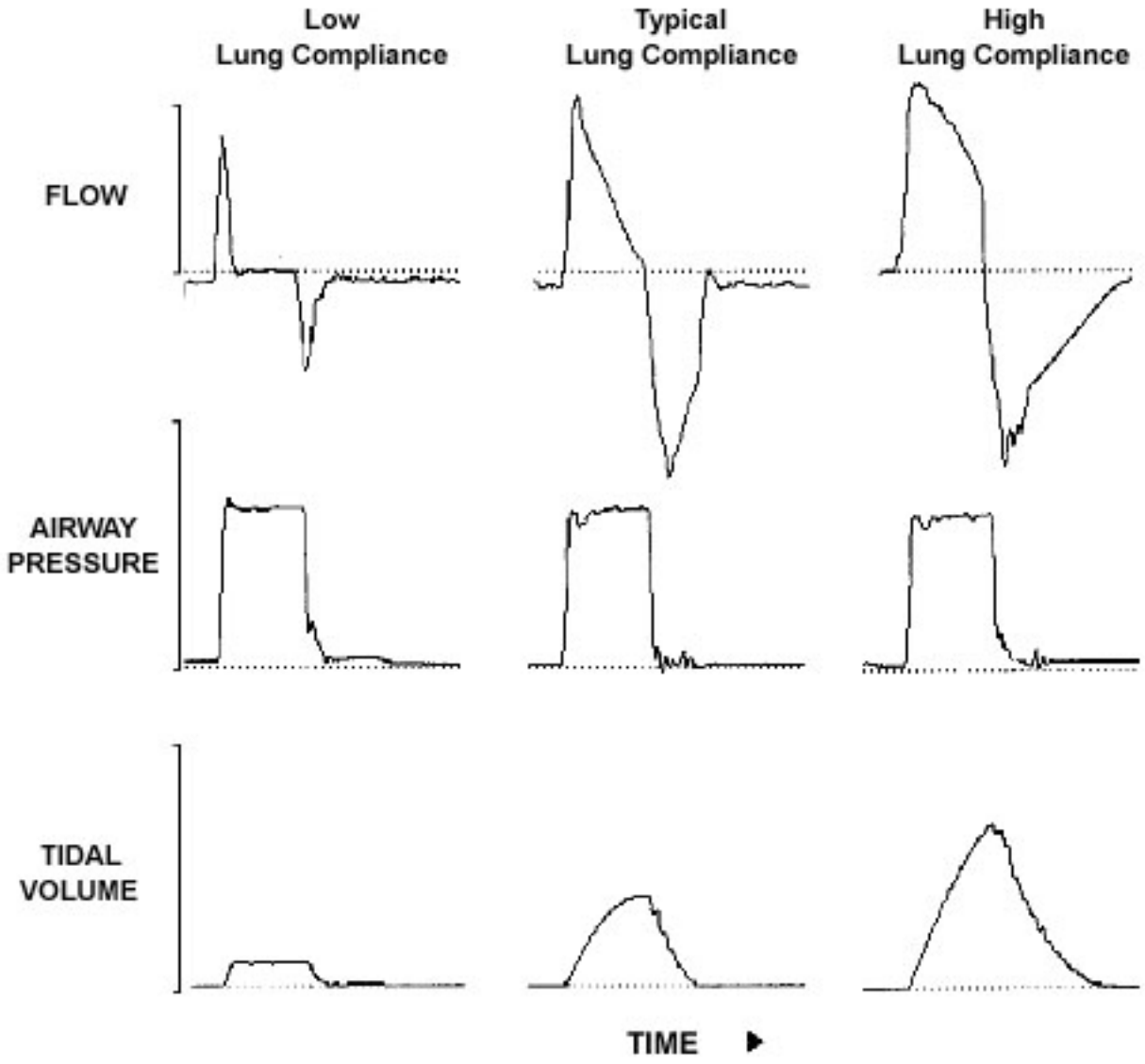
Here are you choices

- Assist/Control (A/C)
- Controlled Ventilation / Controlled Mechanical Ventilation (CMV)
- Volume Assist/Control
- Volume Control / Volume Controlled Ventilation
- Volume Control Controlled Mechanical Ventilation
- Volume Limited Ventilation
- Volume Targeted Ventilation
- Synchronized Intermittent Mandatory Ventilation (SIMV)
- Pressure Assist/Control
- Pressure Control / Pressure Controlled Ventilation
- Pressure Control Controlled Mechanical Ventilation
- Pressure Limited Ventilation
- Pressure Targeted Ventilation
- Spont / Spontaneous
- Pressure Regulated Volume Control (PRVC)
- Mandatory Minute Ventilation (MMV)

Controlled Mechanical Ventilation (Volume Controlled)

- A mandatory mode in which the ventilator delivers a set volume at a set frequency

- Elevated pressure can cause barotrauma
  - Pneumothorax
  - Subcutaneous emphysema
  - Pneumomediastinum
  - Pneumoperitoneum



Pressure Controlled Ventilation

- An mandatory mode in which the ventilator delivers a set pressure for a set time

- Volume depends on airway resistance and lung compliance
  - Hypoventilation
  - Hyperventilation
  - Volutrauma

Compliance of the lung is defined as?

a) pressure differential required for a unit flow change
b) pulmonary volume per unit air flow
c) elastic recoil of the lung
d) volume produced by a unit pressure change
e) change in airway pressure during forced vital capacity

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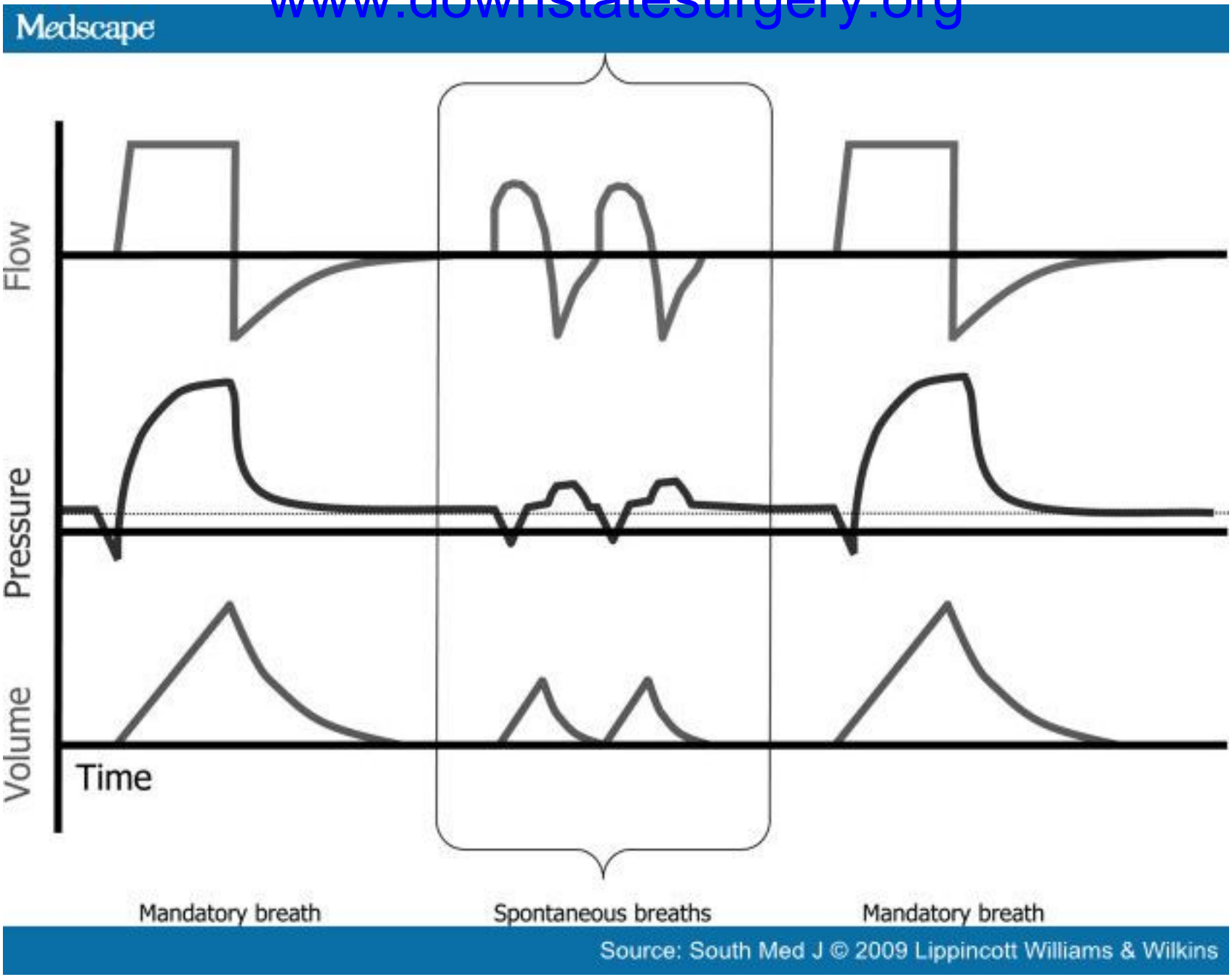
Which Ventilator Mode am I describing?

Part 2

Here are your STANDARDIZED choices

- Volume Controlled Continuous Mandatory Ventilation (VC-CMV)
- Volume Controlled Intermittent Mandatory Ventilation (VC-IMV)
- Pressure Controlled Continuous Mandatory Ventilation (PC-CMV)
- Pressure Controlled Intermittent Mandatory Ventilation (PC-CMV)
- Continuous Spontaneous Ventilation (CSV)



- A composite mode in which the ventilator delivers a set volume at a set frequency and allows the patient to take additional spontaneous breaths

Volume Controlled Intermittent Mandatory Ventilation (VC-IMV) AKA: IMV or SIMV

- A composite mode in which the ventilator delivers a set volume at a set frequency and allows the patient to take additional spontaneous breaths

- A spontaneous mode in which the patient triggers and cycles every breath and the ventilator only controls the pressure during the breath

Continuous Spontaneous Ventilation (CSV) AKA: Pressure Support

- A spontaneous mode in which the patient triggers and cycles every breath and the ventilator only controls the pressure during the breath

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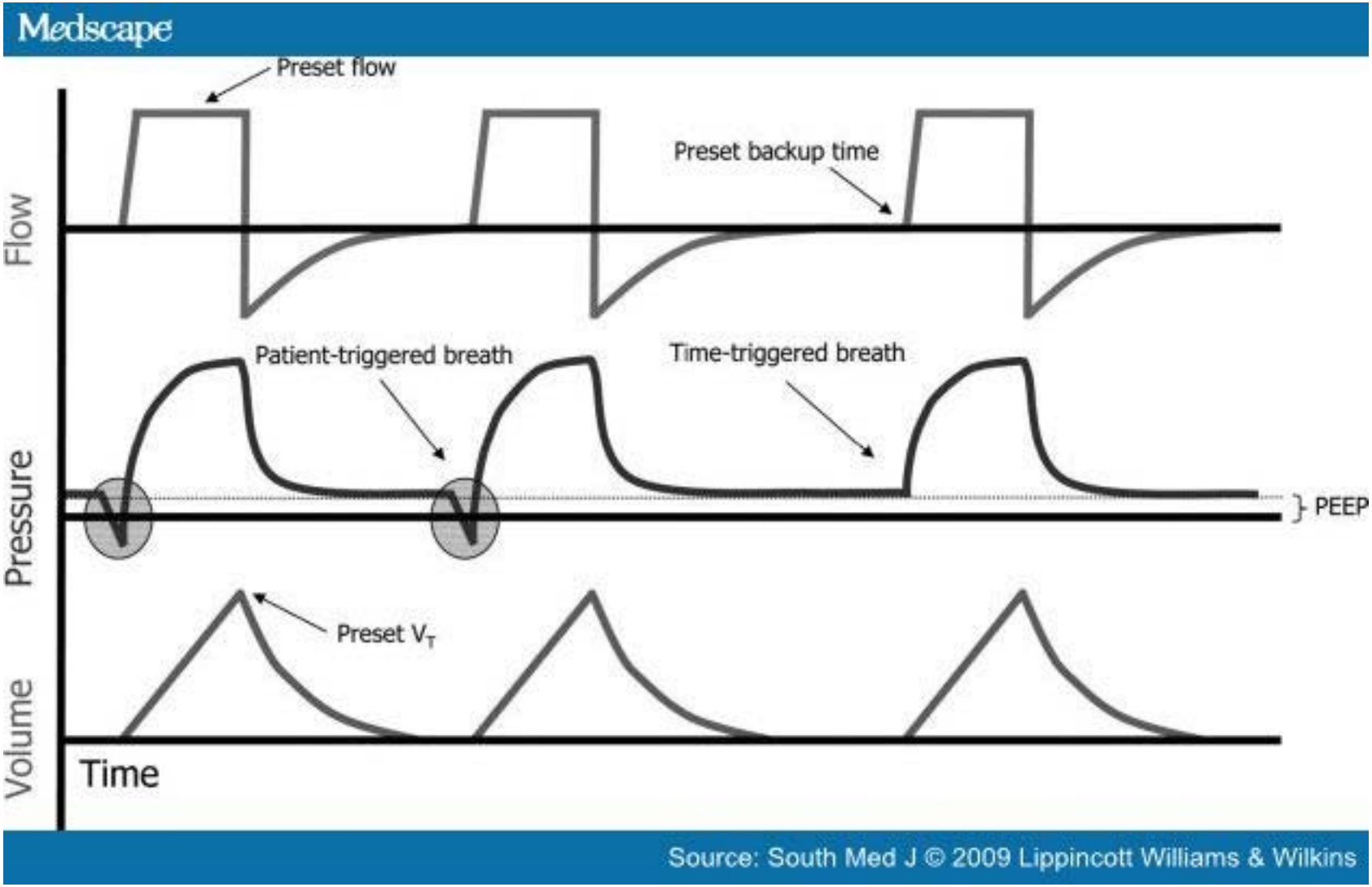

- A mode in which the ventilator delivers a set volume at a minimum set frequency (it allows the patient to initiate additional mandatory breaths of the set volume)

Volume Controlled Continuous Mandatory Ventilation (VC-CMV) AKA: Assist Control (AC)

- A mode in which the ventilator delivers a set volume at a minimum set frequency (it allows the patient to initiate additional mandatory breaths of the set volume)

- Can lead to hyperventilation

Other Modes

- Mandatory minute ventilation (MMV)
- Pressure regulated volume control (PRVC)

- Continuous positive airway pressure (CPAP)
- Bilevel positive airway pressure (BPAP)
- Airway pressure release ventilation (APRV)

- High Frequency Ventilation (HFV)

What is PEEP?

What is PEEP?

- Positive End Expiratory Pressure
- A pressure that is maintained in the airway during expiration

Benefits of PEEP?

Benefits of PEEP?

- Helps to prevent atelectasis
- Increases functional residual capacity
- Can prevent air trapping in emphysema if set to the critical closing pressure of bronchioles

Drawbacks of PEEP?

Drawbacks of PEEP?

- Decreases venous return by increasing intrathoracic pressure
- Can impede exhalation and cause air trapping if set above the critical closing pressure of alveoli

What does ventilation refer to?

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- Excreting carbon dioxide

What variables affect ventilation?

a) PEEP
b) Tidal volume
c) Minute ventilation
d) FiO2
e) Respiratory rate

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minute ventilation =

tidal volume x respiratory rate

What variables affect oxygenation?

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b) Tidal volume

c) Minute ventilation

d) FiO2

e) Respiratory rate

V/Q matching allows the optimal diffusion of oxygen between the alveoli and the capillaries

What value measures the efficiency of equilibrium of oxygen between the alveoli and the blood?

a) Rapid shallow breathing index
b) MELD score
c) CHADS score
d) Alveolar-arterial oxygen gradient
e) Body surface index
f) Serum-ascites albumin gradient

Medical Students?

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So who knows how to calculate the A-a gradient?

$$\text{A-a gradient} = PAO_2 - PaO_2$$

$$PAO_2 = [FiO_2 (atm - vapor) - PCO_2 / RQ]$$

atm – atmospheric pressure

vapor – water vapor pressure

RQ – respiratory quotient

Not a mathematician? Too confusing?

- Try the P/F ratio
- PaO2 normally 80-100 mmHg
- FiO2 = 21% on room air

- P/F = 90 / 0.21 = 428

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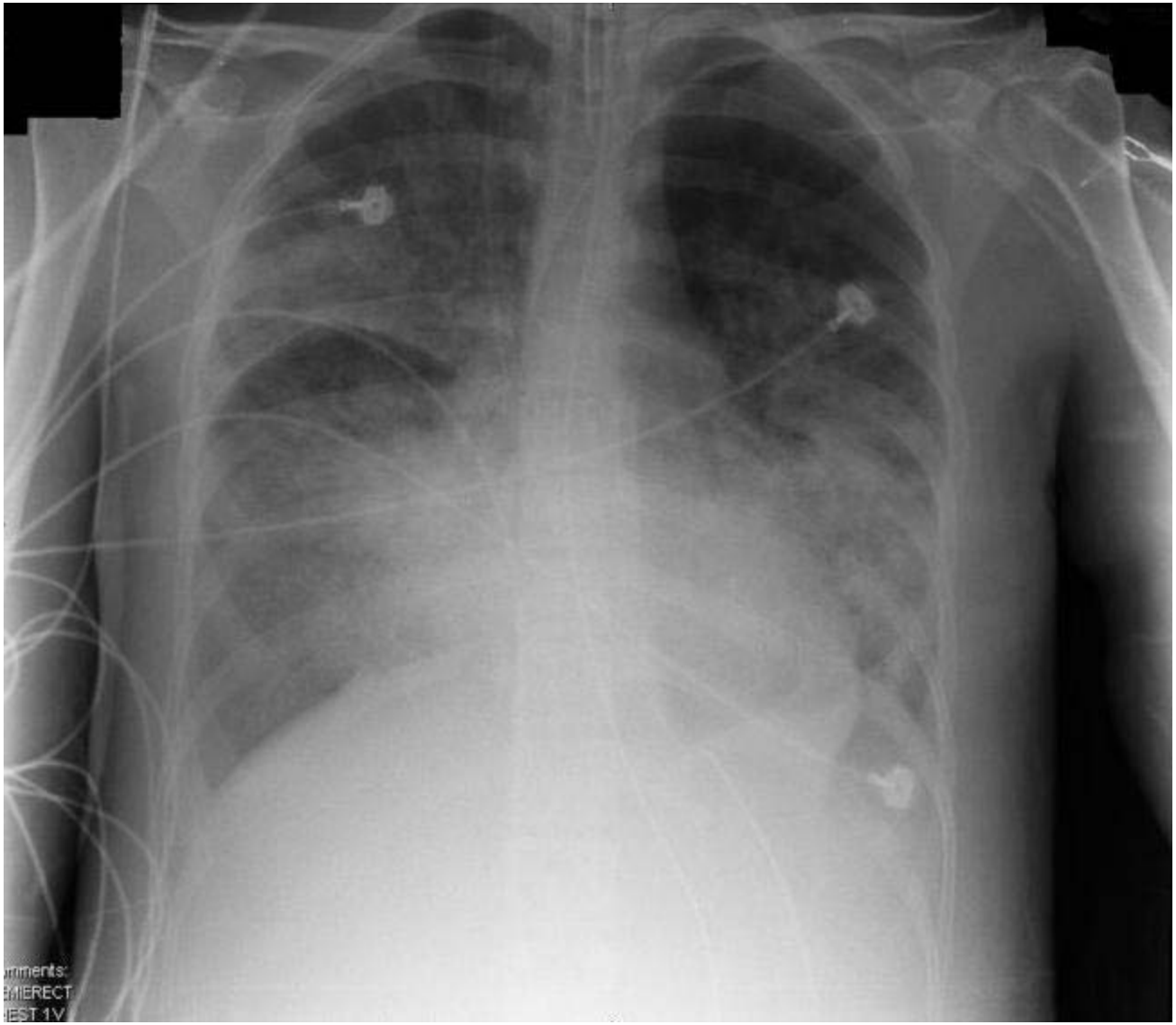
What is ARDS?



What is ARDS?

- P:F ratio < 200
- Acute onset
- Bilateral infiltrates on chest radiograph sparing costophrenic angles
- Pulmonary artery wedge pressure < 18 mmHg OR no clinical evidence of left ventricular failure

And what is ALI?

a) cousin and son-in-law of the Islamic prophet Muhammad
b) 2001 film about Mohammad Ali (boxer)
c) Sacha Baron Cohen (Ali G)
d) A mild case of ARDS with P:F ratio < 300
e) All of the above

Some multiple choice questions

Which of the following is not a criteria for extubation?

a) FiO2 < 50%
b) PEEP < 8 cm H_2O
c) PaO2 > 75 mm Hg
d) Minute ventilation > 15 L/min
e) pH = 7.30 – 7.50

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Other Extubation Criteria?

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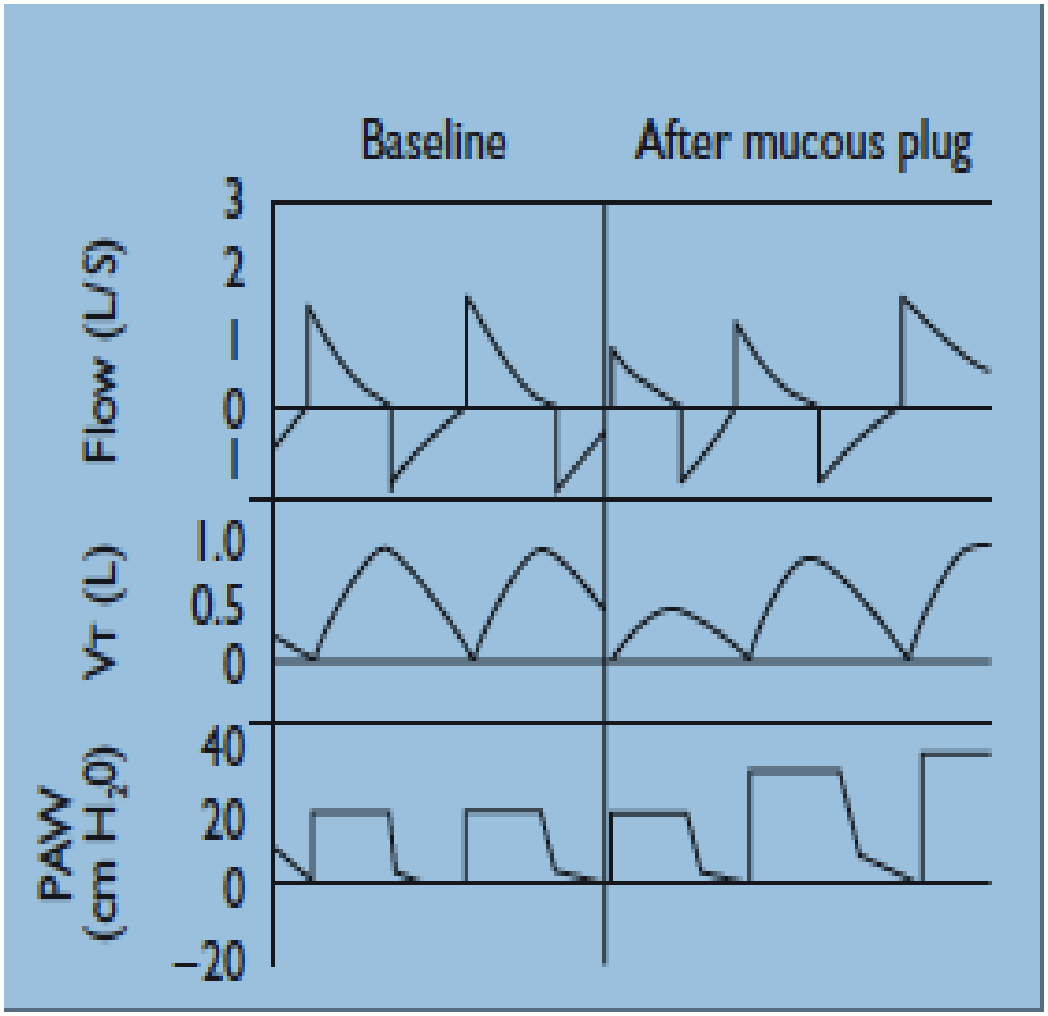
- Respiratory rate < 30 breaths / minute
- Tidal volume > 5 mL / kg
- Negative inspiratory force > 30 cm H20
- Rapid Shallow Breathing Index < 105

- Resolution of the indication for mechanical ventilation

A 35-year-old asthmatic man develops acute respiratory failure requiring mechanical ventilation. A mucous plug develops acutely. Ventilator graphics at baseline and following the mucous plug are shown in the Figure. According to the Figure, what mode of mechanical ventilation is this patient receiving?



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(C) Pressure-support ventilation

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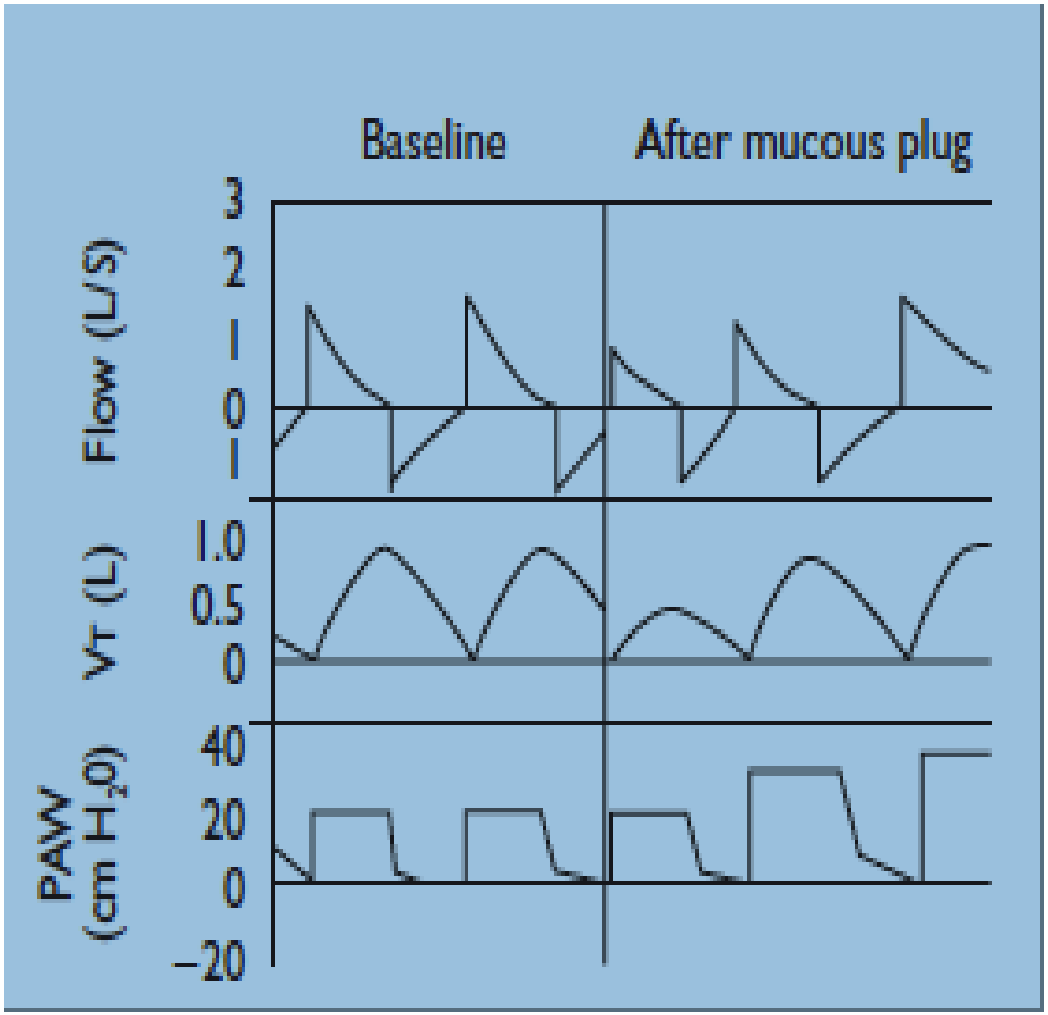

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A 64-year-old man presents to the ED with an exacerbation of COPD.

He is intubated and mechanically ventilated on: assist/control mode; RR, 16 breaths/min; VT, 600 mL; inspiratory flow rate (IFR), 60 L/min; PEEP, 0 cm H_2O; and FiO_2, 40%.

Physical examination reveals: an anxious man in severe respiratory distress; heart rate, 120 bpm; blood pressure, 80/40 mm Hg; RR, 36 breaths/min; and SaO_2, 85%. Cardiac examination is normal; lung examination reveals bilateral expiratory wheezing with equal breath sounds.

PIP is 45 cm H_2O, Pp is 35 cm H_2O, and ventilator graphics show that the expiratory flow waveform does not return to zero before the next ventilator breath is delivered.

Chest radiography reveals hyperinflated lung fields.

Despite intravenous fluids, bronchodilators, and sedation, the patient remains in respiratory distress and is hypoxic and hypotensive.

Which ventilator changes would be most beneficial?

(A) Decrease VT, increase IFR, add PEEP

(B) Increase VT, decrease IFR, add PEEP

(C) Decrease VT, decrease IFR, continue zero PEEP

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A patient is admitted with ARDS sedated and paralyzed on the mechanical ventilator.

The ventilator settings are: pressure control-inverse ratio ventilation mode with an inspiratory pressure of 25 cm H2O; respiratory rate (RR), 15 breaths/min; inspiratory time, 2.5 s; FiO2, 80%; and positive end-expiratory pressure (PEEP), 8 cm H2O.

On these settings, her peak inspiratory pressure (PIP) and plateau pressures (Pp) are 33 cm H2O, and tidal volume (VT) is 350 mL. SaO2 is 92% on pulse oximetry.

Thirty minutes later, she becomes hypotensive, desaturates, and has decreased breath sounds over the left lung. Chest radiography shows a left-sided pneumothorax.

What changes in ventilator parameters do you expect to find at this time?

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(C) PIP, 33 cm H2O; Pp, 33 cm H2O; VT, 200 mL; RR, 15 breaths/min

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