Capnography During Sedation

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New Standards of Monitoring

- American Society of Anesthesiologists (ASA) and the Association of Anaesthestists of Great Britain and Ireland (AAGBI) have revised standards in 2011 to monitor ventilation with capnography for all procedural sedation cases requiring moderate to deep sedation.

Why were they introduced?

- It is difficult to predict how an individual will respond to an administered sedative.
- Incidence of hypoxia is less if capnography was used to monitor ventilation.
- Capnography when used in conjunction with pulse oximetry and visual inspection of chest detected respiratory depression 17 times more often than without capnography.
- Capnography forewarns of impending hypoxia by about 5 to 240 seconds.
- Capnography triggers early intervention and decreases the incidence of oxygen desaturation.
- Administration of supplemental oxygen delays the onset of desaturation following apnea and therefore relying on pulse oximetry alone will delay intervention.

Objectives

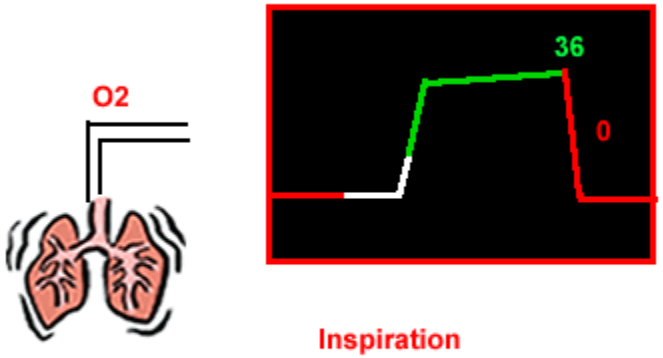
- After reviewing this brief clinical concept, the clinician/nurse will understand the basic physiology of capnography.
- The clinician/nurse will be able to interpret capnography in monitoring ventilation during sedation more effectively and safely

Definitions

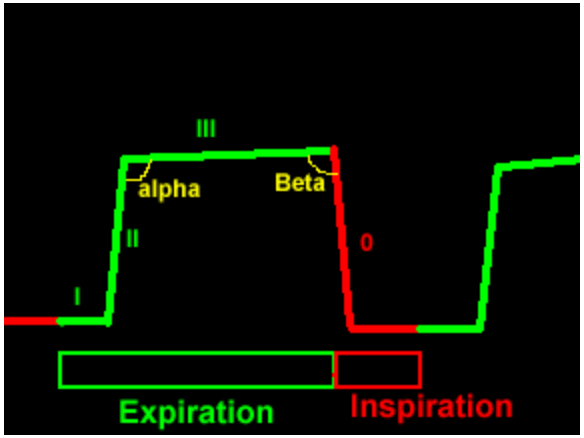
- **$PETCO_2$**: The maximum partial pressure of CO_2 at the end of a breath. It is about 36- 40 mm Hg in healthy adults.
- **$PACO_2$**: Partial pressure of CO_2 in the alveoli.
- **Capnogram**: A plot of PCO_2 versus time (time capnogram), or expired volume (volume capnogram). *Time capnogram* is common in clinical practice

Basic Physiology

- When you inhale CO_2 free air and exhale, and measure partial pressure of CO_2 at the mouth, you get the following trace. Normal values of $PETCO_2$ vary between 35 and 40 mm Hg



Basic Physiology



The expiratory segment is divided into three phases phase I, II, and III

Phase I: Dead space gases

Phase II: Dead space gases mix with alveolar gases resulting in the rise of $PETCO_2$

Phase III: Represent CO_2 evolving from alveoli

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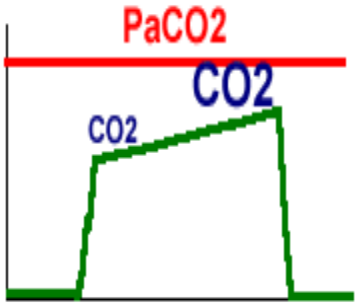
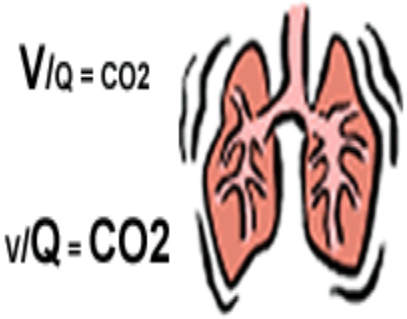
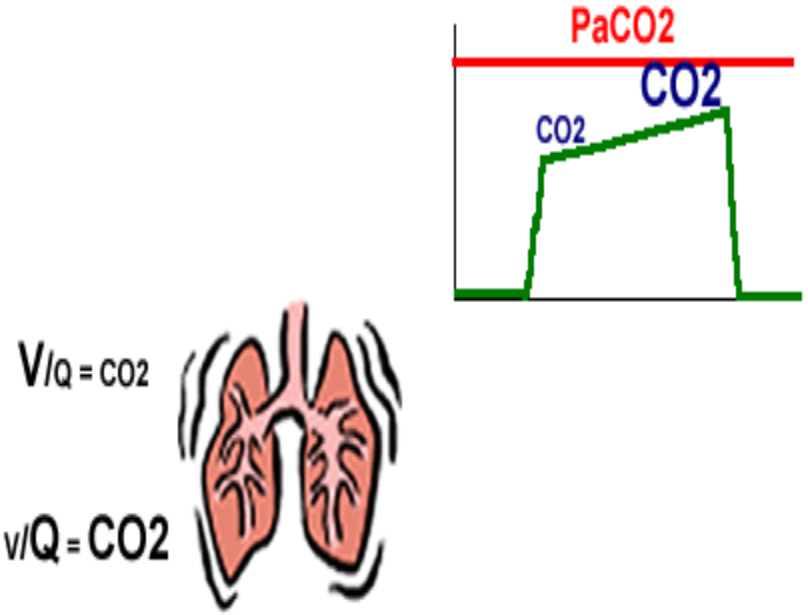
Basic Physiology





The height and slope of the alveolar plateau (phase III) is dependent on the CO_2 content in the alveoli. The CO_2 content is in turn dependent on the V/Q ratio of the alveoli. High V/Q alveoli contain relatively low PCO_2, while low V/Q alveoli contain relatively high PCO_2

Basic Physiology



Hence, it can be concluded that the height and the slope of the alveolar plateau is dependent on ventilation, cardiac output and more importantly on V/Q relationship.

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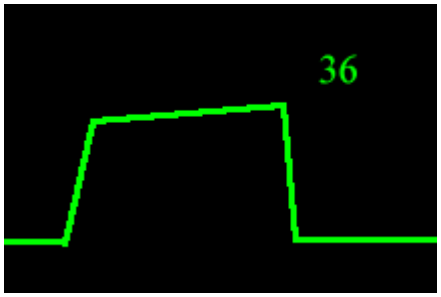

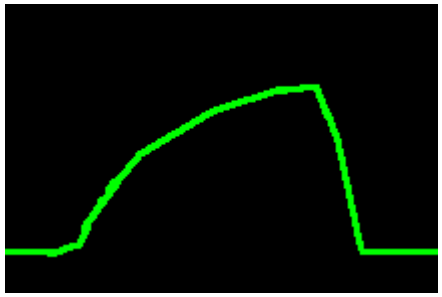

For example in COPD: the V/Q perfusion abnormalities result in a sloping phase II and phase III

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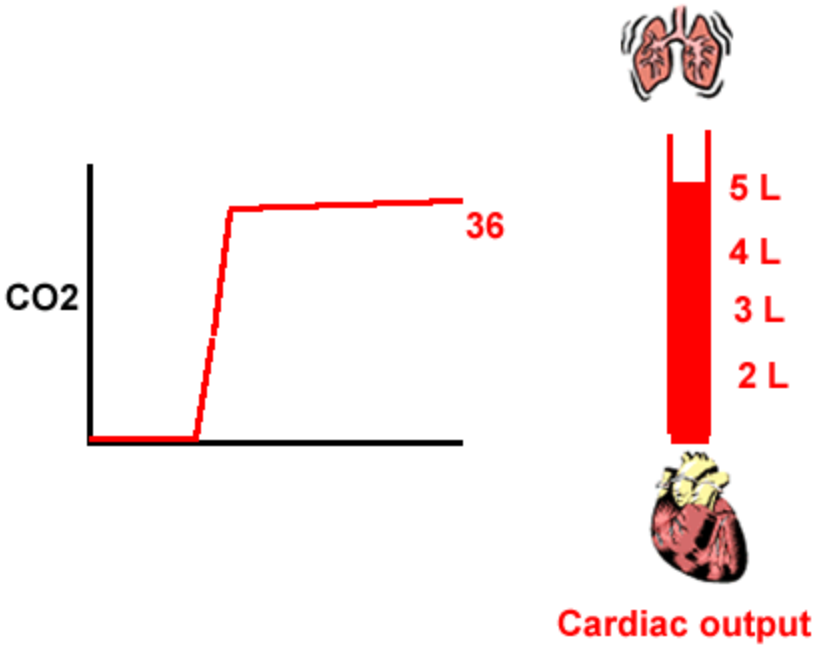
Basic Physiology



In the acute settings, for a given ventilation, $PETCO_2$ is a function of cardiac output (pulmonary perfusion).
This is the basic principle of directing the uses of capnography during CPR

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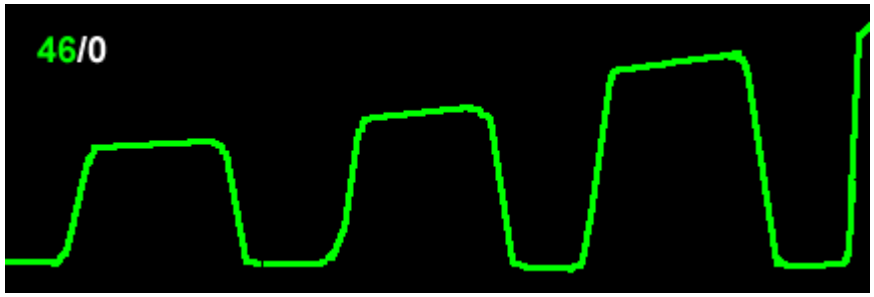
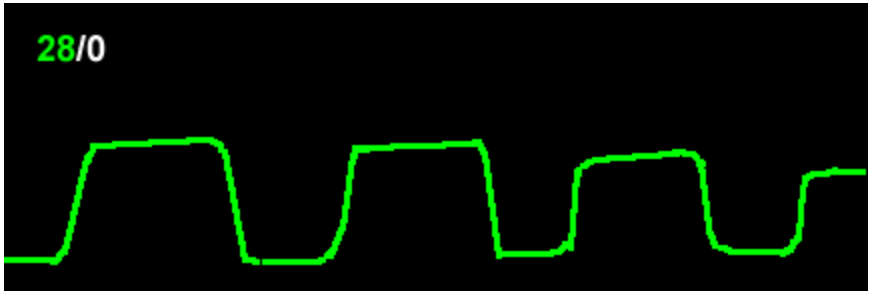
Basic Physiology

Hypoventilation



Hyperventilation



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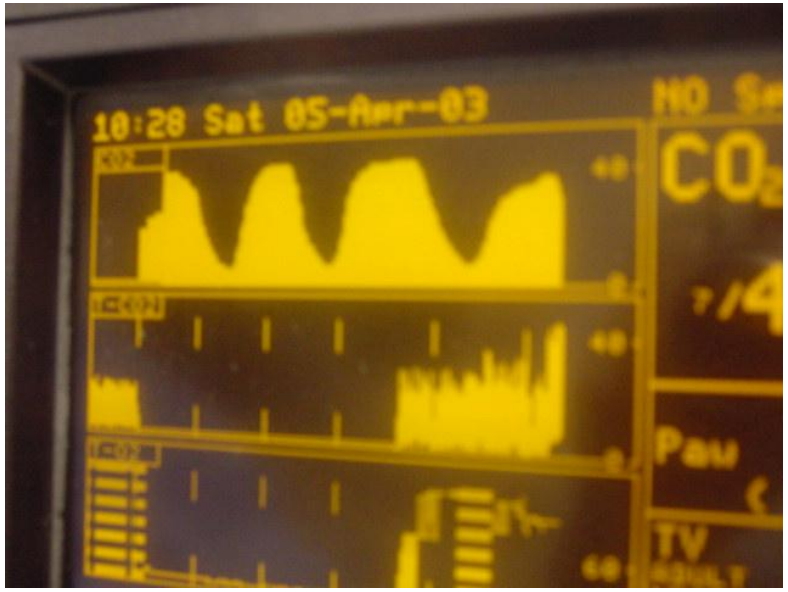
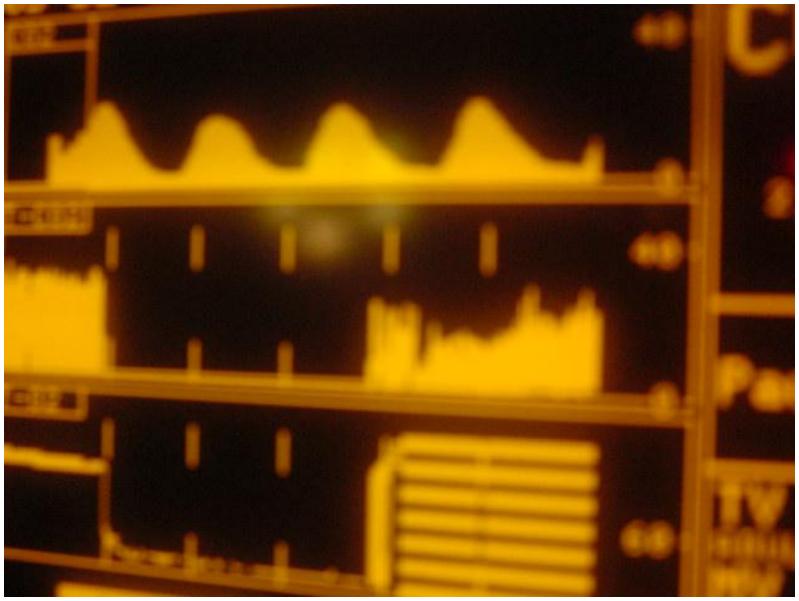
Capnograms during spontaneous ventilation

- The shape of the capnograms obtained when oxygen is being administered via face mask can be different due to dilution of expired CO_2 by oxygen or room air as shown below





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Capnograms during sedation

The important concept here is to determine changes from baseline capnograms

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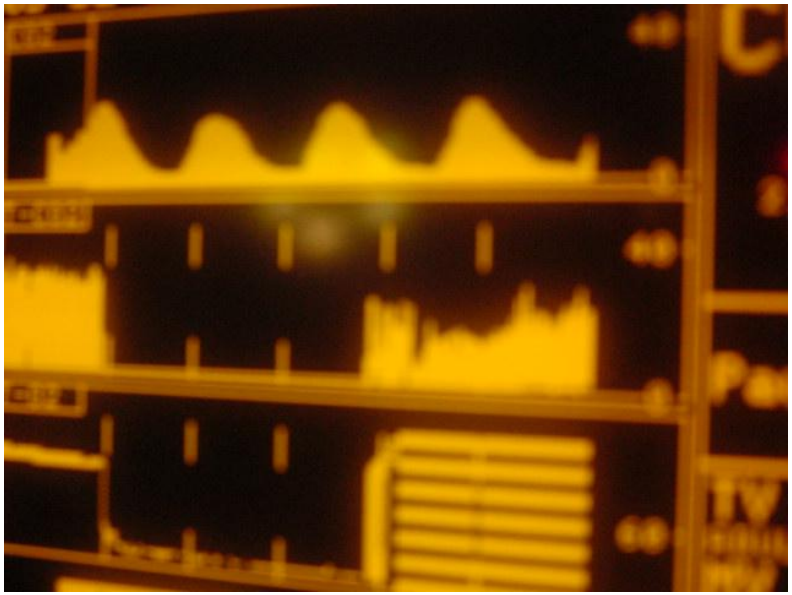
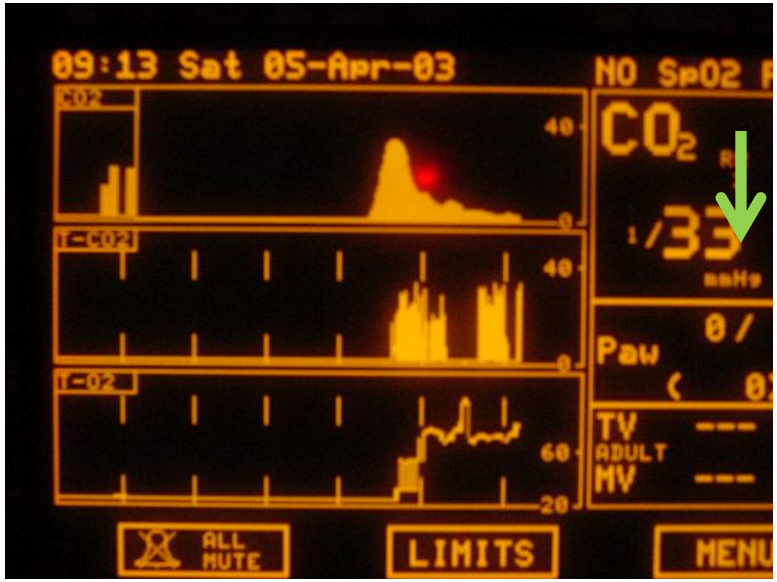
Capnograms during spontaneous ventilation

Look for three important changes from baseline capnograms

- ***Respiratory rate*:** A decreased rate indicates respiratory depression. Increased rate suggests stimulation from the procedure
- *If the $PETCO_2$ increases*, it suggests hypoventilation
- *If the $PETCO_2$ decreases*, it suggests hyperventilation, hypoventilation, or upper airway obstruction depending on the cause. Observe the patient carefully for evidence of respiratory obstruction. If present, give jaw thrust, $PETCO_2$ increases as obstruction is relieved. If there is no improvement in $PETCO_2$, it most likely suggests a central depression. Hyperventilation is indicated by an increased respiratory rate.

Over sedation





Respiratory rate is decreased

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Over sedation

Height of the capnogram $PETCO_2$ decreased

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Hypoventilation

Height of the capnogram ($PETCO_2$) is increased

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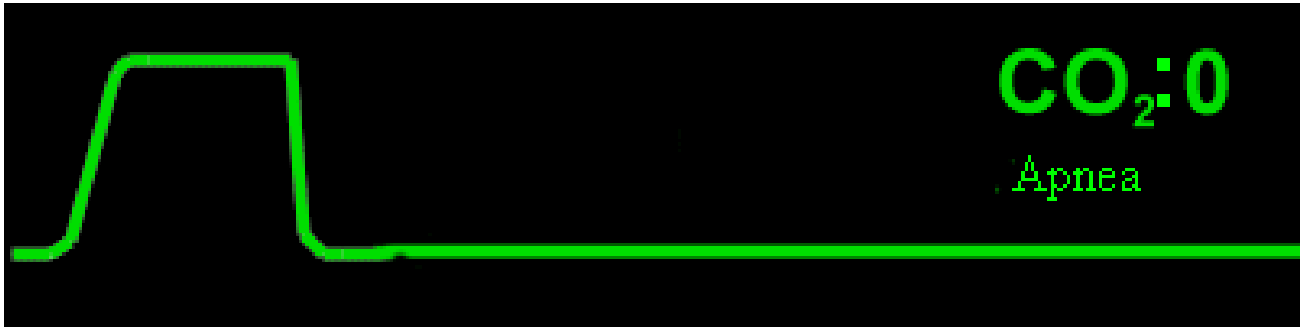
Apnea, or Respiratory obstruction



A flat line indicates that there is apnea, or total respiratory obstruction. It may also indicate disconnection of the CO_2 sampling system, or inability to sample the expired air. These circumstances call for immediate examination of the patient for apnea, or respiratory obstruction, or sampling issues.

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Sampling devices to monitor $PETCO_2$

Here, $PETCO_2$ is being sampled with a nasal sampling cannula (arrow), oxygen is being administered via an oxygen mask. An endoscope is inserted via a flap cut in the mask. This ensures adequate oxygenation and sampling of CO_2

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Some Examples of Devices for CO_2 sampling


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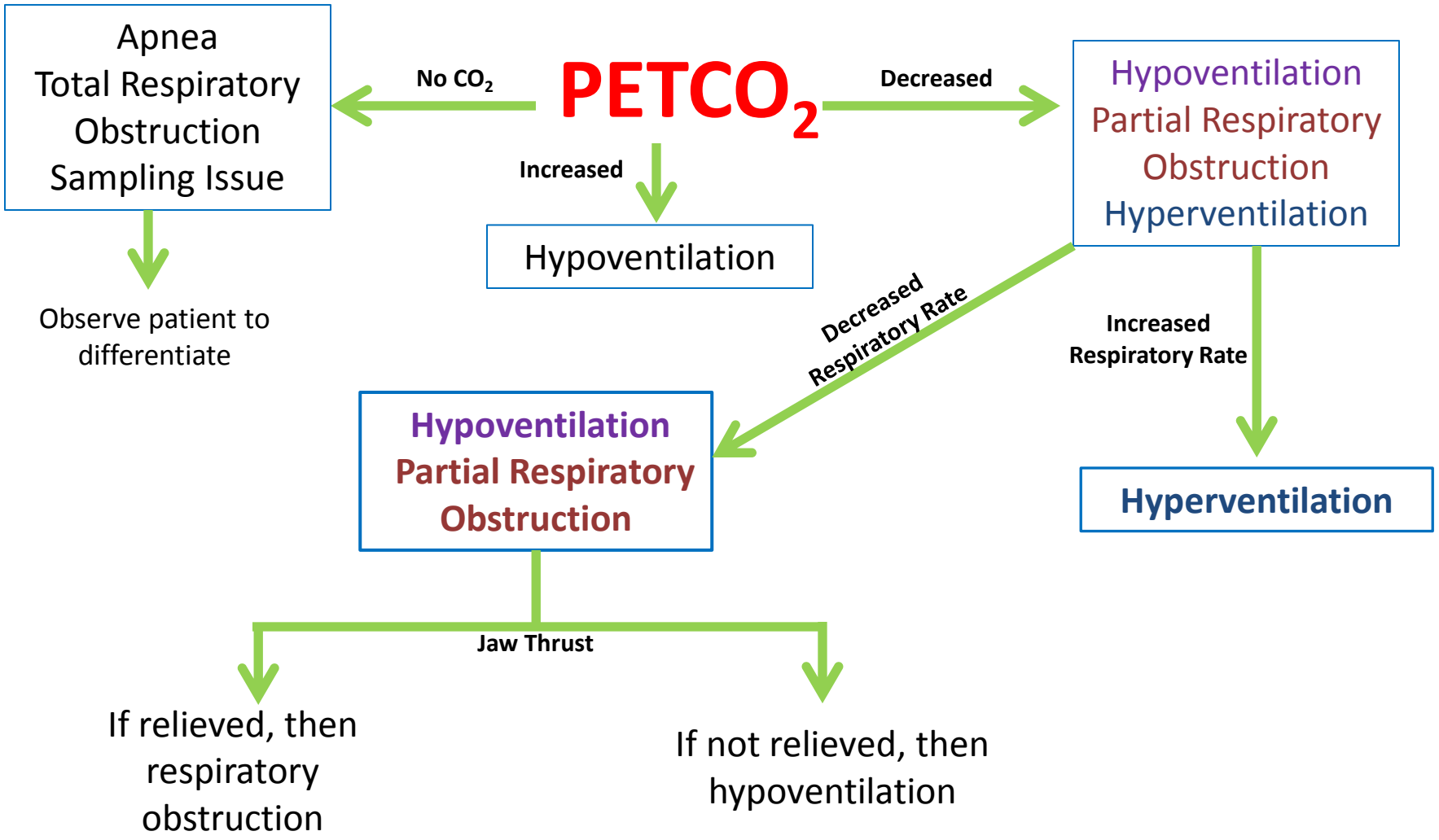
Conclusion

- Place the sampling device and obtain best $PETCO_2$ values and waveforms
- Look for changes from baseline values and shape of capnograms
- Hypoventilation is suggested by decreased respiratory rate, increased $PETCO_2$ values, or decreased $PETCO_2$ values (depending on cause).
- Hyperventilation is indicated by an increase in respiratory rate
- Look for evidence of respiratory obstruction when you begin to see changes in $PETCO_2$ values, or shape.
- Lifting the jaw forwards relieves upper airway obstruction and increased $PETCO_2$ values

Differential Diagnosis of Capnography during Sedation



Pulse Oximetry can be used as an adjunct in differential diagnosis .
Capnography should help to diagnose the problem before changes in SPO_2

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Question 1

- Normal $PETCO_2$ values in healthy adults breathing normally with good sampling

(a) 80 mm Hg

(b) 40 mm Hg

(c) 20 mm Hg

(d) 25 mm Hg

(b)

Question 2

- *During capnography monitoring for sedation, it is important to determine $PETCO_2$ changes from baseline capnograms*

True

False

True

Question 3

- If $PETCO_2$ increases during sedation, it suggests

(a) Hyperventilation

(b) Hypoventilation

(c) Respiratory obstruction

(d) Low cardiac output

(b)

Question 4

- If $PETCO_2$ decreases during sedation, it suggests

(a) Hyperventilation

(b) Respiratory obstruction

(c) Hypoventilation

(d) All of the above

(d)

Question 5

- Generally, capnography changes like hypoventilation, or respiratory obstruction occur before oxygen desaturation
- True
- False
- Neither

True