Capnography During Sedation

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New Standards of Monitoring

• American Society of Anesthesiologists (ASA) and the Association of Anaesthetists 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.
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
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.
Basic Physiology

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

Hypoventilation

Hyperventilation
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 CO₂ by oxygen or room air as shown below.
Capnograms during sedation

The important concept here is to determine changes from baseline capnograms
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 PETCO₂ increases*, it suggests hypoventilation.

• *If the PETCO₂ 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, PETCO₂ increases as obstruction is relieved. If there is no improvement in PETCO₂, it most likely suggests a central depression. Hyperventilation is indicated by an increased respiratory rate.
Over sedation

Respiratory rate is decreased
Over sedation

Height of the capnogram PETCO$_2$ decreased
Hypoventilation

Height of the capnogram (PETCO$_2$) is increased
Apnea, or Respiratory obstruction

A flat line indicates that there is apnea, or total respiratory obstruction. It may also indicate disconnection of the CO\textsubscript{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.
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$_2$.
Some Examples of Devices for CO$_2$ sampling
Conclusion

- Place the sampling device and obtain best PETCO₂ values and waveforms
- Look for changes from baseline values and shape of capnograms
- Hypoventilation is suggested by decreased respiratory rate, increased PETCO₂ values, or decreased PETCO₂ 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 PETCO₂ values, or shape.
- Lifting the jaw forwards relieves upper airway obstruction and increased PETCO₂ values
Differential Diagnosis of Capnography during Sedation

Apnea
Total Respiratory Obstruction
Sampling Issue

Observe patient to differentiate

No CO₂

PETCO₂

Increased

Hypoventilation
Partial Respiratory Obstruction

Increased Respiratory Rate

Decreased Respiratory Rate

If relieved, then respiratory obstruction

Jaw Thrust

If not relieved, then hypoventilation

Hypoventilation
Partial Respiratory Obstruction

Increased

Hyperventilation

Decreased

Hypoventilation

Pulse Oximetry can be used as an adjunct in differential diagnosis. Capnography should help to diagnose the problem before changes in SPO₂.

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www.capnography.com
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Question 1

• Normal PETCO₂ 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 PETCO₂ 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
Question 4

- If PETCO$_2$ decreases during sedation, it suggests
  (a) Hyperventilation
  (b) Respiratory obstruction
  (c) Hypoventilation
  (d) All of the above
Question 5

• Generally, capnography changes like hypoventilation, or respiratory obstruction occur before oxygen desaturation

• True

• False

• Neither
True