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## Capnography Connections Guide

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Patient Monitoring



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# Capnography Introduction

## WHAT IS CAPNOGRAPHY?

1. Tool to assess ventilation by monitoring end tidal carbon dioxide (ETCO<sub>2</sub>)
2. Carbon Dioxide (CO<sub>2</sub>) production
3. CO<sub>2</sub> produced by metabolism and diffused into the blood stream
4. Blood stream then transports the CO<sub>2</sub> to the lungs (circulation/transportation)
5. CO<sub>2</sub> is eliminated with ventilation

## ETCO<sub>2</sub> VALUES

- Normal values 35-45 mmHg
- ETCO<sub>2</sub> and the respiratory rate are inversely related:
  - Increase in RR will decrease ETCO<sub>2</sub>
  - Decrease in RR will increase ETCO<sub>2</sub>

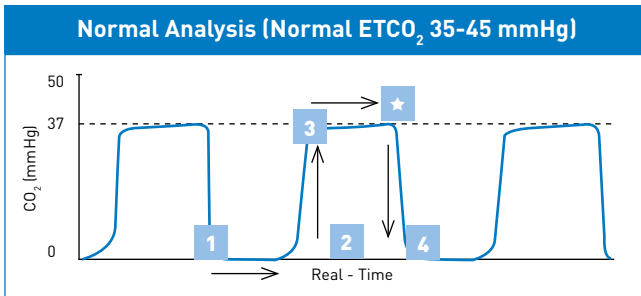
## CLINICAL APPLICATIONS-ERTV

1. Evaluate
  - a) Efficacy of breathing treatments
  - b) Gradient (PaCO<sub>2</sub> - ETCO<sub>2</sub>)
  - c) Patient's respiratory status
2. Resuscitate
  - a) Intubation verification
  - b) Early indicator of return of spontaneous circulation
  - c) Adequacy of CPR (rate, depth and force of compressions)
3. Transport
  - a) Continuous patient assessment
  - b) Adequacy of ventilation
  - c) Endotracheal tube stability and patency
4. Ventilate
  - a) Measures adequacy of ventilation (appropriate settings)
  - b) Weaning, early indicator of respiratory muscle fatigue

## WAVEFORM ANALYSIS

### Five Characteristics of the Waveforms:

1. Evaluate
  - a) Tall = High ETCO<sub>2</sub>
  - b) Small = Low ETCO<sub>2</sub>
2. Rate
  - a) Respiratory rate
3. Rhythm
  - a) Regular
  - b) Increasing/decreasing in size
  - c) Widening
4. Baseline
  - a) Zero
5. Shape of the waveform (square shape)



## NORMAL ANALYSIS (NORMAL ETCO<sub>2</sub> 35-45 MMHG)

1. Baseline = should be zero
2. Upstroke = early exhalation
3. Plateau
  - ★ End tidal concentration
4. Inspiration begins

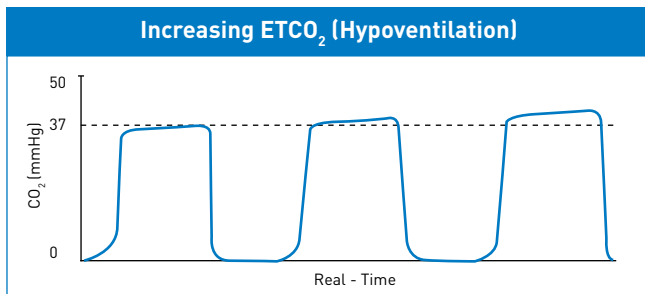
# Capnography Introduction

## WHY USE CAPNOGRAPHY WITH PCA?

- Medications delivered via Patient Controlled Analgesia (PCA) have the potential to impact respiratory efforts, depending on the patient and dosing.
- Capnography monitoring is a non-invasive indicator for assessing the effectiveness of this therapy
- Capnography allows for a breath by breath analysis of the patient's ventilation
- Detecting respiratory depression or apnea related to oversedation
- Detecting hyperventilation due to pain allows clinicians to intervene before an acute respiratory event and make informed decisions about the care of patients receiving PCA
- Alarm parameters can be set to automatically alert the clinician to:
  - Hyperventilation
  - Hypoventilation
  - Apnea (no breath)
  - Airway obstruction

## HOW TO MONITOR:

1. Obtain baseline information
  - a) Respiratory rate
  - b) ETCO<sub>2</sub> value
  - c) Waveform: note the shape, size, etc
2. Monitor patient for changes:
  - a) Baseline information
  - b) Trend and assess



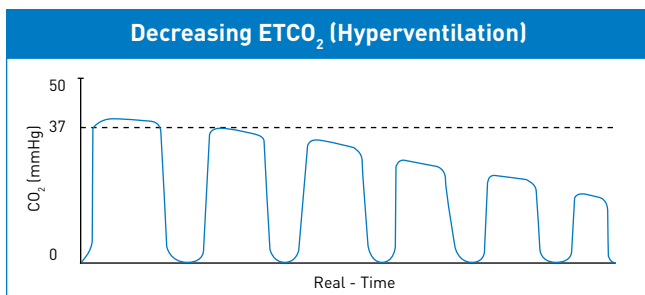
### INCREASING ETCO<sub>2</sub> (HYPOVENTILATION)

#### **Possible causes:**

- Over medication or analgesia
- Snoring or possible obstruction
- Hypertension

#### **Intervention:**

- Adhere to established hospital protocols/guidelines
- Follow hospital BLS protocol for ABC's
- Assess sedation level
- Stimulate patient
- Inform MD



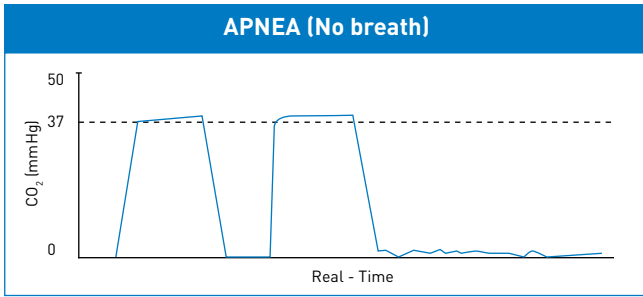
### DECREASING ETCO<sub>2</sub> (HYPERVENTILATION)

#### **Possible causes:**

- Increase in pain level
- Increase in anxiety or fear
- Hypovolemia
- Hypotension
- Respiratory distress or shortness of breath

#### **Intervention:**

- Adhere to established hospital protocols/guidelines
- Treat the cause of increased respiratory rate
- Follow hospital BLS protocol for ABC's
- Reduce pain stimulus
- Inform MD



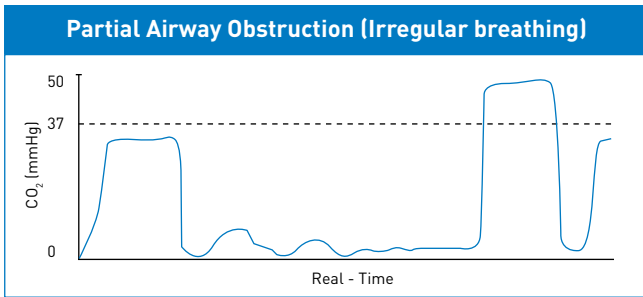
### APNEA (NO BREATH)

**Possible causes:**

- Equipment malfunction, check all connections
- Shallow breathing
- Over medication or sedation

**Intervention:**

- Adhere to established hospital protocols/guidelines
- Follow hospital BLS protocol for ABC's
- Stimulate patient
- Inform MD



### PARTIAL AIRWAY OBSTRUCTION (IRREGULAR BREATHING)

**Possible causes:**

- Poor head or neck alignment
- Shallow breathing
- Over medication or sedation

**Intervention:**

- Adhere to established hospital protocols/guidelines
- Follow hospital BLS protocol for ABC's
- Stimulate patient
- Inform MD





# Capnography & Critical Care

## THE GRADIENT

Observing the difference between arterial and exhaled carbon dioxide can also give valuable data about the patient's condition. The alveolar-arterial gradient is the difference between the alveolar carbon dioxide level (ETCO<sub>2</sub>) and the arterial level (PaCO<sub>2</sub>).

In adults with normal cardiorespiratory function and normal ventilation and perfusion, the ETCO<sub>2</sub> is 2-5 mmHg lower than the PaCO<sub>2</sub>

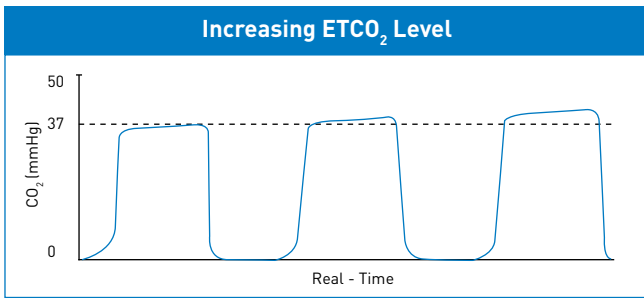
Gradient Equation = PaCO<sub>2</sub>-ETCO<sub>2</sub>

To determine a patient's gradient, draw an arterial blood gas, at the same time note the ETCO<sub>2</sub> value. Once the arterial blood gas results are back, subtract the ETCO<sub>2</sub> value that was noted from the PaCO<sub>2</sub> value. This will provide you an initial gradient to trend. Following this initial gradient, clinicians can utilize the previous PaCO<sub>2</sub> and subtract current ETCO<sub>2</sub> readings. If the gradient is increasing the patient's condition may be becoming worse. The clinician needs to determine if this is due to metabolism, circulation or ventilation.

**Dead space ventilation** occurs when the alveoli are ventilated but not perfused. Clinical situations such as hypotension, hypovolemia, excessive PEEP, pulmonary embolism, or cardiopulmonary arrest result in a decreased ETCO<sub>2</sub> and a widening of the gradient (widening is equal to an

increase in the number or gradient such as a gradient starting at 10 mmHg and then increasing to 15 mmHg).

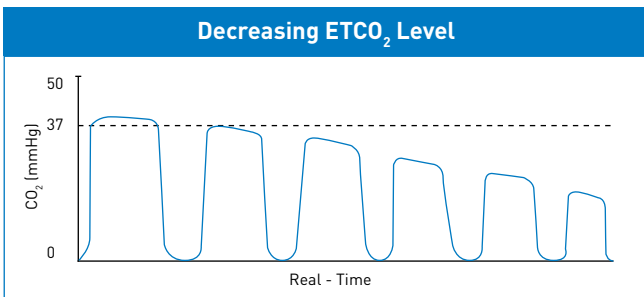
**Shunt perfusion** occurs when the alveoli are perfused but not ventilated. This can be due to pneumonia, mucous plugging, or atelectasis. ETCO<sub>2</sub> may decrease slightly, but carbon dioxide is highly soluble and will diffuse out of the blood into the available alveoli. Therefore, little effect on the gradient is seen. In this case, the patient's oxygenation status may suffer, and positive end expiratory pressure (PEEP) or continuous positive airway pressure will be indicated to re-expand the atelectatic lung units.



### INCREASING ETCO<sub>2</sub> LEVEL

An increase in the level of ETCO<sub>2</sub> from previous levels. Possible causes:

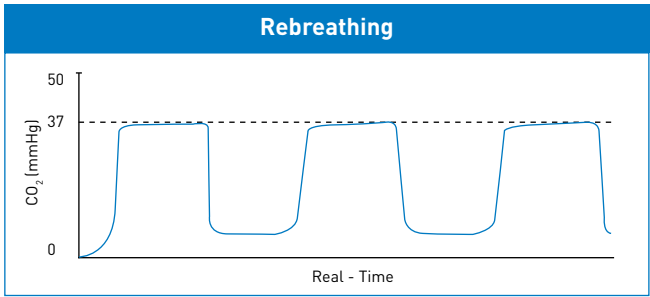
- Decrease in respiratory rate (hypoventilation)
- Decrease in tidal volume
- Increase in metabolic rate
- Rapid rise in body temperature
- Increase in cardiac output
- Exhalation valve malfunction



### DECREASING ETCO<sub>2</sub> LEVEL

Decrease in the level of ETCO<sub>2</sub> from previous levels. Possible causes:

- Increase in respiratory rate (hyperventilation)
- Increase in tidal volume
- Decrease in metabolic rate
- Decrease in core body temperature
- Decrease in cardiac output
- Circuit leak
- Poor sampling

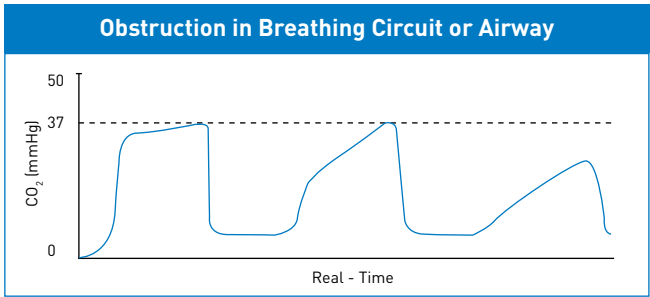


**REBREATHING**

Elevation of the baseline indicates rebreathing (may show increase in ETCO<sub>2</sub>)

Possible Causes:

- Faulty expiratory valve on ventilator or anesthesia machine
- Inadequate inspiratory flow
- Partial rebreathing
- Insufficient expiratory time

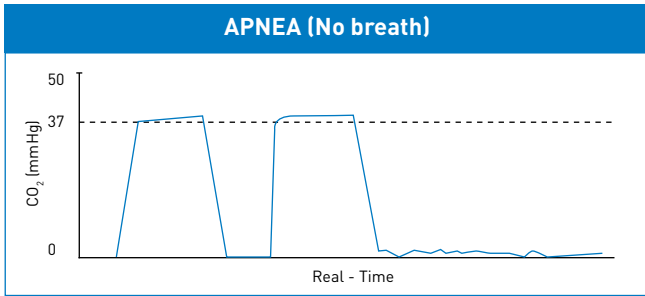


**OBSTRUCTION IN BREATHING CIRCUIT OR AIRWAY**

Elevation of the baseline indicates rebreathing (may show increase in ETCO<sub>2</sub>)

Possible Causes:

- Obstruction in breathing circuit or airway
- Inadequate inspiratory flow
- Presence of a foreign body in the upper airway
- Partially kinked or occluded artificial airway
- Bronchospasm



### APNEA (NO BREATH)

Complete loss of waveform indicating no CO<sub>2</sub> present, since this occurred suddenly consider:

- Endotracheal tube dislodged
- Total obstruction of endotracheal or trach tube
- Equipment malfunction, check all connections

# Capnography & Resuscitation

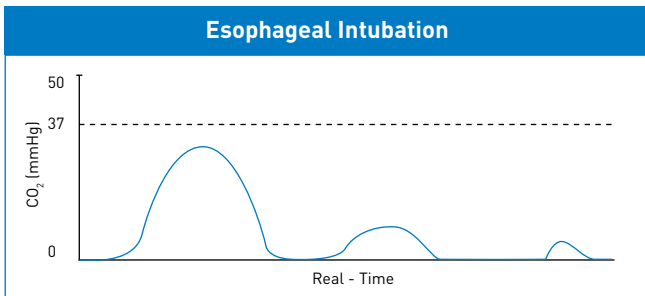
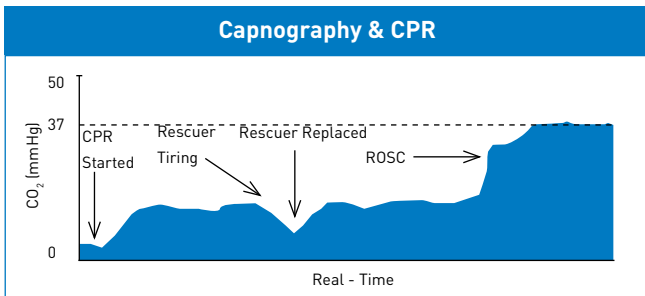
## CAPNOGRAPHY & RESUSCITATION

The AHA stresses the importance of high quality CPR. Compressions need to be at the correct rate, depth and allowing for full recoil. Capnography provides clinicians with a noninvasive method for monitoring CPR effectiveness. When a patient cardiac arrests CO<sub>2</sub> levels fall abruptly because of the absence of cardiac output (blood flow) and pulmonary blood flow. When compressions are initiated cardiac output is generated. The higher the ETCO<sub>2</sub> value during resuscitation the greater the cardiac output. If lower ETCO<sub>2</sub> levels are observed during resuscitation this may signal a need for changes in CPR techniques or compressions. The 2010 AHA and ERC guidelines support the use of capnography to assist during compressions. It is now recommended to utilize quantitative waveform capnography in intubated patients to monitor CPR quality, optimize chest compressions and detect return of spontaneous circulation (ROSC). If ETCO<sub>2</sub> is <10mmHg, the AHA suggests trying to improve CPR quality by optimizing chest compressions. When there is a dramatic sustained increase in ETCO<sub>2</sub> (typically > 40mmHg), it signals ROSC<sup>1</sup>.

American Heart Association (AHA) guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC). Highlights of the 2010 American Heart Association Guidelines for CPR and ECC. Available at: [www.heart.org/idc/groups/heart\\_public/@wcm/@ecc/documents/downloadable/ucm\\_317350.pdf](http://www.heart.org/idc/groups/heart_public/@wcm/@ecc/documents/downloadable/ucm_317350.pdf)

**OBSTRUCTION IN BREATHING CIRCUIT OR AIRWAY**

- Esophageal intubation: ETCO<sub>2</sub> levels 0 or near 0
- Adequate CPR = ETCO<sub>2</sub> levels approximately 10 mmHg
- Return of spontaneous circulation: Sudden increase to near normal ETCO<sub>2</sub> levels of greater than 40 mmHg
- Rescuer fatigue: Decreasing levels of ETCO<sub>2</sub>



# Capnography & Procedural Sedation

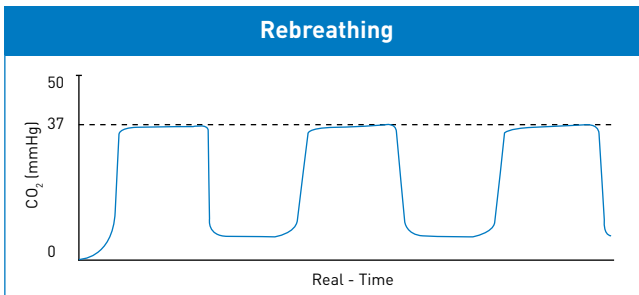
## CAPNOGRAPHY & PROCEDURAL SEDATION

Medications are administered to raise pain thresholds, decrease anxiety and to provide amnesia during procedures while minimally depressing the patient's level of consciousness. Medications used during these events often depress the respiratory system. Monitoring  $\text{ETCO}_2$  will provide a breath by breath analysis of the patient's ventilation status and allow the clinician to intervene before the patient experiences an acute respiratory event. When possible, clinicians should obtain baseline values and observe the waveform. During the procedure,

clinicians should observe for changes in the waveform in addition to changes in value and reassess the patient whenever necessary.

Follow hospital protocols which may include:

- Follow hospital BLS protocol for ABC's
- Patient assessment
- Stimulate patient
- Check position of cannula on patient
- Discontinue delivery of medications if appropriate
- Inform MD
- Reversal agent administration



## REBREATHING

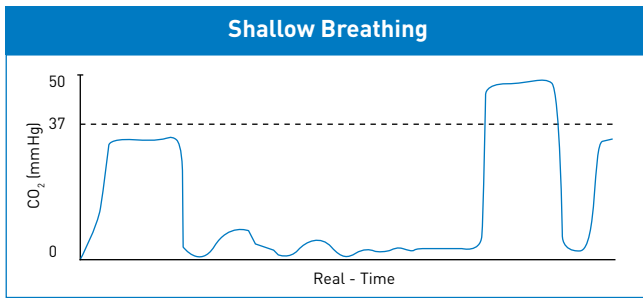
### **Cause:**

- Generally due to shallow respirations

### **Intervention:**

- Adjust head and neck alignment
- Ask patient to take deep breath (shallow breathing)
- Check position of cannula





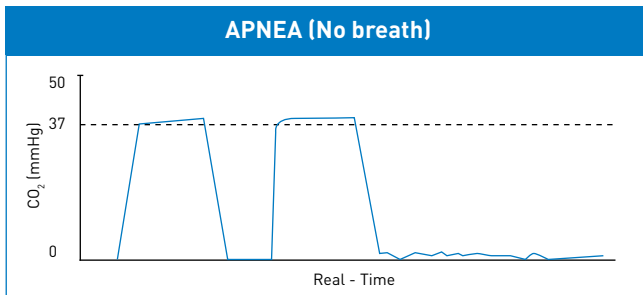
## SHALLOW BREATHING

### Cause:

- Volume of air being exchanged is not adequate

### Intervention:

- Adjust head and neck alignment
- Ask patient to take deep breath
- Check position of cannula
- Observe patient closely



## APNEA (NO BREATH)

### Cause:

- Patient is not breathing or malfunction with equipment

### Intervention:

- Check position of cannula and connections
- Check head and neck alignment
- ABC protocol

# Capnography & EMS

## CAPNOGRAPHY & EMS

### Applications: ERTV

#### Evaluate:

- Efficacy of breathing treatments
- Patient's respiratory status

#### Resuscitate:

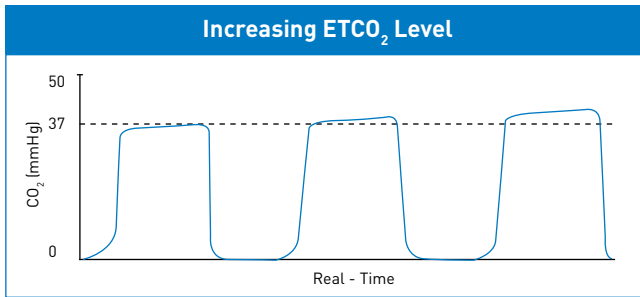
- Intubation verification
- Early indicator of return of spontaneous circulation
- Adequacy of CPR (rate, depth and force of compressions)

#### Transport:

- Continuous patient assessment
- Adequacy of ventilation
- Tube patency

#### Ventilate:

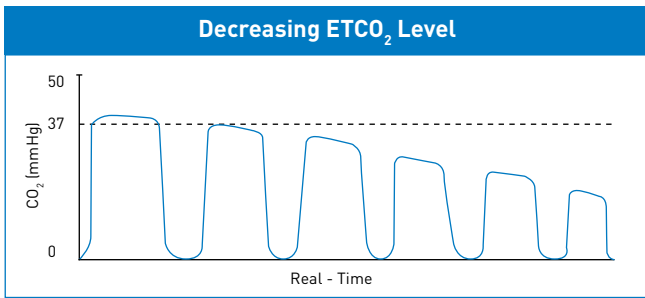
- Measures adequacy of ventilation



## INCREASING ETCO<sub>2</sub> LEVEL

An increase in the level of ETCO<sub>2</sub> from previous levels. Possible causes:

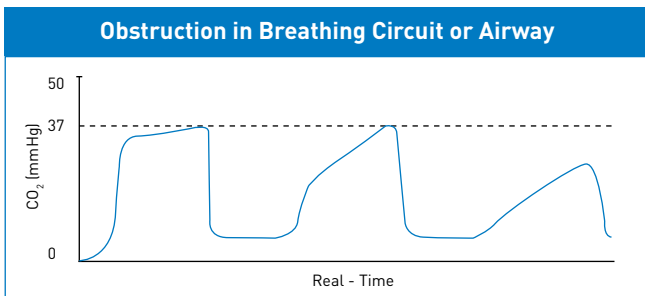
- Decrease in respiratory rate (hypoventilation)
- Decrease in tidal volume
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### DECREASING ETCO<sub>2</sub> LEVEL

Decrease in the level of ETCO<sub>2</sub> from previous levels. Possible causes:

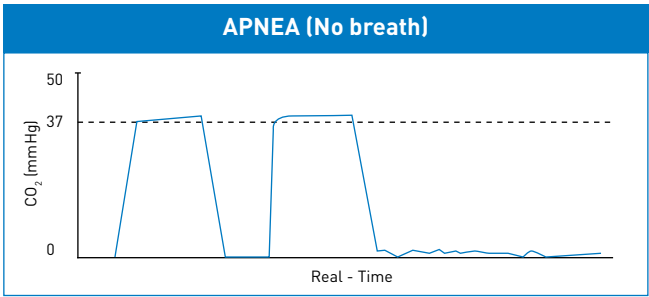
- Increase in respiratory rate (hyperventilation)
- Increase in tidal volume
- Decrease in metabolic rate
- Decrease in core body temperature
- Decrease in cardiac output
- Circuit leak
- Poor sampling



### OBSTRUCTION IN BREATHING CIRCUIT OR AIRWAY

Obstruction expiratory gas flow is noted as a change in the slope of the ascending limb of the capnogram (expiratory plateau may be absent):

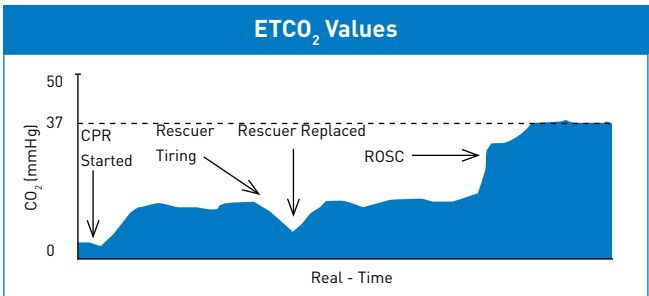
- Obstruction in breathing circuit or airway
- Inadequate inspiratory flow
- Presence of a foreign body in the upper airway
- Partially kinked or occluded artificial airway
- Bronchospasm



**APNEA (NO BREATH)**

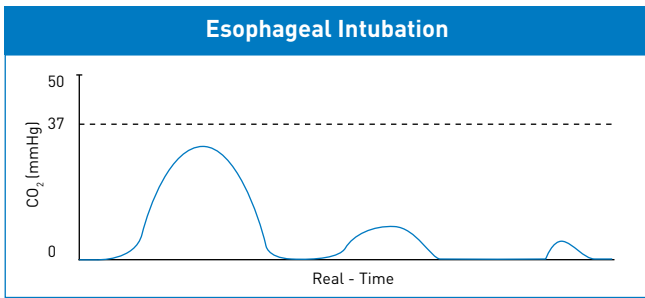
Complete loss of waveform indicating no CO2 present, since this occurred suddenly consider:

- Endotracheal tube dislodged
- Total obstruction of endotracheal or trach tube
- Equipment malfunction, check all connections
- Patient not breathing



**ETCO2 VALUES**

- Esophageal intubation: ETCO<sub>2</sub> levels 0 or near 0
- Adequate CPR = ETCO<sub>2</sub> levels approximately 10 mmHg
- Return of spontaneous circulation: Sudden increase to near normal ETCO<sub>2</sub> levels of greater than 40 mmHg
- Rescuer fatigue: Decreasing levels of ETCO<sub>2</sub>



### ESOPHAGEAL INTUBATION

- No waveform indicating no CO<sub>2</sub> present, endotracheal tube in the esophagus

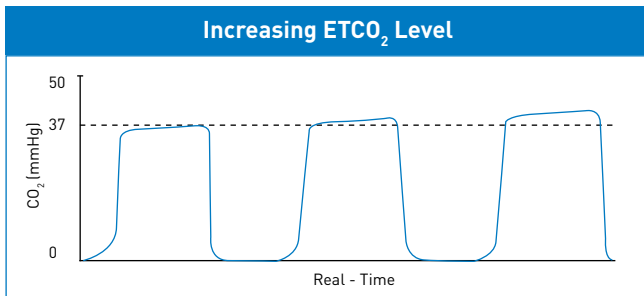
# Capnography & Sleep Studies

## Adults

- Distinguish between central (nervous system) and obstructive (airway) events
- Use for patients with underlying cardiovascular disorders such as congestive heart failure

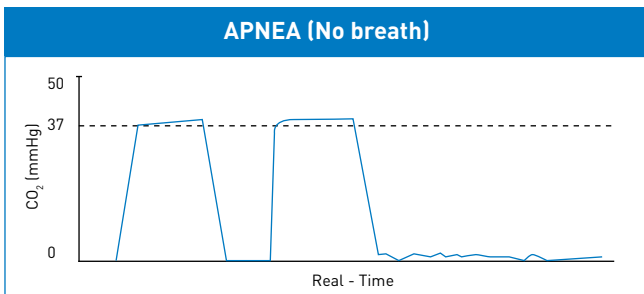
## Pediatrics

- Guideline
- “Hypoventilation...measured by either transcutaneous  $PCO_2$  and/or  $ETCO_2$ ...” [AASM Manual for Scoring of Sleep and Associated Events. Pg. 49]
- Differential diagnosis



## INCREASING $ETCO_2$ LEVEL (HYPOVENTILATION)

- Decrease in respiratory rate (hypoventilation)
- Decrease in tidal volume



## APNEA (NO BREATH)

- No waveform indicating no  $CO_2$  present



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