# Using Capnography (EtCO2) –to Enhance Patient Safety and Clinical Effectiveness

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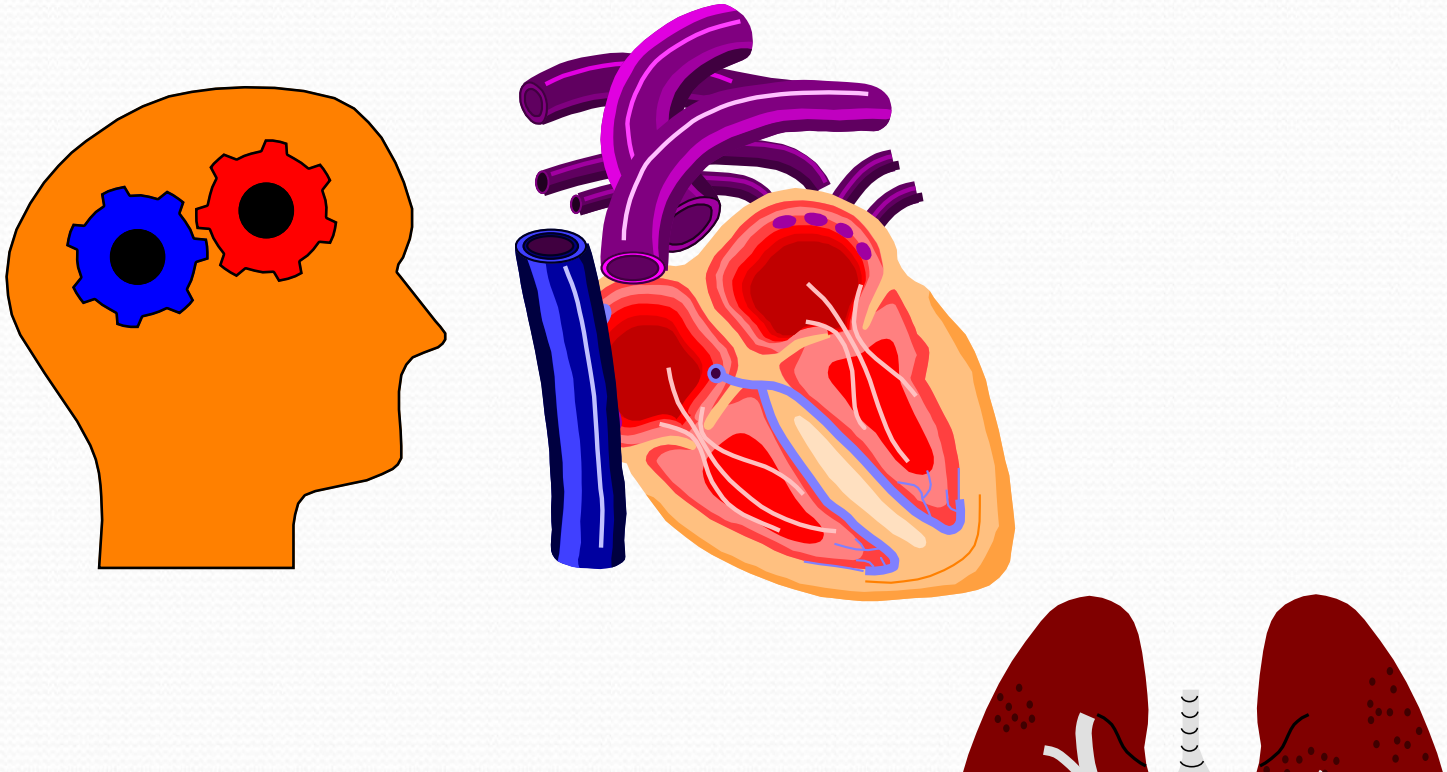


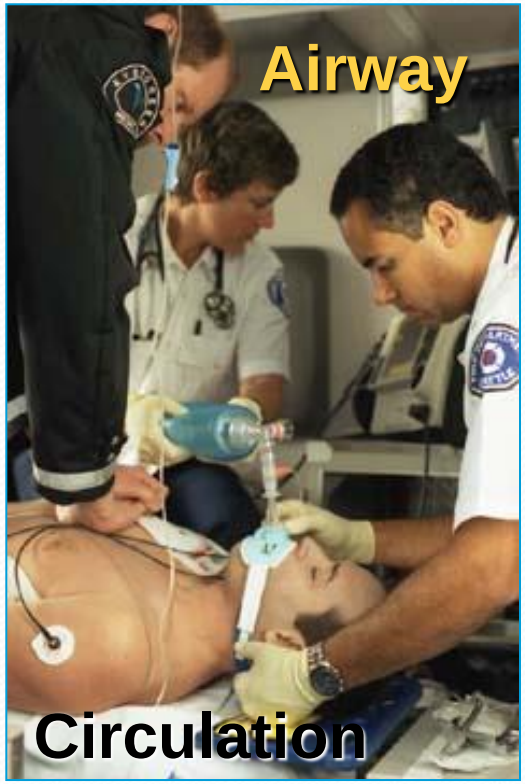
# Learning Objectives--EtCO2

- Objectives
  - Explain indications for EtCO2
  - Illustrate some of the equipment
  - Review related research
  - Define what is a normal EtCO2 value/wave
  - Define what are abnormal EtCO2 their causes and remedies
  - Furnish Add'l Resources

# Related Terminology

- ***Capnography***- Analysis of waveform (and often numeric value) of exhaled $CO_2$
- ***Capnometry***- Measuring the numeric value of exhaled $CO_2$
- Colormetry – Dichotomous measurement—Purple versus Yellow.
  - Less reliable than waveform!!!
    - In CPR, if no circulation, little $CO_2$ reaching the alveoli = little color change.
    - If High $CO_2$, color may stay yellow after initial change

# Capnography-Indications




- *Ventilation*
  - Adequacy of Ventilation & Gas Exchange with Mech. Ventilation
  - Airway- Verification of ET tube placement
  - Monitoring Ventilation of Sedated Patients
  - Monitoring of patients with suspected hypoventilation syndrome
- *Circulation*
  - Check effectiveness of cardiac compressions
  - Monitor low perfusion states
- Predictor of Mortality in ALI/ARDS?

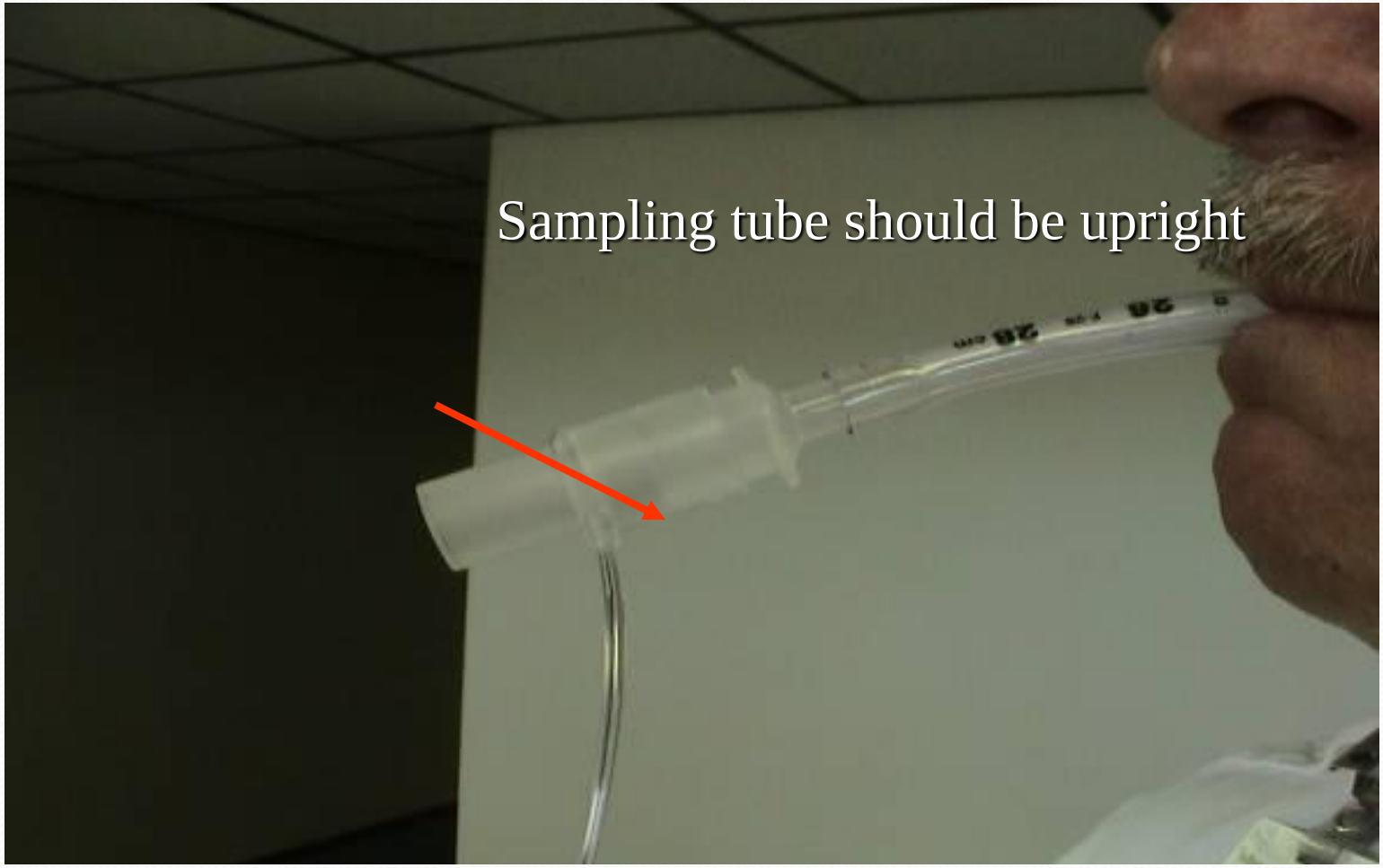
# Who Do We Monitor?

- Immediately following intubation-Tube placement
- During CPR-Effectiveness of:
  - Compressions & Ventilation
- Monitoring mechanically ventilated patients, especially for
  - Acutely Ill -- ARDS
  - Weaning
  - Transport
- Patients at risk for hypoventilation
  - Neuromuscular
  - OSA
  - Moderate sedation

# Devices--Colormetric Detector

# Combo Cannula -- O2 Administration and ETCO2 Monitoring

# LoFlo® Airway Adapter Kit



# A Newer Indication: ETCO2 and Moderate Sedation

- American Society of Anesthesiologists (ASA) Mandatory $EtCO_2$ monitoring during both moderate and deep sedation.
- Studies:
  - Moderate sedation, capnography allowed early detection of respiratory compromise in 163 children having GI endoscopy. Lightdale et al. Pediatrics. (2006).
  - A meta-analysis: Respiratory depression was 28 times more likely to be detected with capnography rather than by traditional methods (pulse oximetry, visual inspection).Waugh J, Khodneva Y, Epps C. (2008).
  - Cases of respiratory depression were 17.6 times more likely to be detected in cases monitored by capnography than in cases not monitored by capnography. Waugh J B, et al, (2011).

# Another *Newer* Indication- Capnography in CPR

- Assess chest compressions
- Early detection of ROSC
- Objective data for decision to cease resuscitation

# ETCO2 & CPR-Some Data

- Sanders, et al, JAMA, 1989- ETCO2 correlates to outcomes in CPR.
- A 2005 study comparing field intubations that used capnography to confirm ETT placement vs. non-capnography use showed a 0% unrecognized misplaced ETT and 23% in the non-EtCO2 monitored group
- Confirm endotracheal intubation with waveform capnography!!

# More Data--$ETCO_2$, CPR & Survival

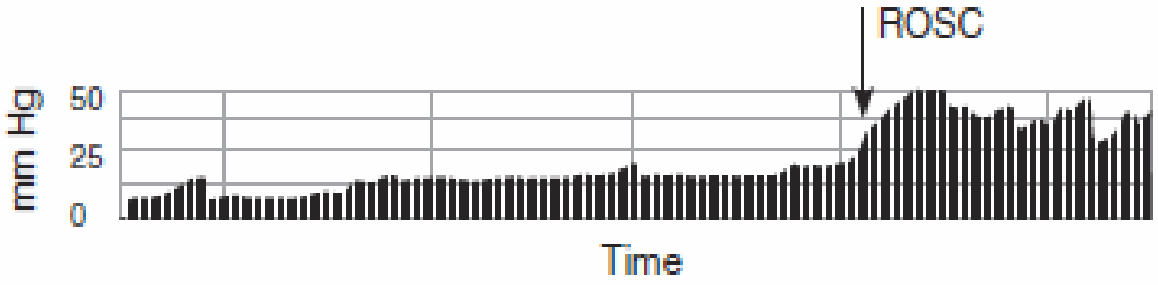
- Non-survivors
  - Average $ETCO_2$: 4-10 mmHg
- Survivors (to discharge)
  - Average $ETCO_2$: >30 mmHg

# Still More Data- ETCO2 & CPR Quality

- CPR Quality:
  - Bad CPR = ETCO2 <15
  - Good CPR = ETCO2 >15
- ROSC = ETCO2 increases
  - Suddenly by 15
  - ETCO2 = 35 - 40

# Graphic Depiction of ROSC

**Figure 6. Capnogram Trend Indicating Return Of Spontaneous Circulation**




During cardiopulmonary resuscitation, an abrupt rise in $ETCO_2$ to normal or greater-than-normal levels indicates improved cardiac output and ROSC.

# Potential Predictive Value

- There may be a ***direct relationship*** between ETCO2 level and Mortality in ARDS/ALI.
- Research:
  - Blanch L, et al (1999) Eur Respir J
  - Lucangelo U, et al (2008) Chest.

# Values--$EtCO_2$

- Normal values
  - Normal Range 7.35 to 7.45
  - Normal $EtCO_2$ is 30-43mmHg
  - Normal $PaCO_2$ is 35-45mmHg
- Abnormal Values
  - Acidosis
    - pH < 7.35
    - $PaCO_2$ > 45
    - $EtCO_2$ > 43
  - Alkalosis
    - pH > 7.45
    - $PaCO_2$ < 35
    - $EtCO_2$ < 30

# Our Response -$EtCO_2$

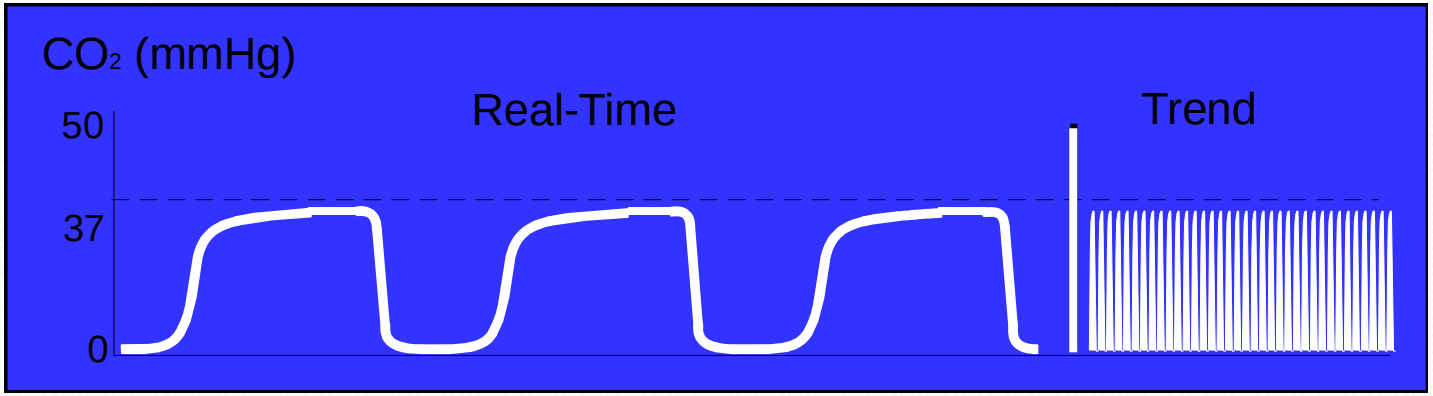
- Stabilizing Abnormal values

  * $EtCO_2$ greater than 43mmHg
    - **Increase tidal volume**
    - **Increase respiratory rate**
  * $EtCO_2$ less than 30mmHg
    - **Decrease respiratory rate and/*or***
    - **Decrease tidal volume**
    - **Add dead-space? — If head injury**

# When to Adjust VT vs. Rate?

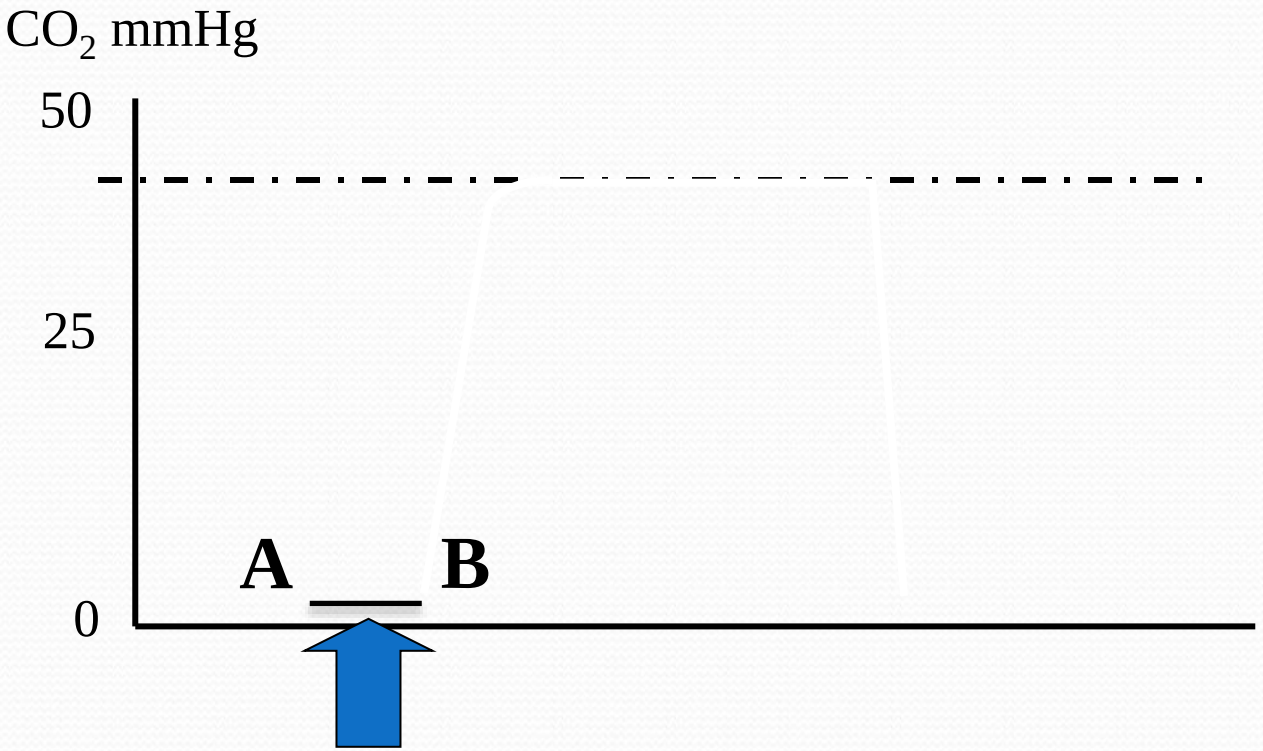
- How do we decide to focus on VT or RR?
  - Examine current VT, relative to recommended 5-8 ml / Kg.
    - Example: If seeking to decrease ETCO2, and VT is currently at/near 4-5 mls / Kg, consider increasing VT.
  - Examine current RR, relative to variables such as normal range (8-30), I:E ratio, evidence of auto-peep.

# Example: Normal Capnogram



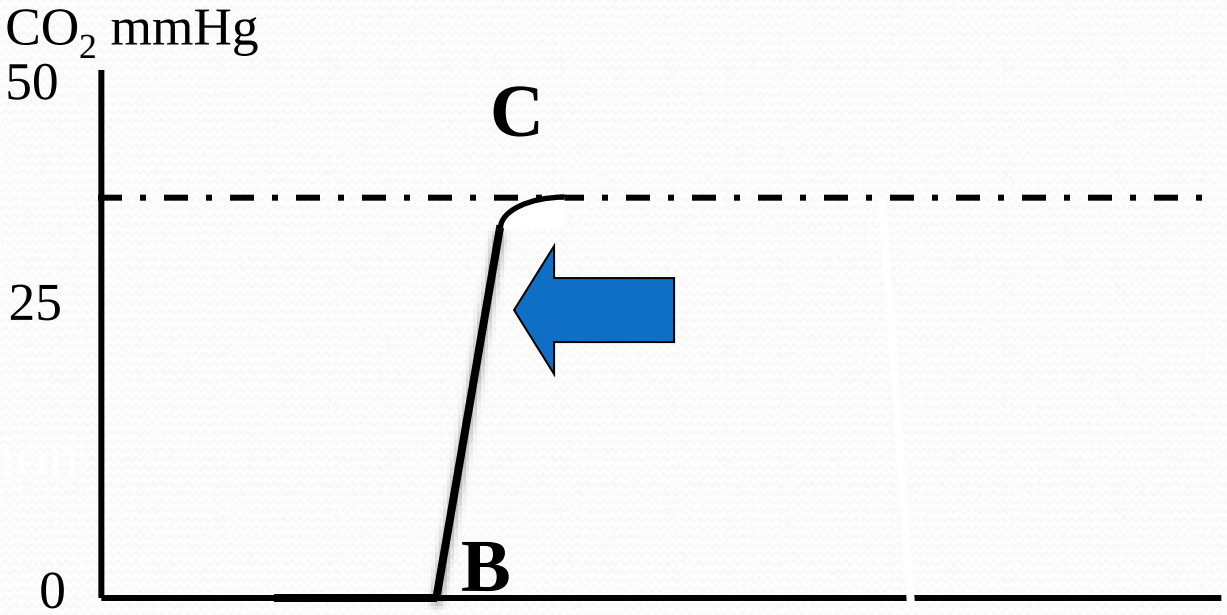

**Normal capnogram, stable trend**
**$ETCO_2$/PaCO2 gradient 4 mmHg**

# Normal Capnogram - Phase I

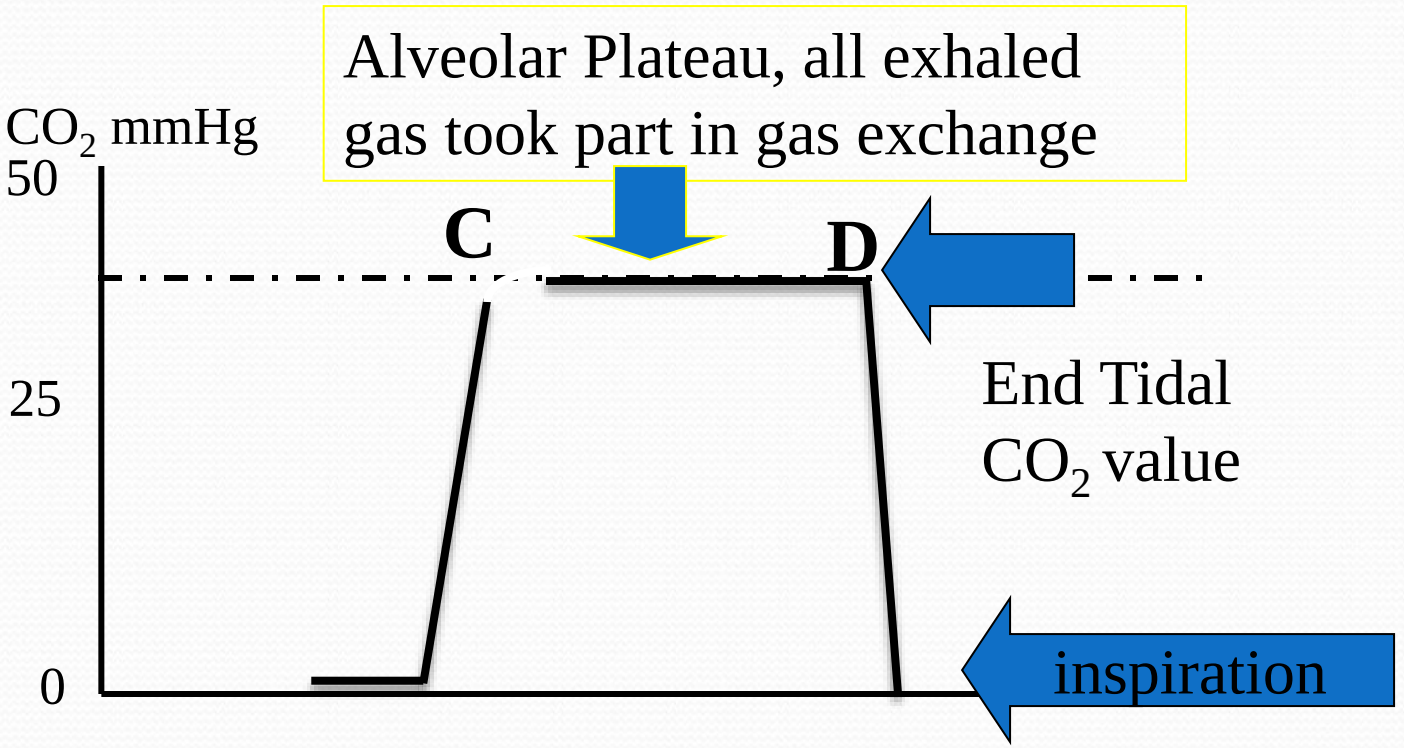



Beginning of expiration = anatomical deadspace with no measurable $CO_2$

# Normal Capnogram - Phase II

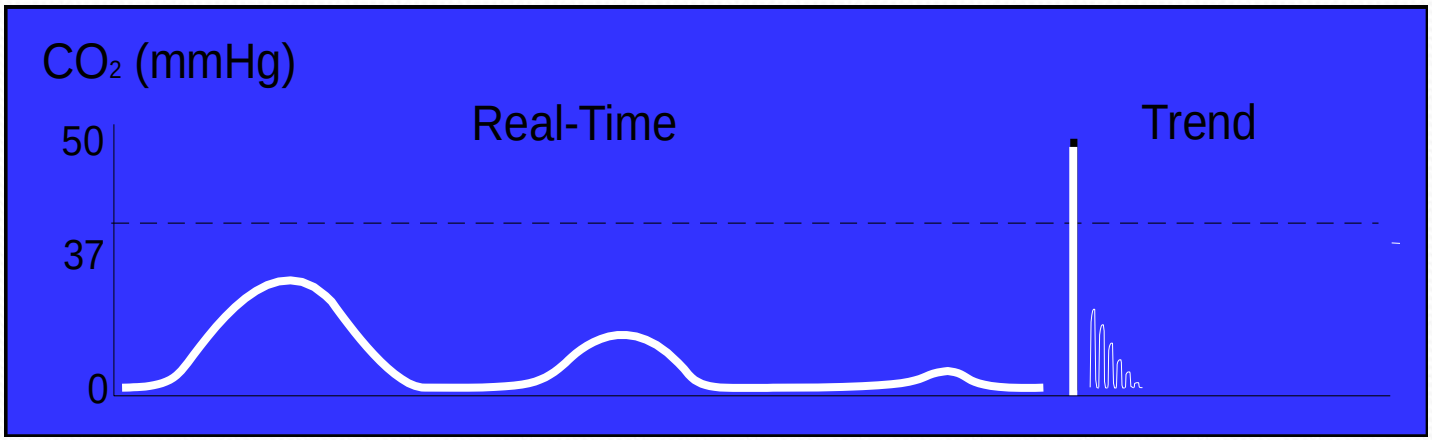


# Normal Capnogram - Phases III & IV



# *Abnormal* Capnograph Waves

Endotracheal Tube in Esophagus

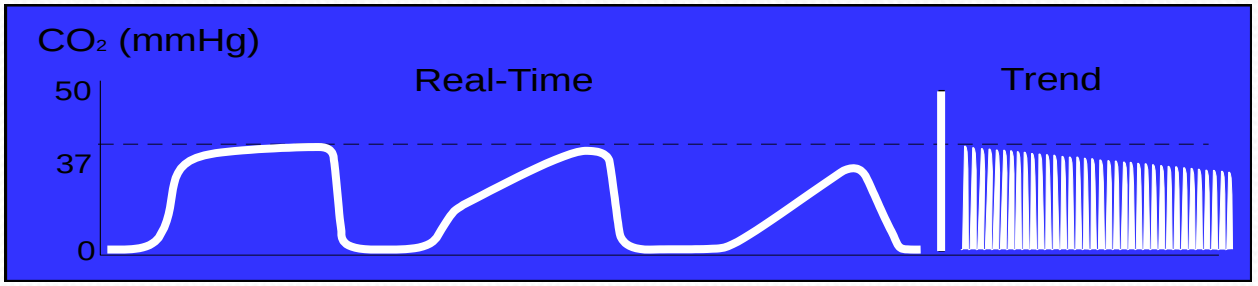



**Possible Causes:**

- Missed intubation
  - When the ET tube is in the esophagus, little or no CO2 is present
  - A normal capnogram is the best indication of proper ET tube placement

# Abnormal Capnograph Waves

Obstruction in Airway or Breathing Circuit

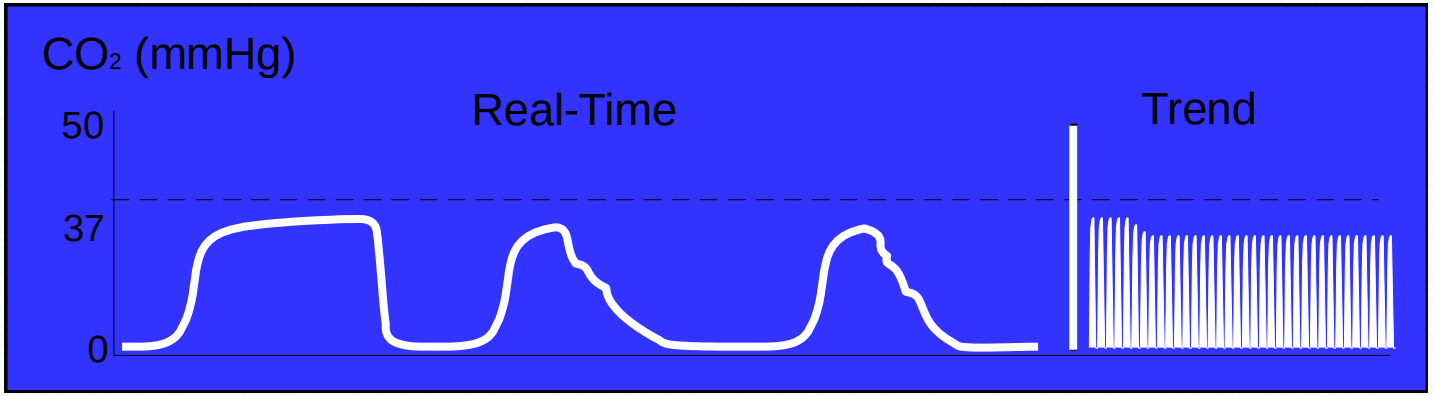



**Possible Causes:**

- Partially kinked or narrowed artificial airway
- Presence of foreign body in the airway
- Obstruction in expiratory limb of breathing circuit
- Bronchospasm

# Abnormal Capnograph Waves

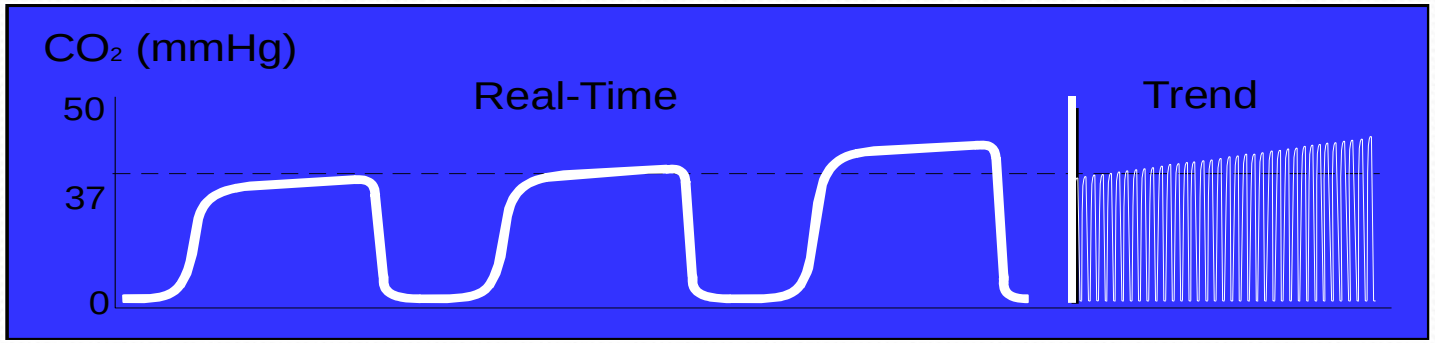
## Inadequate Seal Around ET Tube




**Possible Causes:**

- Leaky or uncuffed endotracheal or trach tube
- Artificial airway that is too small for patient

# Abnormal Capnograph-Hypoventilation

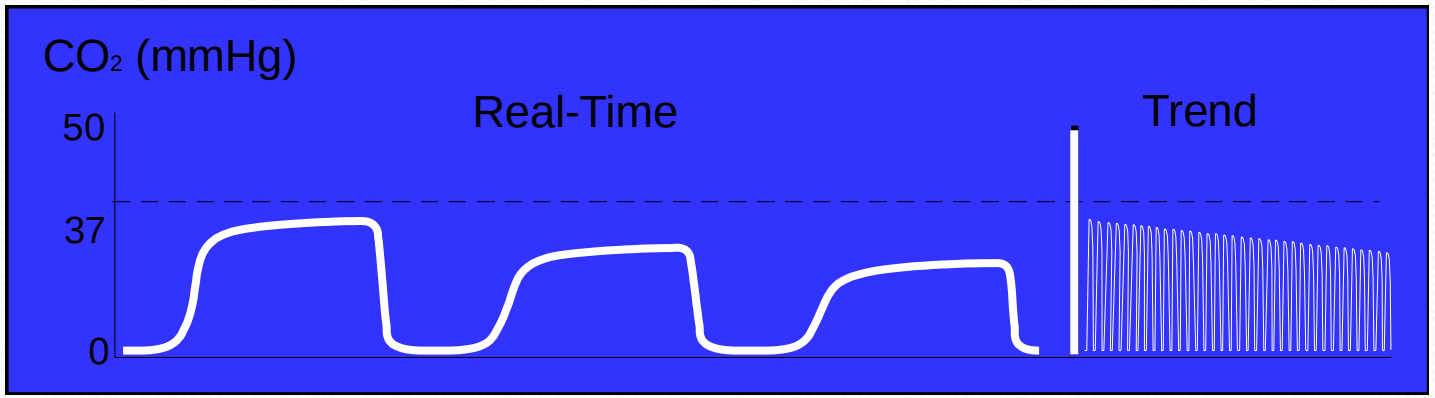



**Possible Causes:**

- Decrease in minute ventilation
- Increase in metabolic rate
- Rapid rise in body temperature
- Less Common:
  - Absorption of insufflated CO2 from laparoscopy
  - Release of a tourniquet from a surgical limb

# Abnormal Capnograph Waves

Hyperventilation - Decrease in $ETCO_2$




**Possible Causes:**

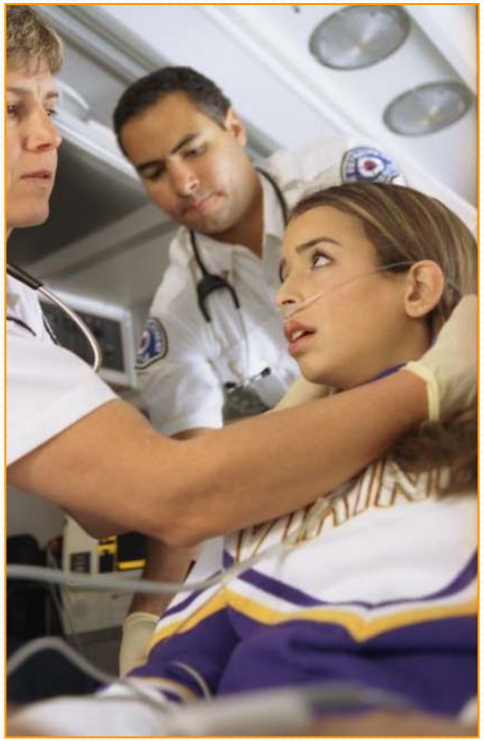
- Increase in respiratory rate
- Increase in tidal volume
- Decrease in metabolic rate
- Fall in body temperature

# Capnography Waveform Question

- How would your capnogram change if you increased your RR from 15 breaths per minute to 30 breaths per minute?
  - Frequency
  - Duration
  - Height

# Capnography Waveform Question

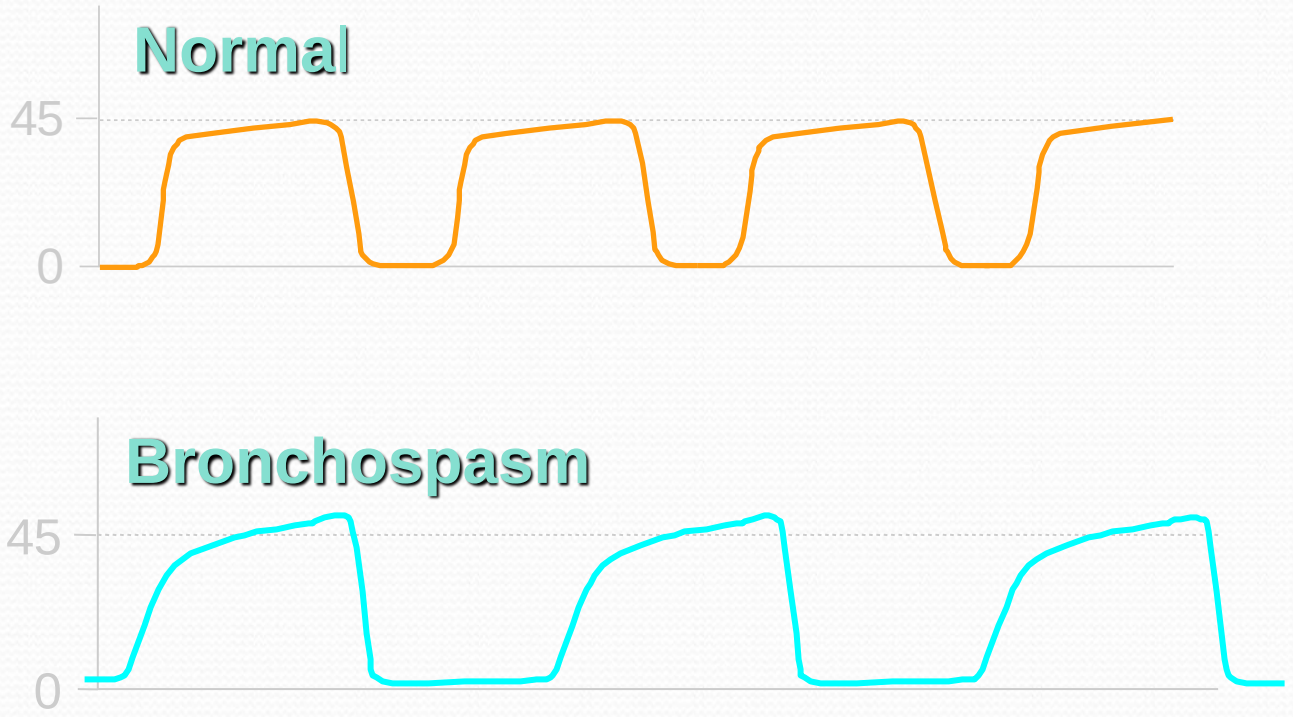
How would the waveform shape change during an asthma attack?



# Bronchospasm Waveform Pattern

- Bronchospasm hampers ventilation
  - Alveoli unevenly filled on inspiration
  - Empty asynchronously during expiration
  - Asynchronous air flow on exhalation dilutes exhaled $CO_2$
- Alters the ascending phase and plateau
  - Slower rise in $CO_2$ concentration
  - Characteristic pattern for bronchospasm
  - “Shark Fin” shape to waveform

# Capnography Waveform Patterns



# Causes of an Elevated ETCO2

- **Metabolism**
  - Overdose / sedation
  - Malignant hyperthermia
- **Circulatory System**
  - Increased cardiac output - with constant ventilation
- **Respiratory System**
  - Respiratory insufficiency
  - Respiratory depression
  - Obstructive lung disease
- **Equipment**
  - Defective exhalation valve

# Causes of a Decreased $EtCO_2$

- **Metabolism**
  - Pain
  - Anxiety
- **Circulatory System**
  - Cardiac arrest
  - Embolism
  - Sudden hypovolemia or hypotension
- **Respiratory System**
  - Alveolar hyperventilation

**Equipment**

- Leak in airway system
- Partial airway obstruction
- ETT in hypopharynx

# Summary

- Capnography can be a useful Assessment Tool
- Understand that it is a relatively straight forward, but valuable tool—A little knowledge can go a long way!!!
- Know the indications  & limitations
- Recognize normal wave forms/values, the abnormals and how to rectify them
- Know where there are add'l resources

# Selected References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