Capnography ($EtCO_2$)- Practical Applications

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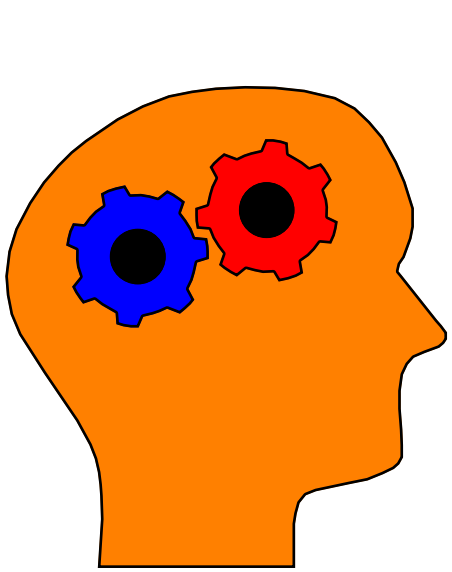
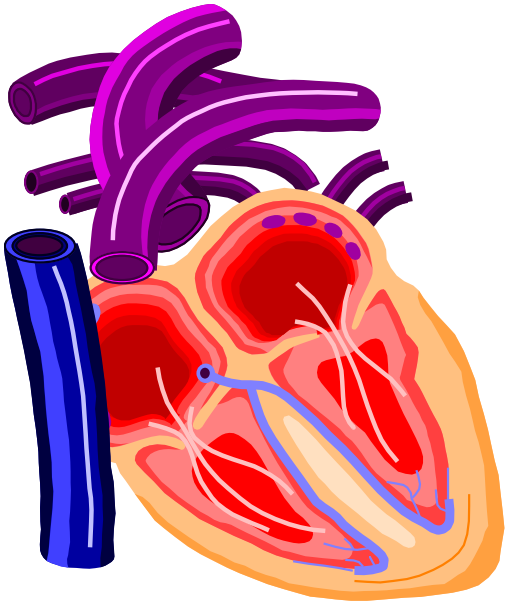
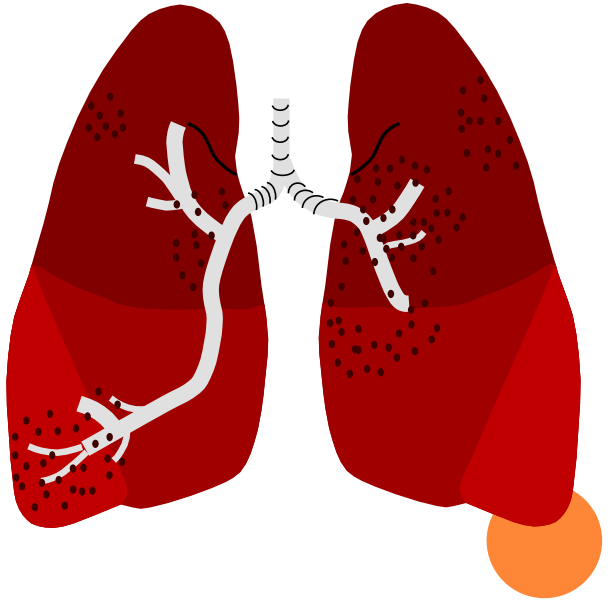






Learning Objectives--EtCO2

- Objectives
  - Explain Indications for EtCO2
  - Illustrate Some of the Equipment
  - Review related research
  - Define what is a normal EtCO2 value
  - Define what are abnormal values/waves & their causes
  - Identify the different wave forms
  - Furnish Add'l Resources

Related Terminology

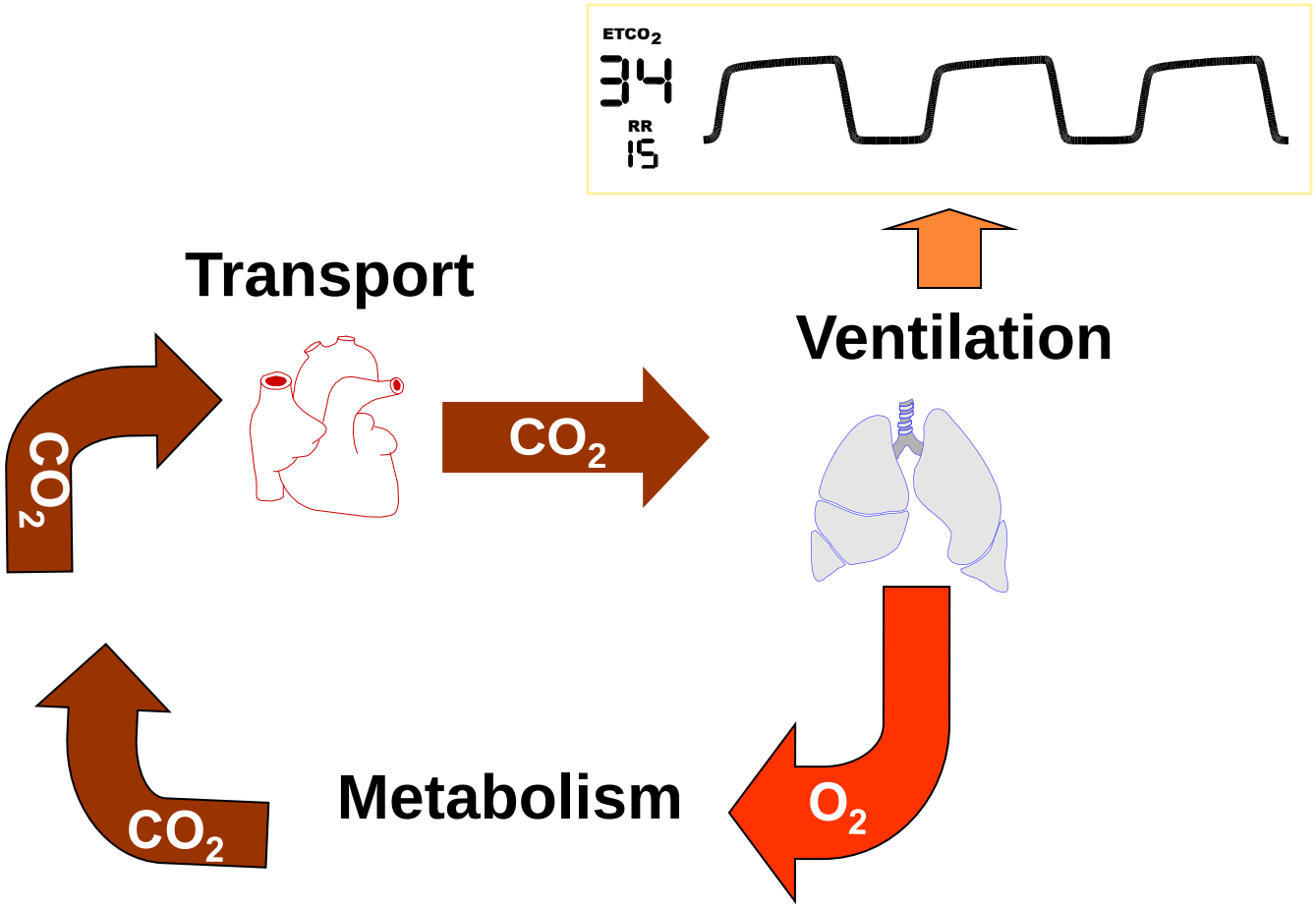
- ***Capnography***- Analysis of waveform (and often numeric value) of exhaled CO2
- ***Capnometry***- Measuring the numeric value of exhaled CO2
- Colormetry – Dichotomous measurement—Purple versus Yellow.
  - Less reliable than waveform!!!
    - In CPR, if no circulation, little CO2 reaching the alveoli = little color change.
    - If High CO2, color may stay yellow after initial change

Who Do We Monitor & Why?

- 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
  - Moderate sedation

Capnography

Capnography Depicts Respiration



Colormetric Detector

Combo Cannula -- O2 Administration and ETCO2 Monitoring

A *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 ETI with waveform capnography!!

More Data--$ETCO_2$, CPR & Survival

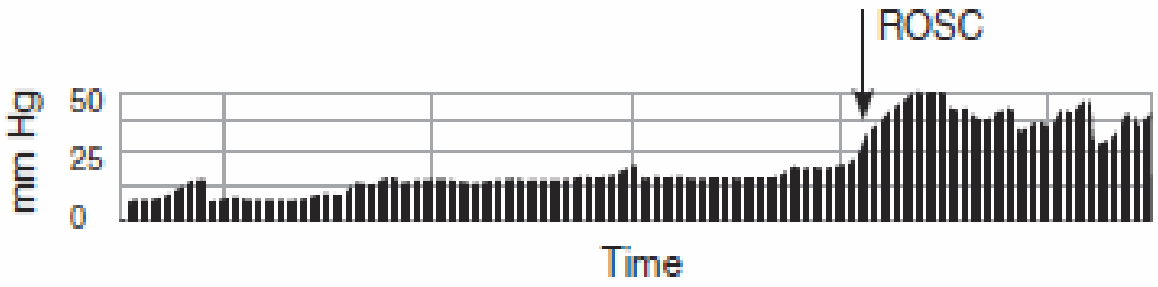
- Non-survivors
  - Average $ETCO_2$: 4-10 mmHg
- Survivors (to discharge)
  - Average $ETCO_2$: >30 mmHg

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.

The Other *Major* Indication- Monitoring Ventilation

- Spontaneous Breathing Patients
  - Neuromuscular
  - COPD
- Mechanically Ventilated Patients
  - Continuous Noninvasive
  - Appropriateness of Settings
  - Weanability

The Numbers--Normal Values

- Normal values
  - Normal Range 7.35 to 7.45
  - Normal EtCO2 is 30-43mmHg
  - Normal PaCO2 is 35-45mmHg

Our Response to Abnormal EtCO2

- How do we stabilize abnormal EtCO2 values?
  - By adjusting minute ventilation
    - If ETCO2 is high - ↑ **V**entilation
    - If ETCO2 is Low - ↓ **V**entilation

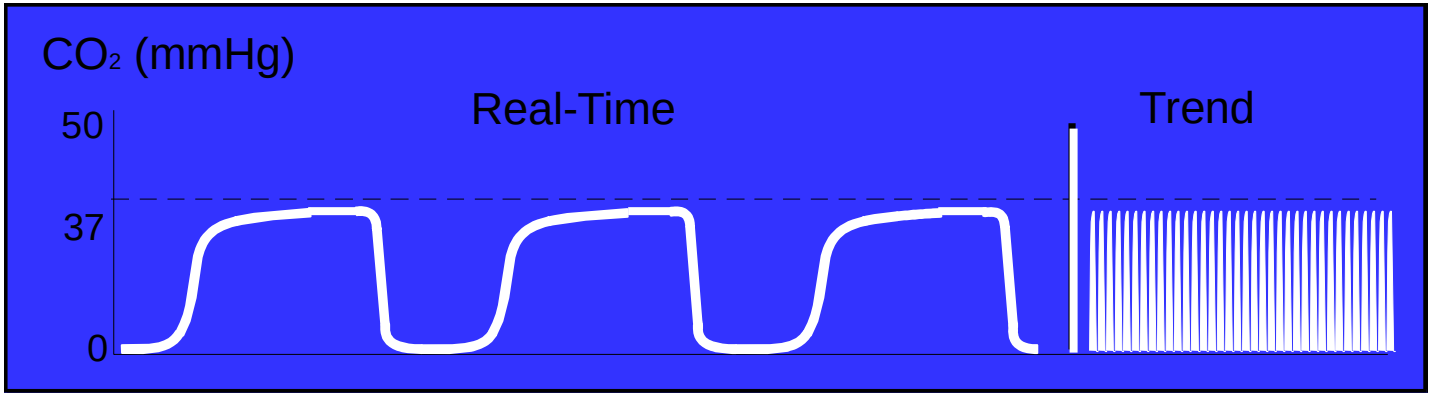
Our Response Cont.-EtCO2

- Stabilizing Abnormal values
  - EtCO2 greater than 43mmHg
    - **Increase tidal volume**
    - **Increase respiratory rate**

Our Response Cont.-EtCO2

- Stabilizing abnormal values
  - EtCO2 less than 30mmHg
    - **Decrease respiratory rate and/*or***
    - **Decrease tidal volume**
    - **Add dead-space? — If head injury**

Example: Normal Capnogram



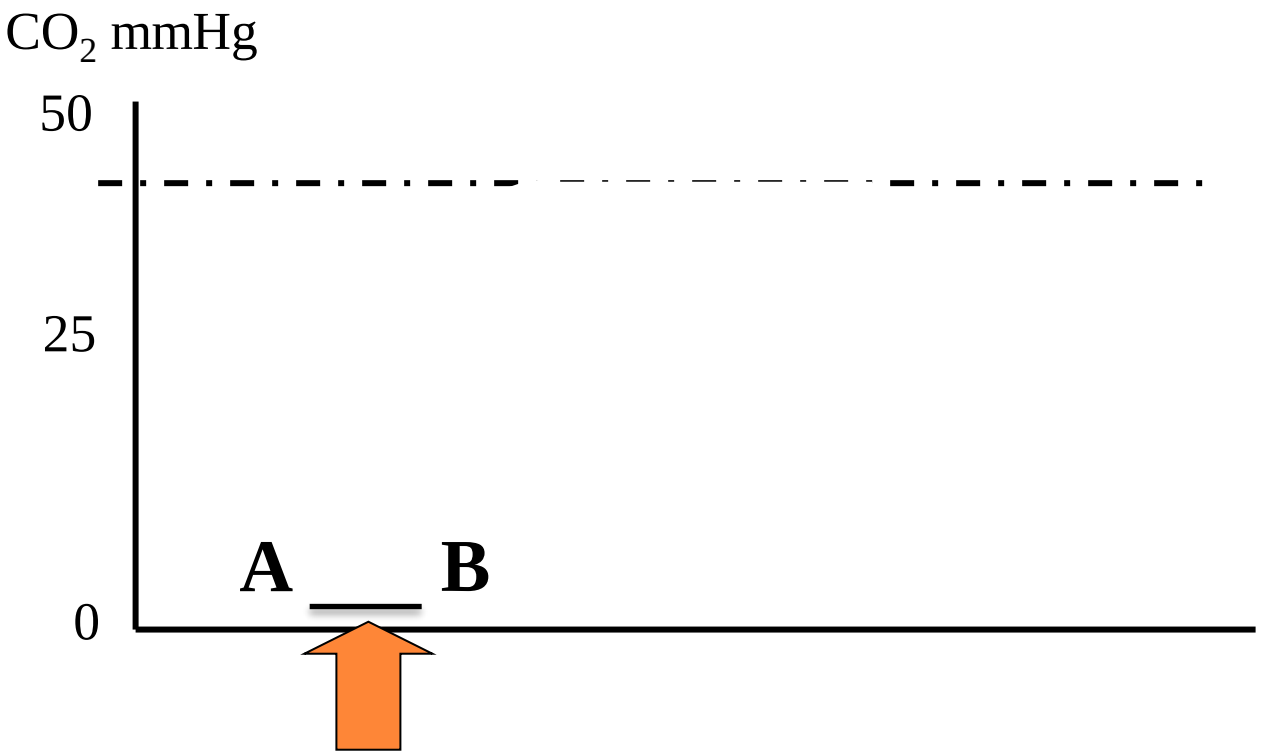
Normal capnogram, stable trend

$ETCO_2$/PaCO2 gradient 4 mmHg

Normal Capnographic *Waveform*

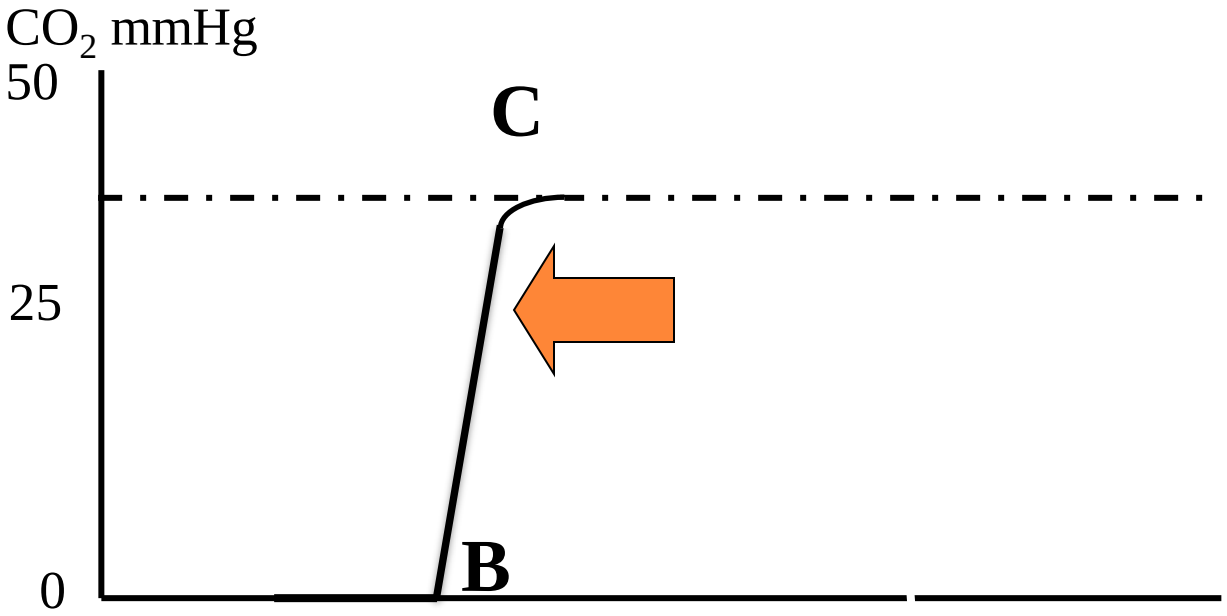
- Normal waveform of one respiratory cycle
- Similar to ECG
  - Height shows amount of CO_2
  - Length depicts time

Normal Capnogram - Phase I

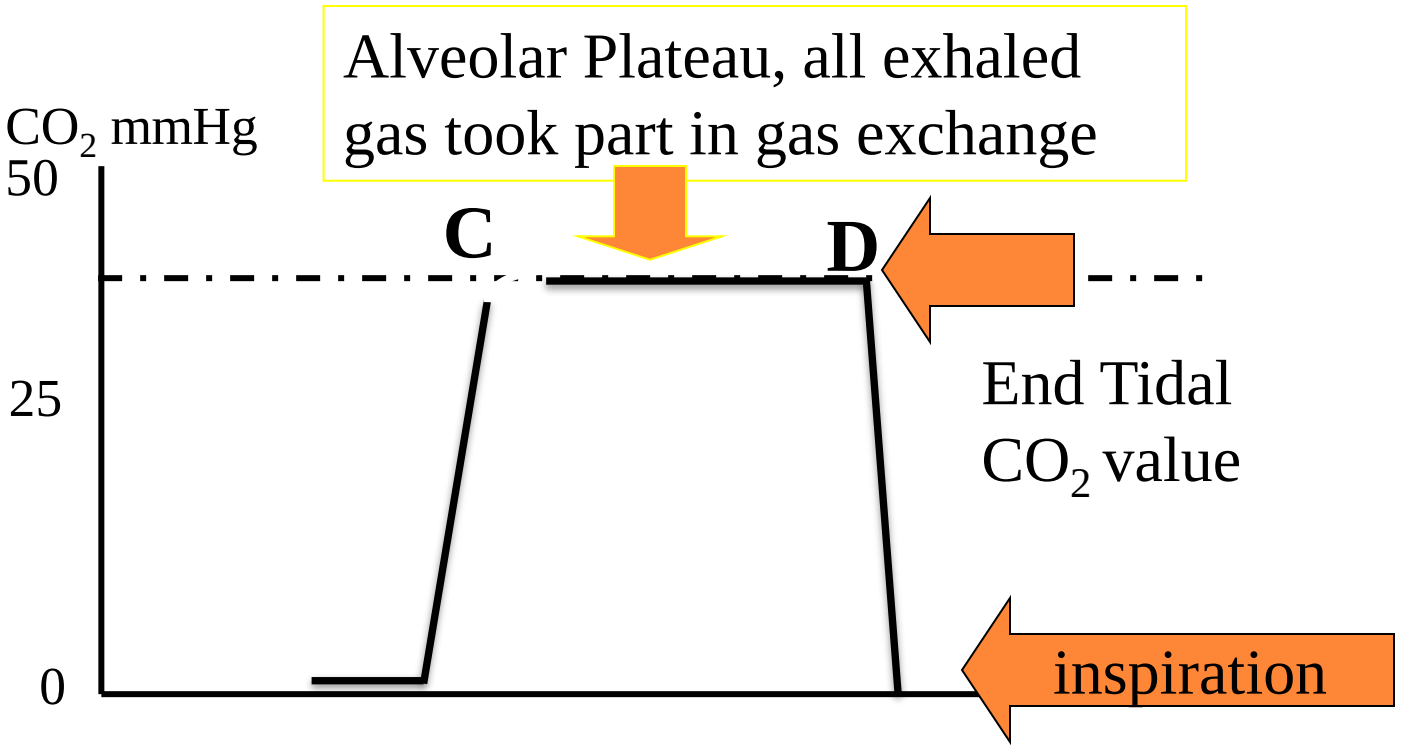


Beginning of expiration = anatomical deadspace with no measurable CO_2

Normal Capnogram - Phase II

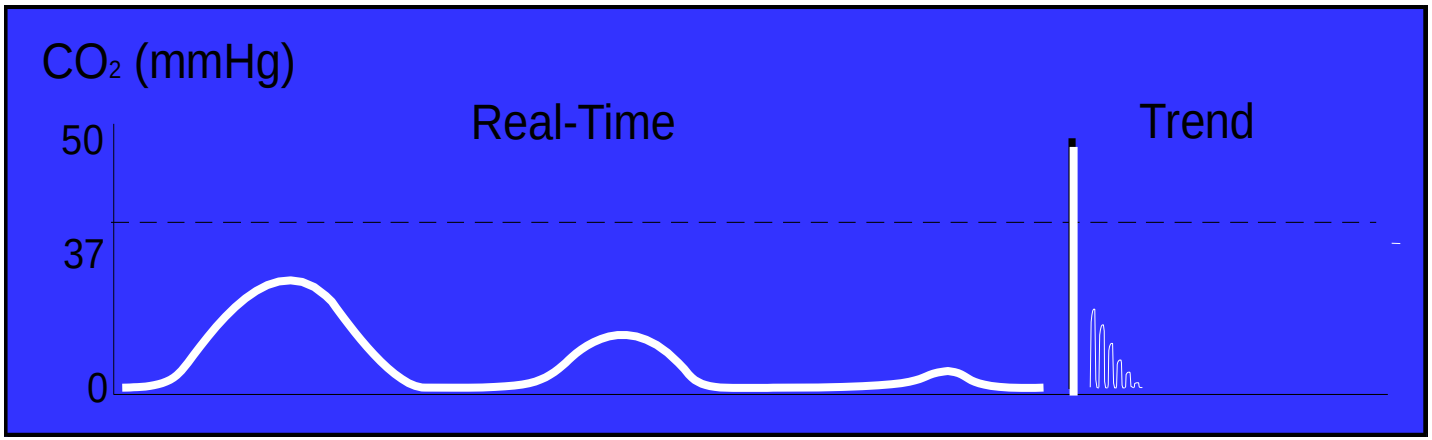


Normal Capnogram - Phases III & IV



Abnormal Capnograph Waves

Endotracheal Tube in Esophagus

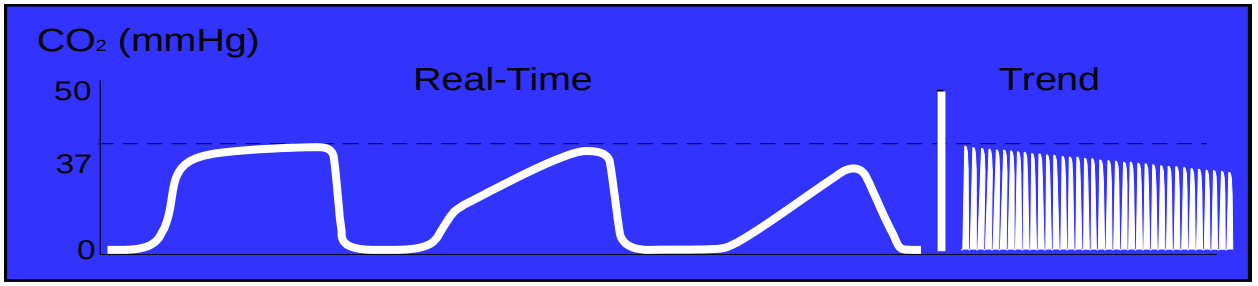


Possible Causes:

- 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

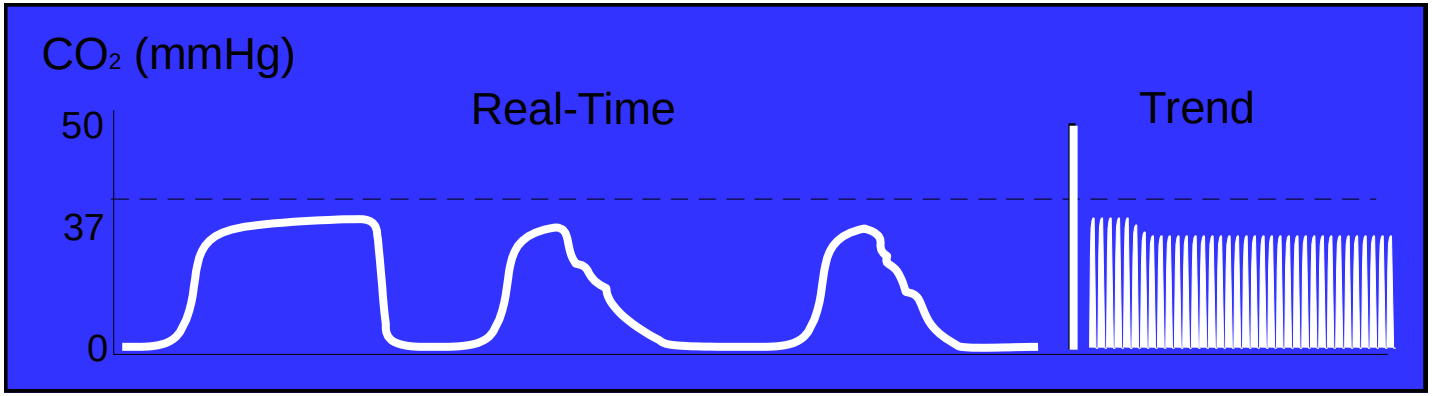


Possible Causes:

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

Abnormal Capnograph Waves

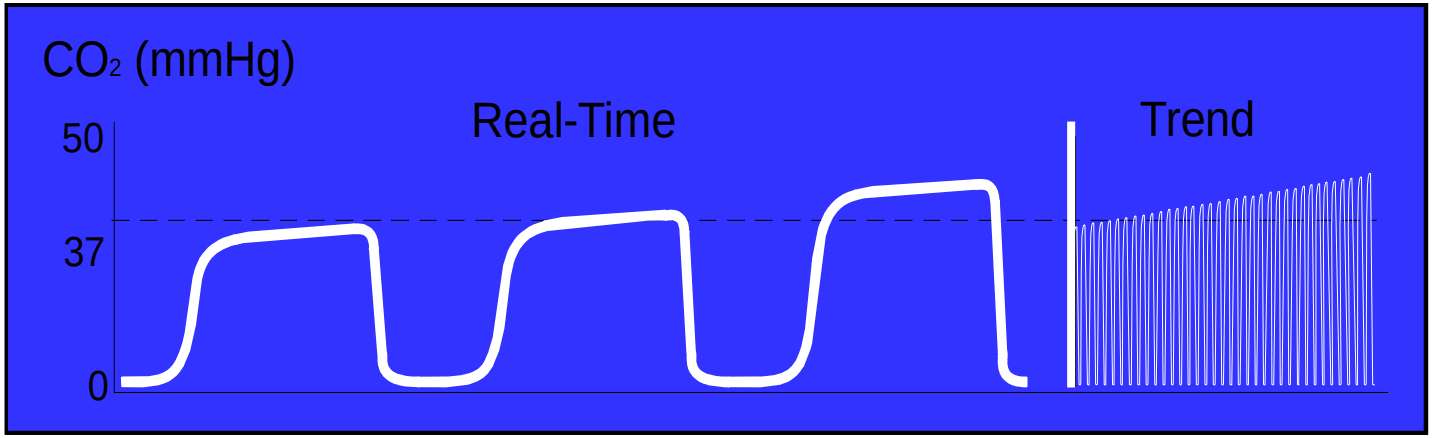
Inadequate Seal Around ET Tube



Possible Causes:

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

Abnormal Capnograph

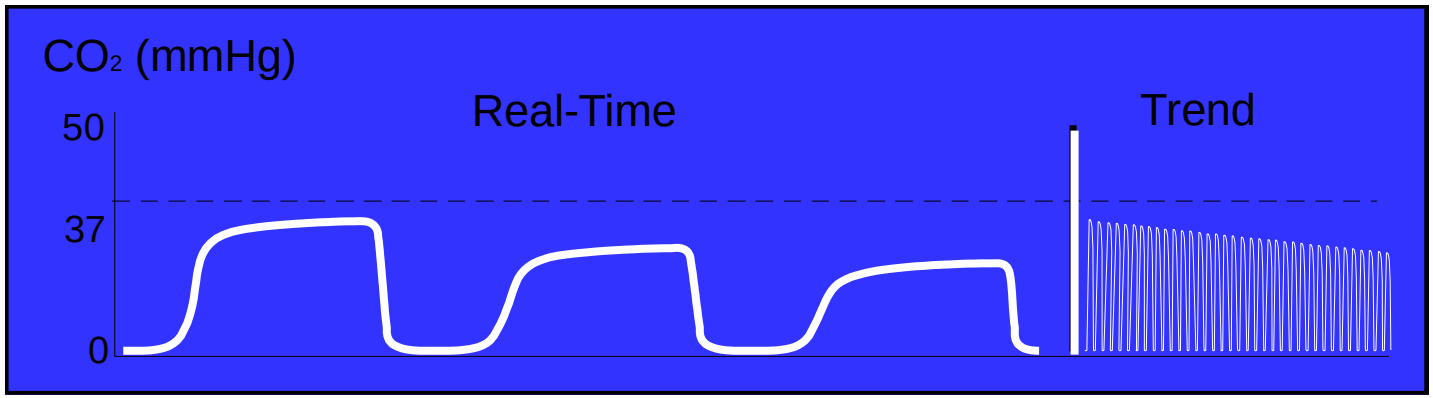


Possible Causes:

- **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

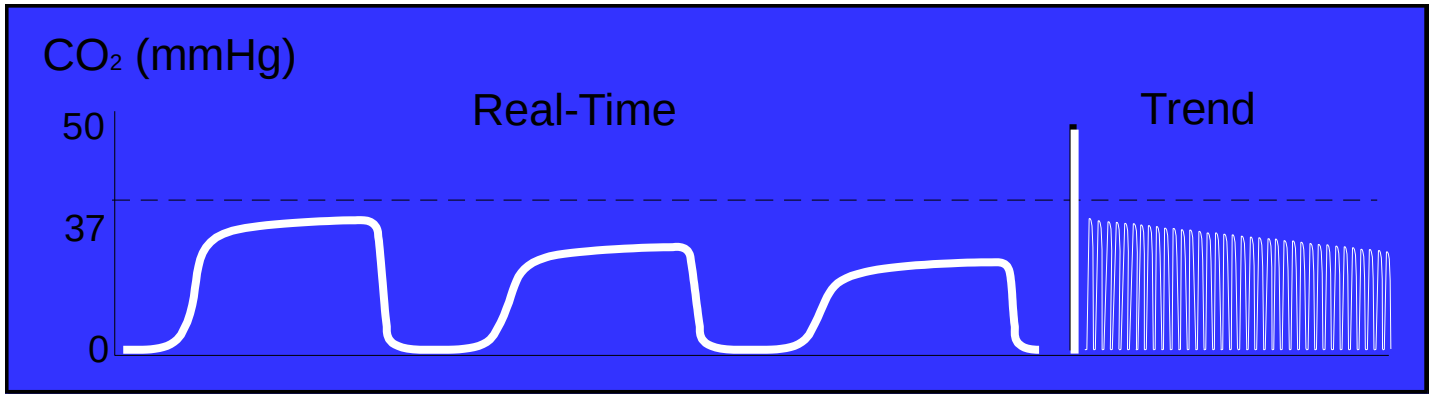
Hyperventilation - Decrease in $ETCO_2$



Possible Causes:

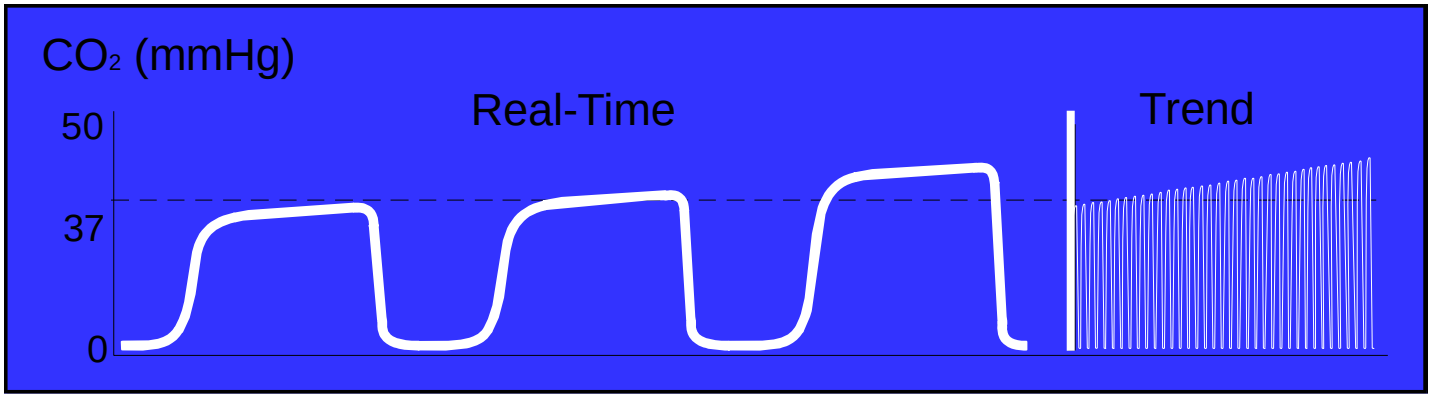
- Increase in respiratory rate
- Increase in tidal volume
- Decrease in metabolic rate
- Fall in body temperature

Common Example: Increase in Minute Ventilation



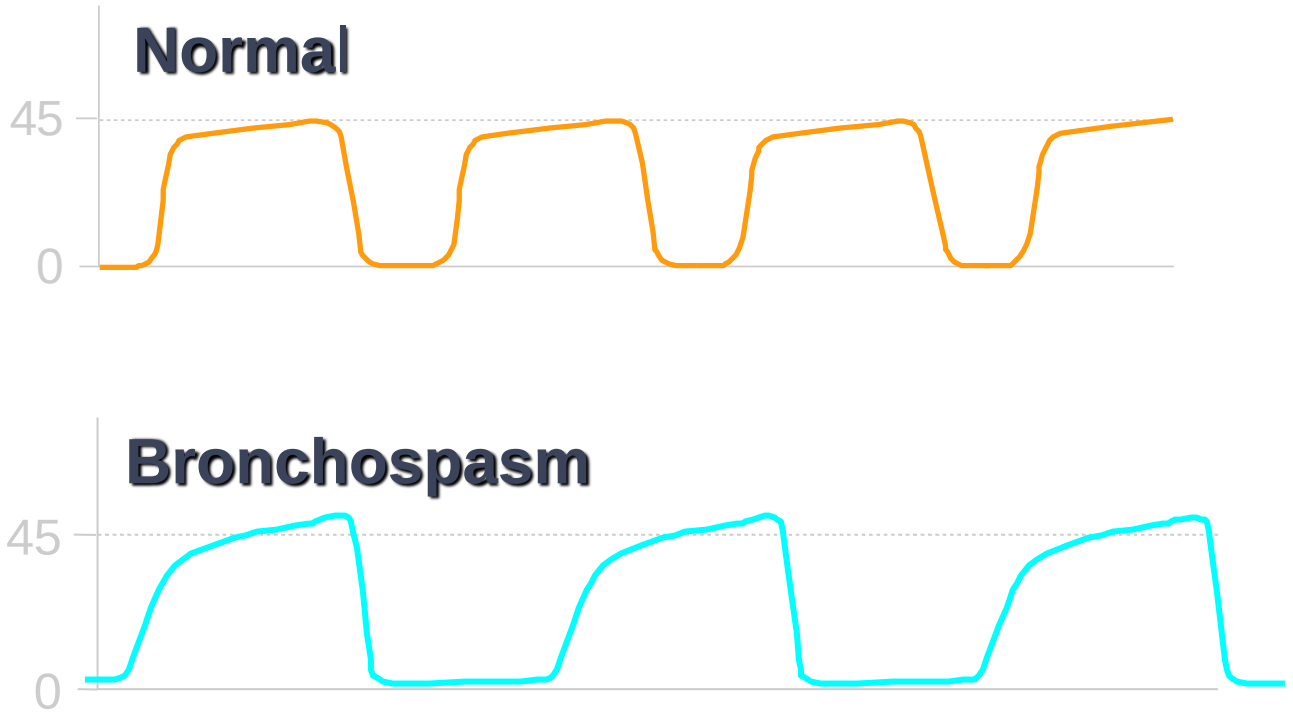
Sudden decrease in $ETCO_2$ from 38 mmHg to 20 mmHg and the RR increases from 12 to 24 bpm

Common Example: Hypoventilation



- Pt. receives 5mg MS for pain
- EtCO2 climbs from 37 mmHg to 45 mmHg

Capnography Waveform Patterns



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

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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- Egan's Fundamentals of Respiratory Care, ed 12, Kacmarek, Stoller & Heuer, 2021.
- Clinical Assessment in Respiratory Care, ed. 8, Heuer & Scanlan, 2018.
- Respiratory Disease: A Case Study Approach to Patient Care, ed 3, 2007.
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