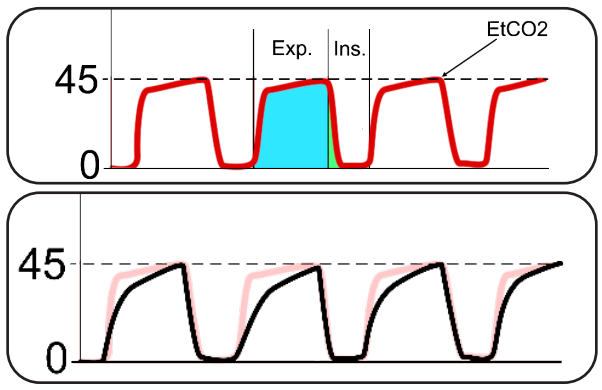
Clinical Considerations with Capnography

GENERAL PHYSIOLOGY / PATHOPHYSIOLOGY:



- **Normal respiratory waveform appears as a plateau ("square" waveform).** When exhalation is prolonged (e.g. airway narrowing, bronchospasm, air trapping, kinked endotracheal tube), the waveform may take on a "shark-fin" appearance (see picture).
- In an individual with normal circulatory and respiratory physiology, a normal end-tidal CO_2 ($EtCO_2$) is 35-45mmHg.
- When the patient experiences respiratory acidosis (e.g. from ventilatory insufficiency), carbon dioxide accumulates in the blood and the $EtCO_2$ increases.
- When the patient experieces respiratory alkalosis (e.g. from hyperventilation), carbon dioxide is excessively removed from the blood so the CO_2 content of the blood is lower ($EtCO_2$ decreases).
- **Patients with abnormal hemodynamics (e.g. shock state) experience metabolic acidosis from poor organ perfusion. In these patients, the $EtCO_2$ may be low because**:
  1. Poorly perfused organs are less metabolically active, and produce less CO_2 (e.g. sepsis, cardiac arrest).
  2. The body increases its respiratory rate to try to remove carbon dioxide to help compensate for the acidosis.
- **Capnography is useful for trending the patient's course** (e.g. worsening versus improving respiratory acidosis) as well as observing response to treatments (e.g. improvement in waveform morphology and $EtCO_2$ level after starting bronchodilators in an asthmatic patient).

BVM, EGD, and ETT

- **End-tidal capnography is MANDATORY to confirm EGD and ETT. It is recommended with BVM.**
- **End-tidal waveforms should appear within three seconds** of connecting the end-tidal probe to the circuit.
- **False positives from esophageal intubation can occur** (e.g. recent consumption of carbonated beverages), but should dissipate within a few ventilations. Usual techniques of confirmation (e.g. breath sounds) should be checked during the first few ventilations.
- It is acceptable to increase ventilatory rate and/or depth to compensate for a high $EtCO_2$.
- **DO NOT attempt to correct a low $EtCO_2$ in a patient with signs of shock (e.g. fast heart rate, low blood pressure, tachypnea).** This is the body's compensatory response to acidosis; if this process is impaired, the patient could become critically acidemic.
- **If a patient with an ETT or EGD loses a previously good capnography waveform, rapid action must be taken to reassess the airway device:**
  1. Connect a BVM (if previously on ventilator) and assess for chest rise, breath sounds, and oxygenation.
  2. Assess the device for migration by comparing the current depth with the depth at the time of placement.
- **If there is evidence that the device has dislodged or ceased to function (e.g. poor ventilation, decreasing oxygen saturation, significant depth migration), immediately remove the device and ventilate by BVM.**
- If other findings are reassuring, consider replacing the capnography circuit before replacing the airway.
  NOTE: *If fluid (e.g. blood, saliva) is introduced into the capnography probe, it may cease to function. If the device takes an impact, it may also engage a reset of the capnography hardware.*

SHOCK AND SEPSIS

- $EtCO_2$ < 25mmHg correlates with both hemorrhagic shock (in trauma patients) and septic shock (in medical patients) and **predicts higher mortality** in both.

CARDIAC ARREST

- **End-tidal capnography should be used routinely in cardiac arrest.**
- An abrupt rise in $EtCO_2$ may be the first sign of improved perfusion (e.g. ROSC).
  NOTE: *The administration of sodium bicarbonate will result in a sudden increase in CO_2 in the blood that can artificially raise the $EtCO_2$.*
- Trends in $EtCO_2$ may indicate the **quality of chest compressions**.
- Low $EtCO_2$ (<10mmHg) is associated with poor survival.
- **The significance of abnormally high $EtCO_2$ (>45mmHg) in cardiac arrest is unclear.**
  When elevated $EtCO_2$ is observed with pulseless electrical activity, it is reasonable to consider respiratory causes of cardiac arrest and to adminster fluid bolus for "pseudo-PEA" (phenomenon where the heart is beating too weakly to generate a pulse).

TRAUMATIC BRAIN INJURY

- **Hyperventilation is NO LONGER RECOMMENDED for patients with traumatic brain injury**, due to concerns about reducing perfusion to threatened parts of the brain.
- If the patient has an **isolated** head injury (e.g. normal hemodynamics) it is reasonable to target a low-normal $EtCO_2$ of 35mmHg.
- If the patient has a head injury **AND** exhibits a shock state, a low $EtCO_2$ is permissible (**and should not be corrected**), as this is the body's attempt to compensate for acidosis.

OBSTRUCTIVE DISEASE

- **Any condition that prolongs the expiratory phase of respiration will lead to a "shark-fin" appearance of the capnography waveform.**
  - Bronchoconstriction
  - Airway narrowing
  - Kinked endotracheal tube
- If the airway narrowing results in air-trapping, CO_2 may accumulate in the blood and $EtCO_2$ may also rise.
- The waveform can be trended to assess response to intervention.