Capnography
An Overview

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Objective

Gain a clear understanding of capnography and its invaluable benefits to the pre-hospital provider.

Capnography

- Non-invasive measurement of the partial pressure of CO_2 in exhaled breath
- Measurement depicts the concentration of CO_2 over time
  - Shown as a waveform or capnogram
    - Changes in the waveform indicate different disease processes
    - Changes in the End-Tidal CO_2 ($EtCO_2$) used to ascertain disease severity or to evaluate treatment response
- Excellent indicator of tracheal placement of ETT

Historical Perspective

- First routine use reported by European anesthesiologists in 1970's
- Progressed to United States in 1980's
  - Considered to be a standard of care for General Anesthesia
- Studied for more than 20 years as a pre-hospital tool

Basic Physiology

- Two separate processes involved in pulmonary gas exchange
  - OXYGENATION
  - VENTILATION

Basic Physiology

- Oxygenation
  - Delivery of Oxygenation to the lungs for use by the cells
    - FiO2
    - PEEP

Basic Physiology

- Ventilation
  - Removal of CO2 from the lungs
    - Increase tidal volume
    - Increase Respiratory Rate

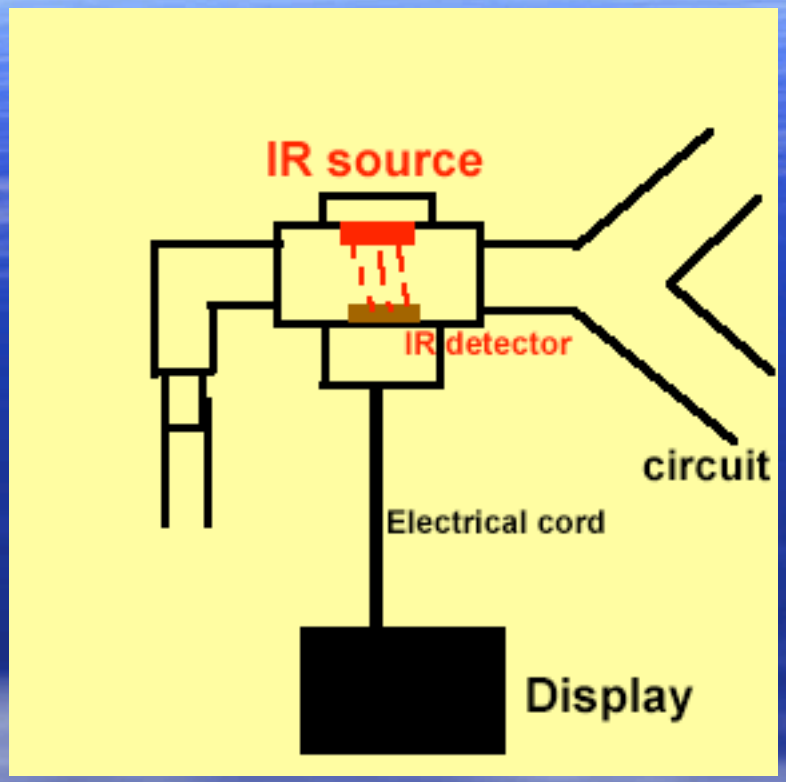
Capnography

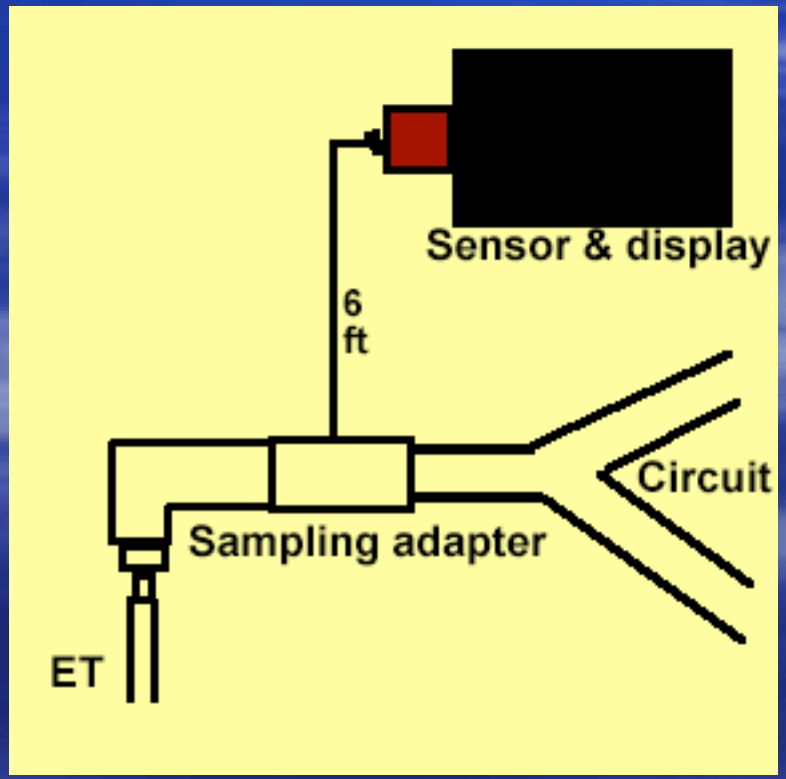
- Assess adequacy of ventilation
- Assess perfusion
- Assess cellular metabolism
- Assess ETT placement

Capnography

- Mainstream devices
  - Measure respiratory gas directly from the airway
  - Designed for intubated patients
- Side stream devices
  - High flow rates (150cc/min)
  - Low Flow rates (50cc/min)

Capnography





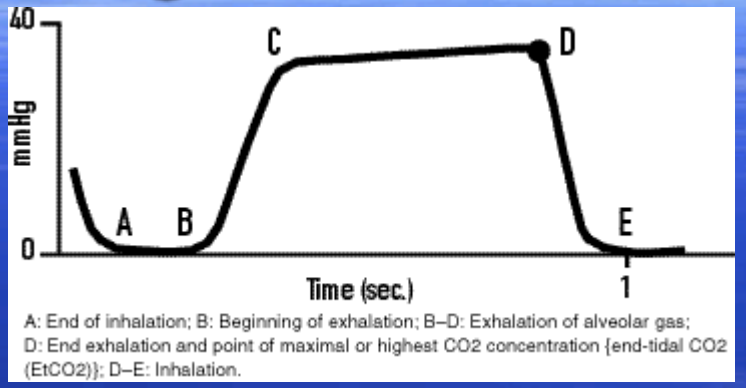
Capnography

- Qualitative measurements
  - Calorimetric EtCO2 detector
    - Look for color change to indicate proper placement fo ETT
    - Litmus paper changes from purple to yellow
      - EtCO2 <3 mmHg PURPLE
      - EtCO2 3-15 mmHg TAN
      - EtCO2 >15 mmHg YELLOW

Capnography

- Quantitative measurements
  - Measure end-tidal CO2 (EtCO2)
    - Capnometry
      - Number only
    - Capnography
      - Number and waveform
  - Infrared radiation measure CO2 molecules

Normal Capnogram



A: End of inhalation; B: Beginning of exhalation; B–D: Exhalation of alveolar gas; D: End exhalation and point of maximal or highest CO2 concentration {end-tidal CO2 (EtCO2)}; D–E: Inhalation.

- Phase 1 (AB)
  - Dead space ventilation
- Phase 2 (BC)
  - Rapid rise in CO2 as air from alveolar region of lungs is exhaled
- Phase 3 (CD)
  - CO2 concentration equalizes in the exhaled breath
  - Point D = ETCO2
- Phase 4 (DE)
  - Inspiratory cycle

Capnography

- Clinical Applications
  - Verification of ETT placement
  - Continuous monitoring of ETT placement during transport
  - Gauging effectiveness or resuscitation and prognosis during CPR
  - Titrating EtCO2 levels in patients with potential for increased ICP
  - Prognosis for trauma
  - Adequacy of ventilation

Verification of ETT placement

- Unrecognized misplaced intubation in EMS
  - Katz and Falk reported UMI rate of 25% in 2001 study
  - Other studies have reported UMI rate of 7-10%

WE MUST DO BETTER!!!

Verification of ETT placement

- Waveform with all phases indicates proper ETT placement
  - Can see normal waveform in right main stem intubation
- Flat waveform USUALLY indicates esophageal ETT

Verification of ETT placement

- Flat capnography waveform
  - Prolonged cardiac arrest
    - Cellular death results in lack of CO2 production
  - Inadequate pulmonary blood flow
    - Poor CPR
  - ETT obstruction
  - Foreign body distal to ETT
  - Technical malfunction of monitor or tubing

Verification of ETT placement

- Take home message...
  - Accuracy of capnography in determining ETT placement depends on availability of CO_2
  - Sensitivities reported close to 100% in patients with spontaneous circulation
  - Sensitivities reported between 62% and 100% in cardiac arrest patients

During Transport

- Monitoring during transport can alleviate un-noticed dislodging of ETT
  - Pitfalls of ETT security during transport
    - Movement
    - Noise
    - Distractions

Effectiveness of CPR

- EtCO2 increase indicates effective CPR
  - During cardiac arrest, EtCO2 reflects pulmonary blood flow because alveolar ventilation and metabolism basically constant
  - Effective CPR
    - increased Cardiac Output
    - increased EtCO2

Return of Spontaneous Circulation

- Return of cardiac activity results in a rapid jump in EtCO2
  - Due to clearing of accumulated CO2 form cardiac arrest.

- Capnography lessens the need to stop CPR to check for pulse
  - Allows increased number of chest compressions as per AHA guidelines for cardiac resuscitation

Prognosis in Cardiac Arrest

- Several studies (prospective, observational)
  - $EtCO_2$ levels of < or = 10 measured 20 minutes after beginning CPR predictive of death in adult patients

Increased ICP

- Capnography can allow for appropriate ventilation
  - Sustained Hypoventilation ($PaCO_2$ > or = 50 mmHg)
    - Increased cerebral blood flow
    - Increased ICP
  - Sustained Hyperventilation ($PaCO_2$ < or = 30 mmHg)
    - Worse neurological outcome

Summary

- Capnography is a tool that the pre-hospital provider should take advantage of
  - Non-invasive
  - Good track record for confirmation of ETT placement
  - Allows for continuous monitoring of EtCO2
  - Capnography best used for assessing pure ventilation, perfusion, and metabolic problems

References

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- http://www.capnography.com/Physics/images/Mainstream.gif
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- http://www.capnography.com/images/Emergencydevice/capnocheck.jpg