BASIC CAPNOGRAPHY

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Outline:

- Why Capnography
- Review Airway Anatomy and Physiology
- Applied Physics
- Types of End Tidal CO2
- Using Capnography in the Field
- Overview of Equipment

NO, IT IS NOT THE PULSE OX!

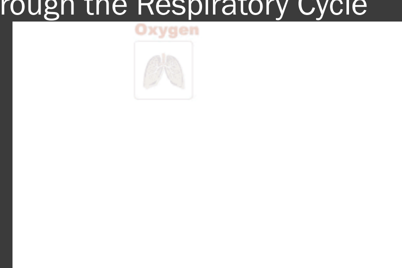
Capnography 2009

- BLS Skill with placement of blind rescue airways
  - King LTD
  - Combitube
- Applies to any ventilated patient
  - Bag-mask
  - ETI and rescue airways
  - Transport vent
  - CPAP?
- Noninvasive applications

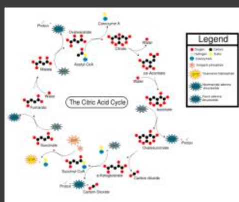
Capnography

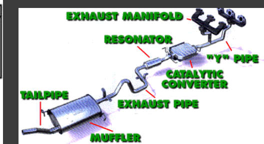
- Defined as the monitoring of exhaled carbon dioxide through the respiratory cycle
- Measuring of End tidal CO2 is considered a standard of care for confirming endotracheal tube placement
- An important adjunct for assessing a critical patient

The Journey of A Molecule Through the Respiratory Cycle



Fundamental Comparison



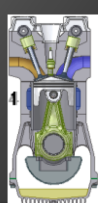


Human Being **Gas Engine**

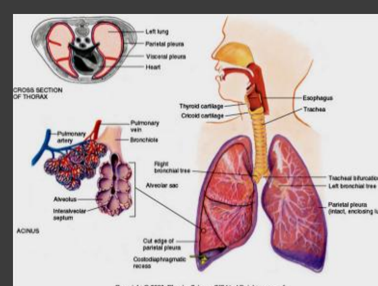
Comparison
Human and Gas Engines

- What do we need to do work (use energy)
  - Fuel (glucose or petroleum)
  - OXYGEN
  - Chemical process: (ignition)
- What do we give off? (Respiration)
  - Human: Carbon Dioxide
  - Engine: Carbon Monoxide

CAPNOGRAPHY: LIKE MEASURING THE EXHAUST OFF OF AN ENGINE



Anatomy Review

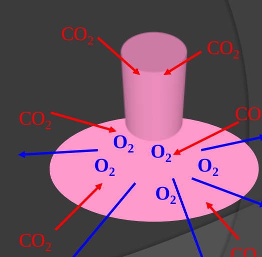


Action at the Alveoli

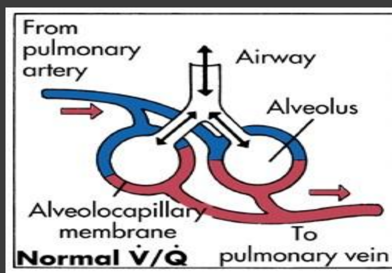
- ***Oxygenation*** of vital organs is the primary function of the respiratory system
- ***Ventilation*** is the movement of air/oxygen into the lungs
- ***Perfusion*** is the oxygenation of the cells through the alveoli
- ***Gas exchange***: In with the good, out with the bad
  - Is the bad leaving?
- ***Ventilation versus perfusion: (V/Q)***
  - Is what you are putting in getting to the cells?

Alveolar Detail

- O2 and CO2 exchange across semi-permeable membrane
- "Pressures" in blood stream and tissue affect quality of exchange



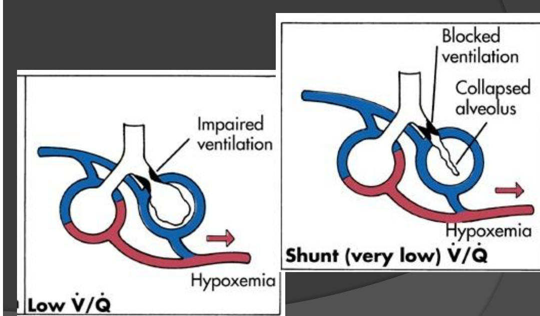
Normal V/Q Ratio



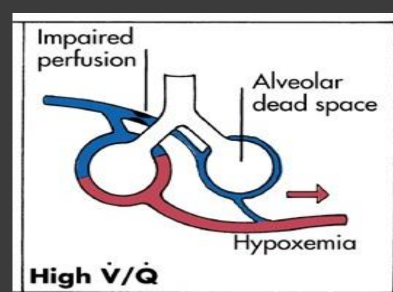
Alveolar Perfusion Problems

- Shunt Problem
  - Blocking of bronchial airways
    - Pneumonia, atelectasis
    - Right main stem intubation
  - Causes retention of CO2, increased levels
- Dead Space Ventilation
  - Capillary flow to alveoli impaired
    - Low Cardiac output, hypotension
    - Excessive PEEP
  - CO2 does not cross into the alveoli for exhalation
  - Decreased levels of expired CO2

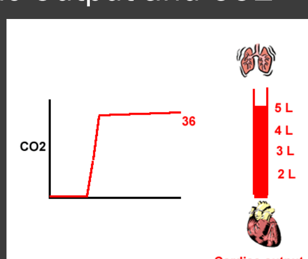
Impaired Ventilation
Shunt Problem



Dead Space Ventilation



Cardiac Output and CO2



Normal Respiration

- Oxygen diffuses into blood stream through the alveoli, and is transported to the cells.
- Cells produce Carbon Dioxide as waste product
- CO2 transport in venous blood to the capillaries of the alveoli, and diffuse across membrane into alveolar space and exhaled

Measuring End Tidal CO2

- Dalton's Law:
  - Total pressure of a gas is the sum of the partial pressures of the gas
- Expired CO2 measured (PetCO2)
  - mmHg in waveform
  - Percentage
- Normal Levels
  - PaO2 85-100mmHg
  - PaCO2 35-45mmHg

Percentage vs. mmHg

- Relate to the air we breath:
  - 78% Nitrogen
  - 21% Oxygen
  - 1% CO2 and other gases
- Exhaled gases:
  - 16% Oxygen
  - 4 to 5% CO2

PetCO2 vs. PaCO2

- PetCO2
  - End tidal measurement from expired or exhaled air
- PaCO2
  - Arterial blood gas sample
- End tidal normally 2-5 mmHg lower than arterial

Comparing Arterial and End-tidal CO2

Review of Airway Confirmation

- Visualization
- Auscultation:
  - Negative Epigastric sounds
  - Equal lung sounds
- Esophageal detector
- End tidal CO2 detector
- Secondary signs: misting, increased SaO2

Types of End-Tidal CO2

- Qualitative
  - Yes or No
  - Nellcor, Portex, or built in to BVM
- Quantitative
  - Numerical value (capnogram)
  - Waveform (capnograph)
  - Mainstream or Sidestream

Capnometry vs. Capnography

- Capnometry is a numerical value only
- Capnography is a waveform, providing a visual representation of a ventilation
  - Provides the numerical value
  - Waveform indicates pattern of breathing
  - Quality of ventilation
  - Rate

Quality is Key

- Poor Perfusion or Poor Ventilation
  - Dramatic alternations in Homeostasis
- Poor Cardiac Output
  - Equals Poor Perfusion
  - Decreased Carbon Dioxide
- Pearl of Wisdom
  - “In with good air, out with bad”
  - “Blood goes round and round”

Qualitative Detectors

- Detect presence or absence of CO2, but do NOT give specific values or levels
- Colorimetric
  - pH sensitive paper
  - Color changes with CO2 exposure
- Limited value once contaminated with moisture, drugs, or body fluids
- Most common: Nellcor EasyCap II, Portex CO2 clip

Quantitative Detectors

- Electronic, infra-red analyzers
- Use IR absorption spectrophotometry
  - Certain gases will Absorb IR light
- Mainstream
  - IR detector in line, at end of ETT, “real time”
- Sidestream
  - IR detector in machine, attached by tubing
  - Intubated and non-intubated
  - 3-5 second time delay

Capnography Monitors

- Wide variety: evolving as devices change
- Oridion supports Microstream
  - Sidestream devices, pulling gases into device
- Respironics/Novametrix supports Zoll, Propaq
  - Mainstream

Sample Capnography Display

Sidestream

- Sensor is located in device like LP12
- Adapter tube attaches to ETI
- Pump in machine pulls air in for measurement
  - 100 to 150 ml air in early devices
  - 50 ml in Microstream
- Concerns:
  - Delay of 3-5 seconds
  - Quality of sample

Sidestream

- Easier to use non-invasively
- Key is quality of the patient's respirations
  - Shallow is poor
  - Mouth breathing is challenging
  - Newer devices assist in increasing accuracy
- Sidestream is LESS specific because of its engineering

Side-stream Detector

Sidestream Detector

Cannula with mouth scoop

Oxygen and sensor

Mainstream Detector

- Sensor at end of cable
  - Disposable adapter to ET tube
- "Real time" values-best for critical care
  - As the gas passes the IR sensor
- Concerns:
  - Not easily adapted to non-intubated patient
  - Can be heavy for pediatric of infant ET tubes
  - Cable is expensive

Mainstream Detector

Lifepak 12

- Monitor/12 lead
- Configures for critical care monitoring
- Defib/pacemaker
- Capnography
  - Sidestream
  - Microstream
- Downloadable, stores 100 activations

Propaq Critical Care Monitor

- Vital signs only
- Capnography
  - Mainstream
- Critical care central line monitoring
- Collects and prints trends
- DOES NOT STORE DATA

Zoll M and E series

- EMS and Critical Care
- Capnography mainstream and sidestream
  - Depends on model
  - Respironics/Novametrix technology
- Data collection

- Multi-parameter monitors
- Capnography
  - Microstream

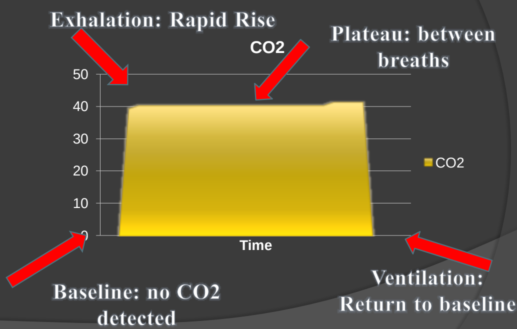
Tidal Wave/Respironics

- Hand held
- Combined Pulse Oximeter and Capnography
- Downloadable

Nellcor N85

- Handheld
- Combined Pulse Oximeter and Capnography

Normal EtCO2 waveform



Parts of the Waveform

- Baseline: no CO2 is passing the sensor
  - Inhalation/ventilation by BVM
- Upslope: rapid rise in CO2 level
  - Exhalation/relaxation of BVM
- Plateau: rest at end of exhalation
  - May have a gradual rise at end
- Down slope: rapid decrease as inhalation occurs

EMS Applications

- Confirmation of airway placement
  - Endotracheal tube (CO2 present)
  - Gastric tube (no CO2 present)
- Quality of Cardiopulmonary Resuscitation
  - Tube confirmed, but CO2 levels remain low
  - Poor cardiac output leads to lower PetCO2
- Clinical Conditions require the use of trend data and constant minute volumes

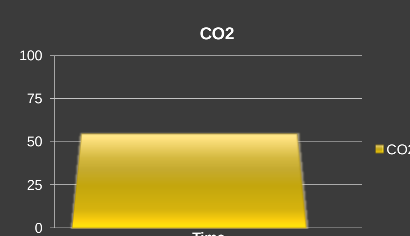
Pathology Associated Capnography

- Oxygen and Carbon Dioxide
  - What do the numbers mean
- Hypoventilation:
  - O2 < 60mm/Hg
  - CO2 > 45mm/Hg (Hypercapnea)
- Hyperventilation:
  - O2 > 100mm/hg (SaO2 above 98%)
  - CO2 < 35mm/Hg

Clinical Conditions with Increased CO2

- Increased CO2 production
  - Bicarbonate administration, fever, seizures, sepsis, thyroid storm
- Decreased alveolar ventilation
  - COPD (retaining CO2), hypoventilation, muscular paralysis, respiratory depression
- Equipment Problem
  - Rebreathing, ventilator leak

Hypoventilation

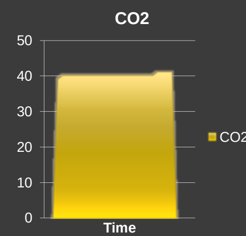


Gradual increase in CO2 levels, often from retention or V/Q mis-match

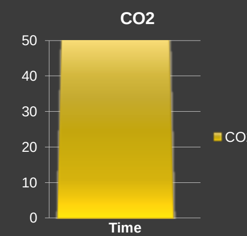
Hypercapnea

Increased CO2 levels with normal waveform

Comparing Waveforms



Normal

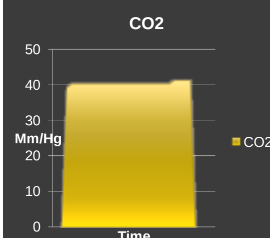


Hypercapnea

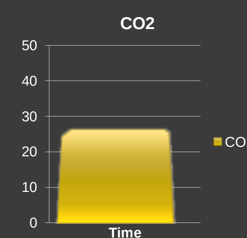
Clinical Conditions with Decreased CO2

- Decreased CO2 production
  - Cardiac arrest, hypotension, hypothermia, pulmonary emboli, pulmonary hypoperfusion
- Increased alveolar ventilation
  - Hyperventilation
- Equipment Problems
  - Airway obstruction, esophageal intubation, ETT leak, incomplete exhalation, poor sampling, ventilator disconnect

Comparing Waveforms



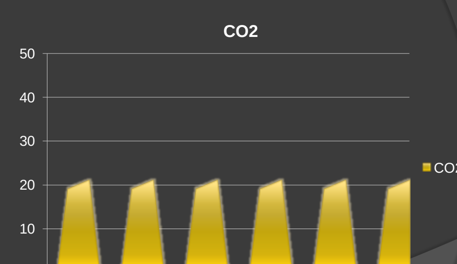
Normal



Hypocapnea

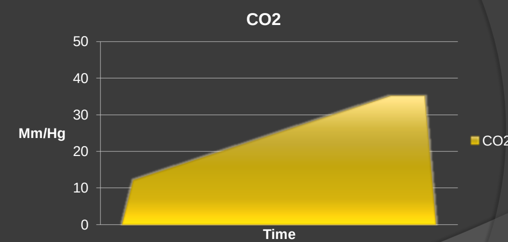
Hyperventilation

Hyperventilation



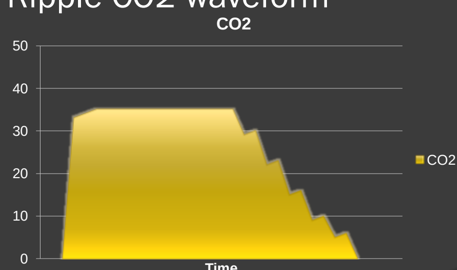
Waveforms

Bronchospasm/Asthma



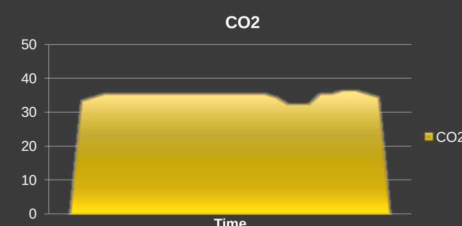
Air is “forced” out during exhalation, resulting in up slope

Ripple-CO2 waveform



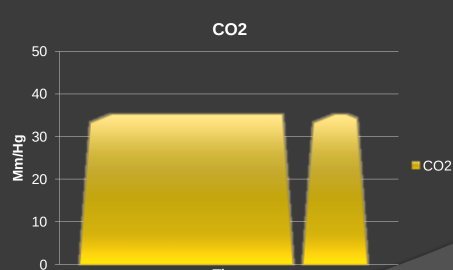
Occurs during CPR or other types of chest movement

Curare Cleft

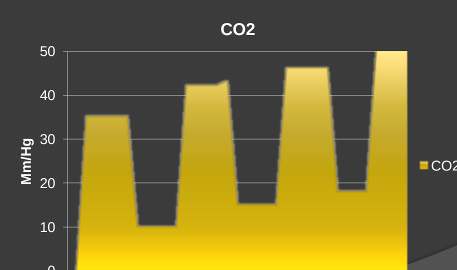


Intubated Patient with Spontaneous Respiration

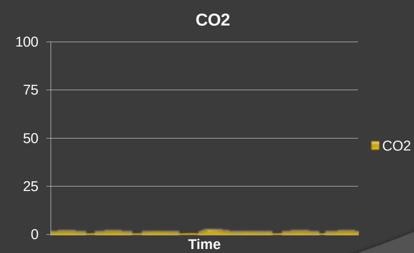
Breathing Against Ventilation



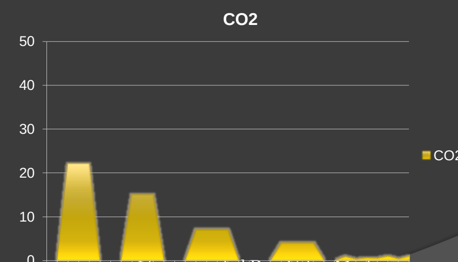
Rebreathing



Esophageal Intubation



Esophageal Intubation



After extended Bag-Valve-Mask ventilation

Procedure

- Perform standard interventions per protocol for managing Airway, Breathing, and Circulation
- Prepare intubation equipment including end tidal CO2 detector
- Depending on device, the electronic capnograms may need to cycle or warm up

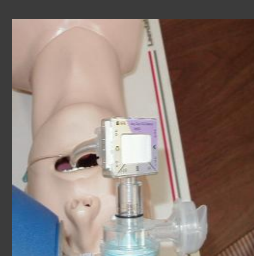
Device Placement

- Place per protocol
  - Endotracheal Tube
  - Combitube
  - King LT airway
- Inflate distal cuff, attach BVM
- Auscultate for Lung sounds
  - 3 quick, shallow ventilations – more distinct
  - Abdomen first, then opposing sides of chest

Colormetric/Qualitative

- Place between Bag-valve and airway
- Perform 6 quality ventilations
  - 1 ventilation per 5-6 seconds
  - Full, consistent depth
- Observe for color change from purple (No CO2 present) to yellow (CO2 present)
  - YEAH for YELLOW
- Purple <4mmHg, Tan 4 to <15mmHg, Yellow 15 to 38 mmHg
- Replace after 2 hours or exposure to fluids

Colormetric Detectors



Nellcor Easy Cap II

Porttex CO2 clip

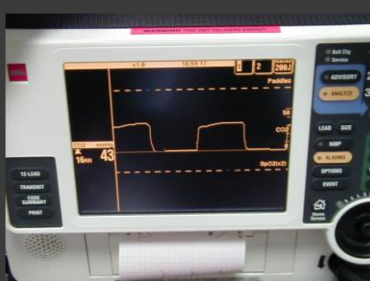
Basic Operations

- Connect sensor to activate mode in monitor
- Place sensor between ETT and Bag-valve
- Perform quality ventilations
- May take 15-30 second for detector to initialize
- Observe for waveform
- Discard if tubing becomes obstructed

Sidestream Attachment

LP12 port

LP12 CO2 Display



LP12 Capnography Display

- Offers waveform with slight delay
- Very succeptible to ventilation style
  - Bad pattern or rhythm gives choppy display
- Scale measured one right side of screen
  - Autoscale: adjusts to waveform
  - Range: 0 to 50mmHg, or 0 to 100mmHg

Display also gives respiratory/ventilatory rate

Common Problems

- Machine needs to warm up
- Screen glare difficult to interpret
- Sensor adapters can clog with debris, moisture
- Sidestream requires air movement: pulls air into device

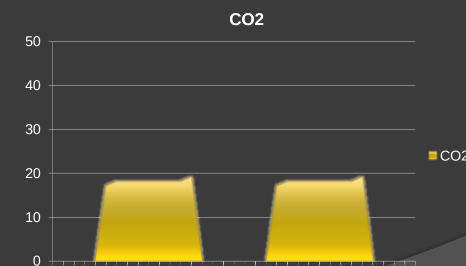
Ventilation and Capnography

- Provides a guideline
  - Educate your crews on techniqe
- Rate:
  - Too fast = End Tidal Drops
  - Too slow = End Tidal Rises
- Volume:
  - Too much = End Tidal Drops
  - Not enough = End Tidal Rises

Scenario 1

- 52 year old cardiac arrest-witnessed
- AED, CPR, BLS prior to ALS arrival
- Advanced Airway placement as appropriate for protocol
- Continued ventricular fibrillation, medications per ACLS guidelines

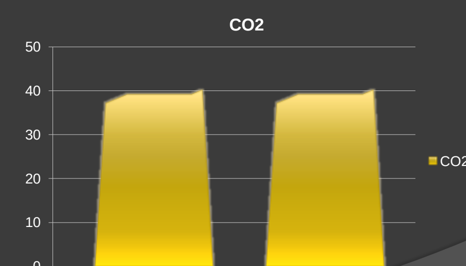
Scenario 1



Scenario 1

- Is the airway adequate? Correctly placed?
- What guidance can the AIC offer to
  - The ventilator?
  - The chest compressors?
- After 4 defibrillations, a PEA rhythm results:

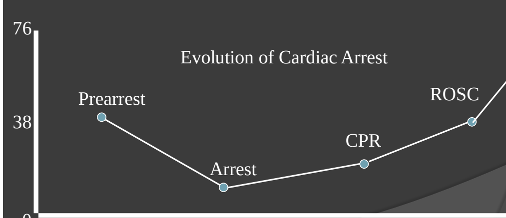
Scenario 1



Scenario 1

- What has happened?
- What considerations for the resuscitation team/

CO2 Trend During Cardiac Arrest



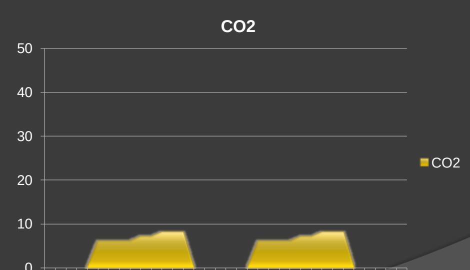
Scenario 2

- 65 year old obese trauma patient
- Predicted Difficult Intubation
- Multiple Injuries
  - Chest Contusions
  - Abdominal Distention
  - Fractures of right upper leg, left lower leg, and right arm
- Complains of Respiratory Distress

Scenario 2

- Initial Et CO2 6-7mm/Hg
- Intermittent sensor detection of numerical value
- Waveform present
- Low “shark fin” appearance
- What is going on?
- Is the ET good?

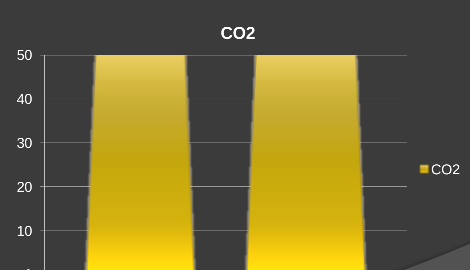
Scenario 2



Scenario 3

- 45 year old respiratory arrest
- Progressive dyspnea, fever for two days prior, found down in bed by family
- EMS arrives; unable to ventilate through clenched teeth
  - RSI medications administered
  - Oral ETI attempts times two unsuccessful
- King LT airway placed

Scenario 3



Data Collection Capability

- Limited Number of Devices
- Software support
- Type of data:
  - Snap shot: LP12
  - Continuous: Tidal wave
- How do you evaluate?

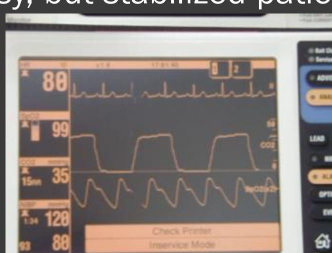
Data Evaluation

- Benchmarks of Procedure
  - Correlate PCR times and machine
- Trend data: single point is often not useful
- Alarms:
  - Decrease SaO2 waveform after intubation
  - Pulse Oximeter correlation with EtCO2
  - Pre intubation SaO2

Future

- Integrated data systems
  - Ability to collect over long transports
- Military evacuations have identified need for an improved, comprehensive physiological monitor

A busy, but stabilized patient

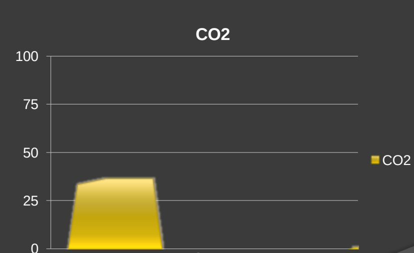


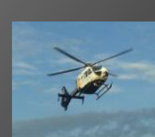
Courtesy of the simulator mode on the machine

Capnography Summary

- Required for documentation of Endotracheal Intubation
- Adjunct for Monitoring the quality of ventilations
- Fundamental Understanding of Principles offers:
  - Increased awareness of potential problems
  - Enhances scope and quality of pre-hospital practice

Sign of a Problem??





ANY QUESTIONS???

Sources

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THANK YOU!!!

ANY QUESTIONS??