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Advanced Case Concepts

Capnography

Virginia EMS Symposium 2010

Objectives

- Brief Review Capnography
  - History
  - Anatomy and Physiology
- Case Presentations
  - Pathophysiology of Respiration and Ventilation
  - Capnography integrated with the critical care patient
  - “Advanced” application of capnography
  - Alternative Applications

- 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 2010

First Priority

- Maintenance of Intubation
  - Confirm and re-confirm placement
  - Visualization
  - Auscultation
  - Observation
- Quality of Ventilation
- Capnography:
  - “Memorial, we have confirmed tube placement with a BEAUTIFUL BOX SHAPED waveform at 35 to 40!”

Intubation Confirmation

- When you put the tube in the trachea
  - Watching it pass through the cords
- When your assistant moves the BVM the wrong way
  - When the hairs on you neck stand up
- When you move the patient
  - From the house, to the stretcher, to the ambulance, to the hospital, on the code bed

- Quantitative, graphical measurement of instantaneous CO2 concentration
- American Society of Anesthesiologists (ASA) standards:
  - *Every patient receiving anesthesia shall have adequate ventilation continually evaluated*
  - *Continual monitoring for the presence of expired carbon dioxide shall be performed unless invalidated by the nature of patient, procedure, or equipment*
  - *Continual EtCO2 analysis, in use from the time of ET placement, until extubation, removal of laryngeal mask shall be performed using a quantitative method, such as capnography, capnometry, or mass spectroscopy*

EVERY INTUBATED PATIENT..

Continuous Monitoring..

Quantitative..

Capnography

History of Capnography

- Developed in 1961 (For practical purposes)
- Expensive and bulky product limited to OR anesthesia
- In mid 1980s, anesthesia related fatalities led to need for improvements in airway management
  - Malpractice costs rise 1975 to 1985

- 1988: Anesthesia standardized use of pulse oximeters and capnography
  - Malpractice claims from hypoxic related injury almost eliminated -Massachusetts
  - Insurance claims from anesthesia drops from 11% to 3% over 15 years
  - In 2002, anesthesia insurance premium was $18,000, the same as it was in 1985

History of Capnography

Integration of Capnography

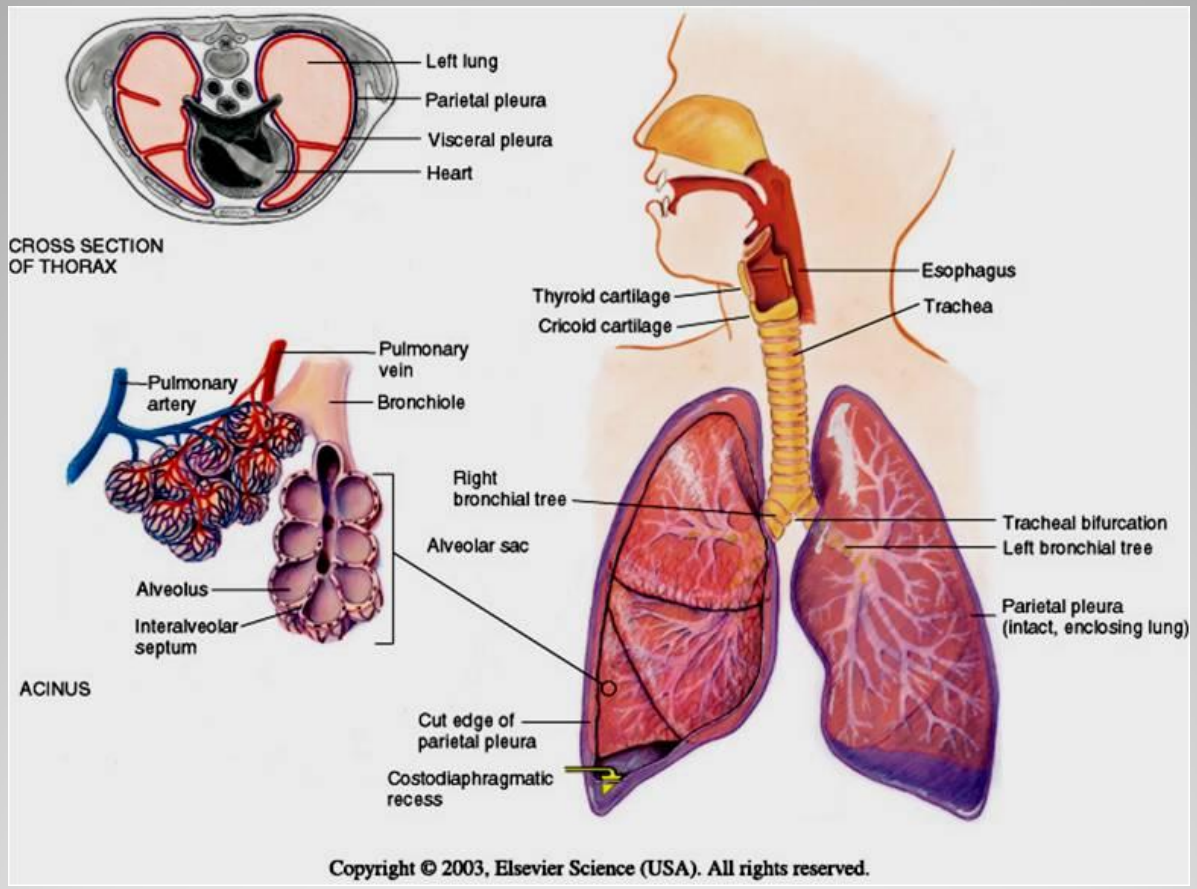
- In Anesthesia, capnography is an industry standard
- In EMS, it is a standard, but not there are variables
  - "No, its not the pulse ox!"
  - Waveform versus colormetric
- It is not common in Emergency Departments, and varied in ICUs

Patient Safety

ABOVE ALL, DO NO HARM

A&P for Capnography:

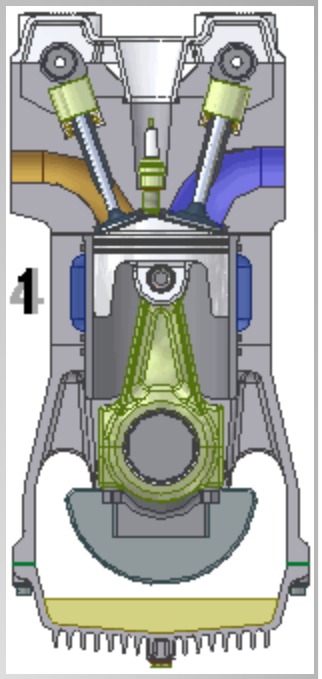
- What is important:
  - Air movement
  - Surface area of lungs
  - Blood flow to lungs and body
- Respiratory Cycle
  - Alveolar level
  - Cellular level



Respiratory Anatomy

Review of Metabolism

- Aerobic:
  - Oxygen and Glucose metabolize to produce Energy to do work
  - Carbon Dioxide and Water are the byproducts
  - Krebs Cycle
  - Most efficient process
    - Improves with exercise



Review of Metabolism

- Anerobic:
  - Lack of oxygen causes build up of acids
  - Lactic Acid and Pyruvic Acid
- Buffer System
  - Hydrogen Ions of the Acid (pH) combine with Bicarbonate to form Carbonic Acid
  - This breaks down into water and carbon dioxide
  - Increased CO2 stimulate increased ventilation rate to remove it

Carbon Dioxide

- By-product of normal respiration
- Measured as a Partial Pressure
  - 35-45 Mm/Hg
- Measured as a Percentage
  - 5-6%
- Key for: respiratory drive, ph balance
- Considered “acidic”

Drive to Breathe

- CO_2 triggers breathing
- NOT ENOUGH
  - Hypoventilation leads to hypercarbia
  - Hypercarbia leads to respiratory acidosis
- TOO MUCH
  - Hyperventilation leads to hypocarbia
  - Hypocarbia leads to respiratory alkalosis

- Oxygen and Carbon Dioxide
- Hypoventilation:
  - O_2 < 60mm/Hg
  - CO_2 > 45mm/Hg (Hypercapnea)
- Hyperventilation:
  - O_2 > 100mm/hg (SaO_2 above 98%)
  - CO_2 < 35mm/Hg

What do the numbers mean?

CO_2 on the BRAIN

- Decreased CO_2 from hyperventilation
  - Cerebral Vasoconstriction
  - Balancing
- Indication: (old school)
  - Traumatic head injury/CVA
  - Maintain perfusion without worsening bleeding
    - End-tidal CO_2 target is 33 to 35mm/Hg

CO_2 on the Brain

- Elevated CO_2
  - Permissive Hypercarbia
  - Above 45mm/Hg
  - With adequate oxygenation
- Potential Benefits
  - Cerebral and systemic vasodilation
  - Increase cellular oxygen supply
  - Decrease oxygen demand

- Adequate Oxygenation
- Adequate Ventilation
- Avoid tunnel vision
  - Use your tools
- Quality over Quantity

HYPOXIA KILLS

Priority is Oxygenation

Dalton's Law: Partial Pressure of Gas

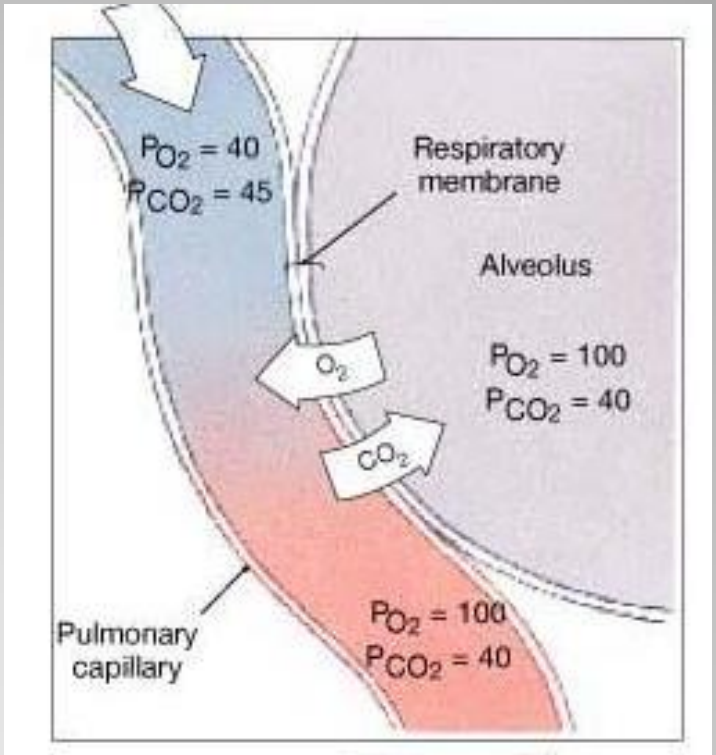
- Total pressure of a gas is equal to the SUM of the partial pressures of the gas
  - Atmospheric pressure is 760mm/Hg at sea level
  - Under NORMAL conditions, all of the atmospheric gas pressures add up to 760
    - Oxygen is 159.2 mm/Hg
    - Nitrogen is 592.8 mm/Hg
    - CO2 is 0.23 mm/Hg
    - Other gases, like Argon = 8mm/Hg

Atmospheric Gases

- Convert percentage to pressure
- Normal gas Percentage
  - Oxygen at sea level: 21%
  - CO2 and other gases: 1%
  - Nitrogen: 78%

Partial Pressure

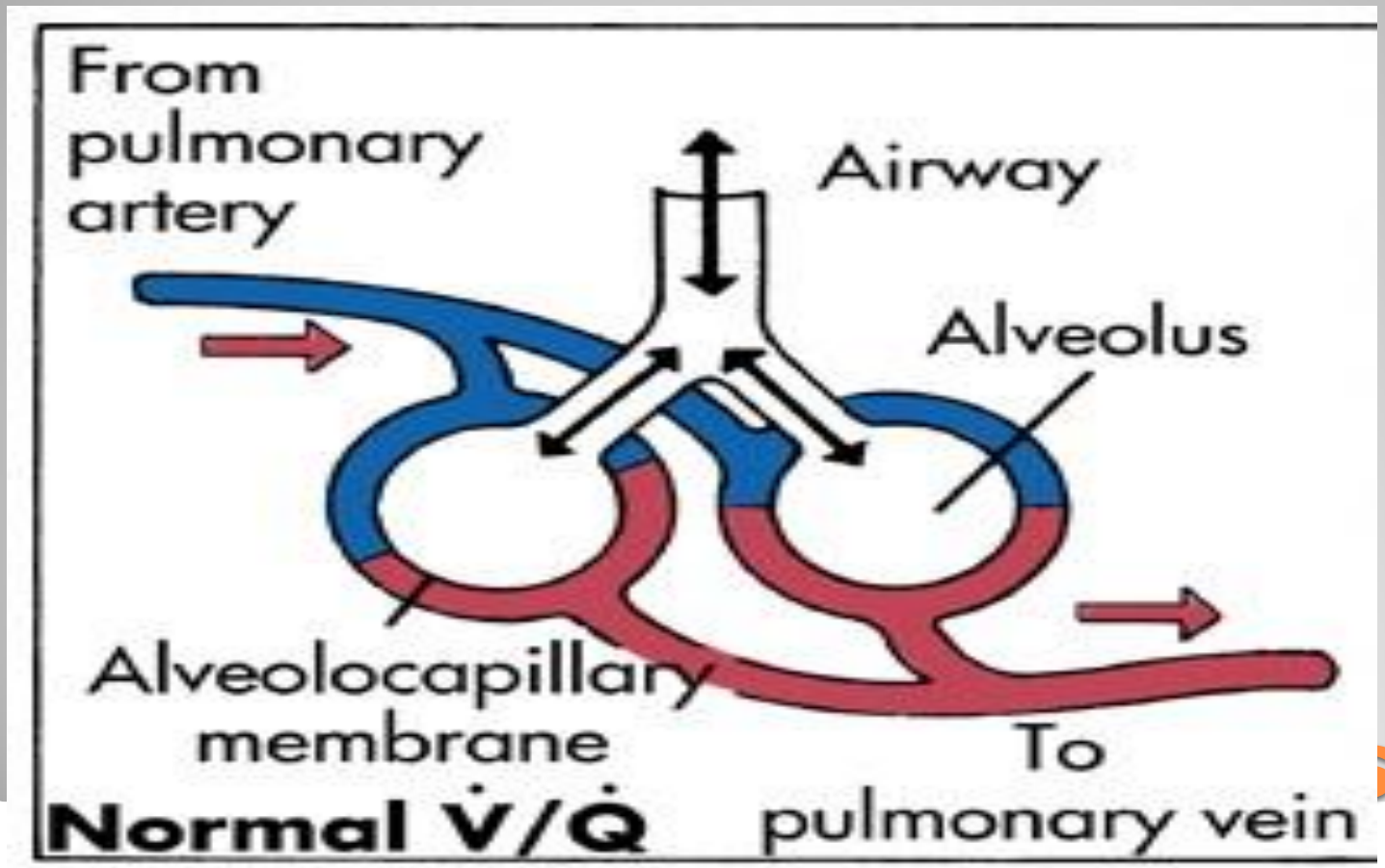
- Gradient
- The exchange of gases based on pressure gradient
  - Pressure forces Oxygen onto Hemoglobin



Ventilation and perfusion

Pathology that Impacts CO2

- Ventilation Problems
  - Inability to move air in and out of the alveoli
  - Hyperventilation, hypoventilation
- Perfusion Problems
  - Oxygen transport to cells
  - Lack of blood flow
  - Ability of blood to carry oxygen


From pulmonary artery
Airway
Alveolus
Alveolocapillary membrane
To pulmonary vein
Normal V̇/Q̇

sion

Alveolar Perfusion Problems

- Shunt Problem
  - Blocking of bronchial airways
    - Pneumonia, atelectasis
    - Right mainstem 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 CO2

Clinical Conditions with Increased CO2

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

Clinical Conditions: Decreased CO_2

- Decreased CO_2 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***

Normal EtCO2 waveform