Capnography:
Not just for confirmation

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Pennsylvania DOH ALS Protocol
2032-ALS

Just because it is protocol ???

• Know why

Capnography

• What is it?
• Why use it?
• How to use it?
Never missed a tube ????
Intubation Confirmation

• DIRECT VISUALIZATION

• End Tidal CO₂
• Pulse Oximetry
• Breath sounds
• Lack of epigastric sounds
• Misting in the endotracheal tube

Pulse Oximetry

• “Normal” pulse oximetry readings
  – carbon MONOXIDE poisoning
  – potentially high despite true hypoxia
  – similar wavelength absorption

• Accurate but misleading
  – cyanide poisoning
  – oxygen “NOT USABLE”

Pulse Oximetry

• Direct monitoring of hemoglobin saturation

• Little information about peripheral tissue metabolism of oxygen
Breath sounds confirmation

• Limitations
  – Noisy environment
  – Indeterminate exam
  – Mistaken sounds from esophageal intubation

Capnography

• Indirect measure of oxygen METABOLISM

• Information about CO₂ production
  – Pulmonary perfusion
    • Cardiac output
    • Venous return
  – Alveolar ventilation
  – Minute volume
    • Elimination of CO₂

Capnography vs Capnometry

• Waveform interpretation
• End tidal value

Why use it?
Variety of Studies

• Sanders et al. Annals of EM 18(12) 1287-1290 1989
  – Higher mean ET CO₂ in ROSC (pulse and BP)
  – 9 of 35 with ROSC (15 ± 4 mmHg)
  – 26 of 35 without ROSC (7 ± 5 mmHg)
• Callaham and Barton, Critical Care Med 18(4) 358-362 1990
  – ET CO₂ within 5 min of ED arrival
  – ROSC (19 ± 14 mmHg) vs
  – NO ROSC (4 ± mmHg)
Lack of Use

- Variable PaCO₂
  - 16-86 mmHg
  - Significant hypo and hyperventilation

What is it?

- End tidal CO₂ monitoring
  - Qualitative
  - Quantitative

Qualitative

- Colorimetric
- Chemical reaction
- Reacts to CO₂ in exhaled gas
- Change in color
  - Yellow (YES)
  - Purple (PULL)
  - (may vary with different manufacturers)

Quantitative

- Direct/proportional measure of amount of CO₂
Qualitative

• Limitations
  – CO₂ in esophagus
  – Low values (< 4 and 4-15 mmHg)
    • No waveform data
    • Difficult to interpret in low flow states
• Easy Cap II
  – Patient must be > 15 kg
    • Rebreathing CO₂ from device
    • Pediatric version available

Quantitative

• Mainstream sampler
  – Infrared beam
  – Photodetector
  – Absorption of beam
    • Amount of CO₂
    – Intubated patient

Mainstream

• Limitations
  – Sensor/Equipment vulnerable to damage
    • Disposable components available
  – Warm up time
    • Condensation in “viewing window”
  – Bulk to ventilator circuit
Quantitative

- Sidestream sampler
  - May be adapted to a nasal cannula

Datascope Passport Monitors
Limitations

- Sampling rates
  - ~50-200 cc/min
  - Distort waveforms
    - Especially with lower tidal volumes
Problems with Monitoring

- Increase in dead space volume
  - ETT adaptor/connector
  - More important in pediatrics
    - Especially newborns
    - Equipment specific limitations

Where else does CO₂ come from?

- Part of the buffer system

\[ \text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

which is used to maintain a normal pH

Where does CO₂ come from?

- Final product in aerobic metabolism

\[ \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

Metabolism of glucose as well as fatty acids and proteins

Where does CO₂ come from?

- Transported throughout the body in the blood
  - As dissolved CO₂
  - As HCO₃⁻
**Amount of CO₂**

- Pulmonary capillaries: 40 mmHg
- Alveoli: ~38 mmHg

- Difference allows for diffusion from capillaries to alveoli
- NOT ACTIVE TRANSPORT

**How does this help us?**

- CO₂ is produced in the tissues
- transported through the venous system
- back to the right side of the heart
- into the pulmonary arteries
- to the pulmonary capillaries
- to the alveoli

**Alveolar Ventilation**

- Dead space
  - Unused for ventilation
- Tidal volume
  - Fills only to terminal bronchioles
- Last portion of airway
  - Diffusion
  - Individual gas molecules moving at high velocity

**Alveolar Ventilation**

- Dead space
  - First portion of gas \(\text{exhaled}\) (last portion of gas \(\text{inhaled}\))
  - Contains no CO₂
  - Not involved in actual ventilation
Alveolar Ventilation

- First part of mixed gas
  - Rapid rise of CO₂ level
- Last part of mixed gas
  - Plateau of CO₂ level

So what does all this mean?

- Good waveform implies
  - Adequate circulation to deliver O₂ to tissues
  - Aerobic metabolism
    - Using O₂ and producing CO₂
    - Adequate circulation to return CO₂ to lungs
    - Adequate ventilation to expire CO₂

Cardiopulmonary Resuscitation Goals

- Restore Circulation
- Restore Ventilation
- Restore Oxygenation

Why not just use pulse oximetry?

- Preoxygenation may give up to 4 minutes of reserve
- Requires peripheral pulses
- Frequently vasoconstricted
  - Vasopressors
  - “Clamped” extremities
Why not just use pulse oximetry?

- Detects inadvertent esophageal intubation
  - faster than pulse oximetry
  - especially in the preoxygenated patient
  - before deteriorating physiological parameters


Not just for confirmation…

- Interpreting the waveform
- Following the trends
  - Changes in the patient
  - Changes in tube placement

Waveforms

FIGURE 1 Example of normal capnogram (A), alveolar hypoventilation (B), and apnea (C)
Esophageal Intubation

- False positive with qualitative
- Must interpret the waveform

No Plateau

- Partial obstruction
  - Kinked tube
  - Bronchospasm

Drop to Zero

- Extubated
- Totally obstructed tube
- Sampler disconnect
- Ventilator failure

Asthma

- Before
- After beta agonist
Gradual Decrease

- Hyperventilation
  - “Blowing down CO₂”
- Failing perfusion
  - Decreased venous return

Sudden Drop (not to zero)

- ETT leak
- Sampler leak
- Mild obstruction
  - Mucous plug
  - Condensation

Gradual Increase

- Hypoventilation
- Sudden increase in perfusion
- Bicarbonate infusion

End Tidal CO₂

- Goal measurement (majority of patients)
  - 35 mmHg
- COPD with chronic hypercapnia
  - Baseline elevated
  - May target higher than 40
  - No reliable estimate without knowing actual levels

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Guide Resuscitation Efforts

• Improving ET CO2
  – Adequate perfusion/ventilation/oxygenation
  – Lower values = lower rate or survival


• Early termination of efforts
  – < 10 mmHg after 20 minutes of ALS
  – NO SURVIVORS


Endotracheal Tube Placement

• Monitor/document
  – Quality assurance
  – Medical legal

• Any patient movement
• Transfer from stretcher
• Movement of stretcher
• Transfer of care

Not just because you have to…..

• Because
  – you know why
  – and how it helps your patients
Questions???