Capnography: The Most Vital Sign

Mike McEvoy, PhD, NRP, RN, CCRN
Cardiac Surgical ICU RN & Chair Resuscitation Committee – Albany Medical Center
EMS Coordinator – Saratoga County, NY

www.mikemcevoy.com
CO₂ In the Blood

- CO₂ is your drive to breathe
- ↑ CO₂ causes air hunger
- Goal is to maintain PaCO₂ at 40
  - Body adjusts respiratory rate & depth
- Oxygen does not affect respirations
Question:
What would happen if you injected CO$_2$ into the blood?

Respiratory rate and depth would $\uparrow$
Question: Why do swimmers who hyperventilate lose consciousness underwater?

$\downarrow$ CO$_2$ eliminates the drive to breathe
Measuring Exhaled CO₂

Colorimetric

Capnometry

Capnography

Turns yellow when CO₂ is detected
Measuring Exhaled CO$_2$

- Colorimetric
- Capnometry
- Capnography
Measuring Exhaled CO$_2$

Colorimetric

Capnometry

Capnography
Infrared Spectroscopy

- CO$_2$ absorbs 4.26 $\mu$m wavelength
- Infrared light aimed at sample
- Infrared sensors detect absorption and calculate CO$_2$
Oxygenation and Ventilation

**Oxygenation (Pulse Ox)**
- $O_2$ for metabolism
- $SpO_2$ measures % of $O_2$ in RBCs
- Reflects changes in oxygenation within 5 minutes

**Ventilation (Capnography)**
- $CO_2$ from metabolism
- $EtCO_2$ measures exhaled $CO_2$ at point of exit
- Reflects changes in ventilation within 10 seconds
Back to CO$_2$...

What does exhaled CO$_2$ tell us?

1. Ventilation
2. Perfusion
3. Metabolism
End Tidal Device

- Airway adapter plugs into monitor
- Be sure adapter is tightly attached
- If not seated, waveform may flatten
Capnography Information

- Respiratory Rate: 20
- End Tidal Carbon Dioxide: 38
- Capnography Waveform
Capnography Waveforms

- The higher the waveform, the more CO$_2$
- Normal EtCO$_2$ is 35 – 45 mmHg (usually the same as arterial CO$_2$)
Capnography Waveforms

- The length of the waveform corresponds to respiratory rate.

**Hyperventilation**

**Hypoventilation**
Review
Where is $\text{EtCO}_2$ Measured?

Normal $\text{EtCO}_2$ is 35 – 45 mmHg
Intubation

- 86 yo open AAA severe respiratory distress post-extubation; reintubated
- HR 128, RR 14 by BVM, SpO₂ 99%

- Esophageal intubation
- 6 breaths to evacuate gastric CO₂
What about the Pulse Ox?

SpO₂ will not drop for several minutes (5+ minutes)
Intubation

- Anesthesia reintubates
- This is the capnography waveform:

- Is the tube in?
- Is the ventilation rate and depth appropriate?
Transport to CAT Scan

• Your vent patient needs a head CT. After placing her in the scanner, you see this on the capnography:

• What happened?
• When is this most likely to occur?
• Tubes most commonly displace during patient movement
ICU Admission

• You admit a 23 yo GSW to the head to your neurosurgical ICU
• He is intubated and sedated:
  • $\text{EtCO}_2 = 35$, RR = 24
  • “Curare Cleft” = diaphragmatic movement (breathing over drugs)
ICU Admission

• You don’t make any changes
• The patient appears to awaken:
  • EtCO₂ = 30, RR = 38
  • “Curare Cleft” = diaphragmatic movement (breathing over drugs)
  • “Bucking” ventilation needs drug tx
You admit a cardiac arrest reversal. He’s unresponsive, BVM ventilation

BP 110/58, HR 90, RR 22, SpO₂ 97

Is the patient ventilating? NOT WELL

Causes: cuff leak, ETT displaced…
Code Team: CPR in progress

- Compression depth
- Compression rate
- Compressor
- Extreme acidosis
- Futility
- Other?
High-Quality CPR = \( \uparrow \text{CO}_2 \)
Goals During Cardiac Arrest

• Try to maintain a minimum $\text{EtCO}_2$ of ?
• 10 mmHg

- Push
  - HARD ($\geq 2''$ or 5 cm)
  - FAST (at least 100)

- Change rescuer
  - Every 2 minutes
CPR – What Causes This?

- Notice the small “ripples”?

- Compressions generate air movement – this expels CO$_2$
Bronchospasm

- Asthma, COPD...
- Elevation of $\alpha$ angle, loss of alveolar plateau ("shark-fin" appearance)
- Degree of angle = severity
Effects of Treatments

on arrival 10:35

after start of treatment 10:37

after 2 combinations 11:12
Air Trapping

- Emphysema results in prolonged expiration
- Increases $\beta$ angle:
Rapid Response - Unconscious

- 32 yo unresponsive in GI lab following colonoscopy

- Hypoventilation (? pharmaceutical)
- Use capnography on EVERY conscious sedation patient!
Peds Step Down Floor

- 14 yo asthmatic – severely SOB
- Hyperventilation
- No evidence of airway obstruction or air trapping
Adult Rapid Response

- 81 yo COPD & heart failure
- Acutely SOB

- Normal waveform, hyperventilation
- ? Pulmonary edema
Same Patient - SOB

- 81 yo COPD & heart failure
- Acutely SOB

- Slow upstroke = bronchospasm
Post Cardiothoracic Surgery

- 59 yo POD #1, s/p CABGx5
- Extubated, 2L n/c, VSS, no issues

“Cardiac oscillations” – cardiac pressures being transmitted to airway (ripple effect)
Perfusion and pH

• Cardiac arrest = no CO$_2$
  – Capnography reflects perfusion
  – $\downarrow$ cardiac output = $\downarrow$ EtCO$_2$

• CO$_2$ is transported in the blood as bicarbonate (HCO$_3^-$)
  – In severe acidosis, $\downarrow$ HCO$_3^-$ = $\downarrow$ EtCO$_2$
Post Cardiac Arrest Patient

• You admit a 55 yo post arrest patient for therapeutic hypothermia
• The patient is unresponsive, on a vent; sats 96%, BP is falling

• Suspect falling cardiac output!
17 yo pt. in DKA

- You admit a patient from the ED in DKA
- The patient is alert and oriented; blood sugar is reportedly 880

pH? 6.93
Rapid Response: RN Worried

- You are called to see a 75 yo heart failure pt. with general weakness
- She is cool, BP 80/50, HR 128 afib
- What does the capnography say?

Cardiogenic Shock!
MSOF Patient

- 81 yo MSOF patient multiple drips
- BP falling, not responding to pressors
Be suspicious of rounded waveforms:

- These often imply low perfusion, acidosis, sepsis, poisoning or other metabolic derangements
Ventilator Patient

- 45 yo auto-pedestrian, open abdomen, on CRRT, BP 120/60 (80), HR 90, SpO2 97%, EtCO2 45

- Normal waveform
Questions?

Thanks for your attention!

Slides posted at:

www.mikemcevoy.com