Capnography: What Your Mother Never Told You

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

www.mikemcevoy.com
Outline

• Quick review
• Resuscitation
• Weird capno waves
• NIV
• Sepsis and PE
• Alternative airways
Infrared Spectroscopy

- CO$_2$ absorbs 4.26 µm wavelength
- Infrared light aimed at sample
- Infrared sensors detect absorption and calculate CO$_2$
Waveform Capnography – EtCO$_2$
Back to CO$_2$...

What does exhaled CO$_2$ tell us?

1. Ventilation
2. Perfusion
3. Metabolism
AHA Guidelines 2015

Continuous quantitative waveform capnography recommended for intubated patients throughout peri-arrest period. In adults:

1. Confirm ETT placement
2. Monitor CPR quality
3. Detect ROSC with EtCO$_2$ values
Goals During Cardiac Arrest

• Try to maintain a minimum EtCO$_2$ of ?
• 10 mmHg (???)
• Push
  ✓ HARD (2 – 2.4” or 5-6 cm)
  ✓ FAST (100 - 120)
• Change rescuer
  ✓ Every 2 minutes
Code Team: CPR in progress

- Compression depth
- Compression rate
- Compressor
- Extreme acidosis
- Futility
- Other?
High-Quality CPR = $\uparrow$ CO$_2$
ICU Resuscitation

• Good CPR in progress
CPR – What Causes This?

• Notice the small “ripples”? 

Chest Compression Oscillations

• Compressions generate air movement – this expels CO₂

? Wholey theoretical
Warning

• Incidence of cardiac oscillations is high in cardiac arrest (73%)
• Does NOT imply tube is tracheal
• Several reports of oscillations with esophageal ET tubes!

CPR in Progress

- Sudden increase in EtCO$_2$ to 80
- No pulses, no cardiac motion on US
**Bicarb administration**

CO$_2$ is transported in the blood as bicarbonate (HCO$_3^-$)

- $\uparrow$ HCO$_3^-$ = $\uparrow$ EtCO$_2$
  
  Bicarb administration, metabolic alkalosis

- $\downarrow$ HCO$_3^-$ = $\downarrow$ EtCO$_2$
  
  Severe acidosis (DKA, lactic acidosis, etc)
How long does this last?

• Return to slightly > baseline (5 min):
Post-arrest (ROSC) patient

- HR 103, SpO2 99%, NIBP 102/54
- EtCO$_2$ 8
80 yo AAA arrives from OR

• Extubated in OR, obtunded and appears SOB. Initial capnogram:

• Resp failure in absence of COPD = CO$_2$ > 70
Of course, he gets a tube

- Hypotensive, vent settings 100%, SIMV 12, $V_T$ 600, no PEEP

- You cannot determine his EtCO$_2$
- “Cardiogenic oscillations”
Cardiogenic Oscillations

- Unknown etiology
- Tx = PEEP
Spontaneously Breathing

Capnography helps assess:
– Accurate respiratory rate
– Airway patency (bronchospasm, air trapping, obstruction)
– Shock states
– Response to treatment
Titration of NIV

- CPAP, BiPAP (but not HFNC)
NIV: Nasal Capnography

- Requires cannula w/ pillow (oral)
Sepsis?

- EtCO$_2$ reflects lactate & mortality
- Inverse, linear relationship
  - $\downarrow$ EtCO$_2 = \uparrow$ lactate
- Lactate requires blood testing
  - 172 minutes lab, 21 minutes POC
- Capnography is instantaneous

Mean Values (n=201)

<table>
<thead>
<tr>
<th></th>
<th>Lactate mmol/L</th>
<th>EtCO₂</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected Sepsis</td>
<td>1.79</td>
<td>33</td>
<td>2 SIRS criteria</td>
</tr>
<tr>
<td>Severe Sepsis</td>
<td>6.20</td>
<td>28</td>
<td>Sepsis + end organ dysfunction</td>
</tr>
<tr>
<td>Septic Shock</td>
<td>4.90</td>
<td>30</td>
<td>Sepsis + refractory hypotension</td>
</tr>
</tbody>
</table>

R/O Pulmonary Embolus

- 30 yo female smoker on BCP, SOB
- 104/80, P 110, 85% on NRBM
- 7.38, 70, 38, 22, -2.0, 85%

EtCO₂ = 40
PE?

- Same patient (same VS & ABG)
- 104/80, P 110, 85% on NRB
- 7.38, 70, 38, 22, -2.0, 85%

EtCO$_2$ = 18
Alveolar Perfusion

- A-a gradient ($\text{EtCO}_2 < \text{PaCO}_2$)

**Figure 2B. (Example) Acute decrease in alveolar perfusion (deadspace ventilation)**

Lung "A" is ventilated, but not perfused.

- $\text{etCO}_2 = 18 \text{ mmHg}$
- $46$ mm Hg
- $20$ mm Hg
- $40$ mm Hg

*The alveolar CO$_2$ would not drop to zero in the deadspace unit under clinical conditions. This figure is strictly a conceptual illustration.*

$P(a$-et$)\text{CO}_2 = 22 \text{ mmHg}$
Intubation

- 86 yo s/p CABG, severe SOB, unable to reintubate after failed extubation
- EM fellow places a King™ airway
Intubation

- HR 128, RR 14 by BVM, SpO₂ 99%
- Initial EtCO₂ is 2 with this waveform:
- The fellow says the airway is in proper position and he does not expect to see a normal waveform with a supraglottic airway (SGA)
Alternative Airways

Should you expect the same capno waveform as seen with ET tubes when using an alternative airway?

Yes
No
Alternative Airways

- Expect the same EtCO$_2$ values and capnographic waveforms as seen with ET tubes when using:
  - Alternative airways of any type
  - Nasal cannula end tidal devices

- Interpret capno waveform variations in spontaneously breathing patients and alternative airways the same as those obtained from ETT.
Capnogram Angles

\[ \alpha \text{ (alpha angle)} \]
\[ \beta \text{ (beta angle)} \]

- \( \alpha \text{ normal} = 100 - 110^\circ \)
- Airway obstruction will ↑

- \( \beta \text{ normal} = 90^\circ \)
- Rebreathing will ↑
Bronchospasm

• Asthma, COPD…
• Elevation of $\alpha$ angle, loss of alveolar plateau (“shark-fin” appearance)
• Degree of angle = severity
Distinguishing COPD & HF

- 81 yo COPD & heart failure
- Acutely SOB

- Slow upstroke = bronchospasm
Adult Rapid Response

• 81 yo COPD & heart failure
• Acutely SOB

• Normal waveform, hyperventilation
• ? Pulmonary edema
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!
Peds Step Down Floor

- 14 yo asthmatic – severely SOB

- Hyperventilation
- No evidence of airway obstruction or air trapping
Rounded Waveforms

Be suspicious of rounded waveforms:

- These often imply low perfusion, acidosis, sepsis, poisoning or other metabolic derangements
Questions?

Thanks for your attention!

Slides posted at:

www.mikemcevoy.com