CAPNOGRAPHY:
IT TELLS YOU ABOUT MORE THAN VENTILATION!

Emergency Nurses Association - 2016

Objectives:

- Discuss the integration of Capnography into a resuscitation program
- Discuss normal & abnormal V/Q relationships
- Describe Capnography as an indicator of fluid responsiveness
### 2015 Capnography & Ventilation Levels of Evidence – ILCOR/AHA

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Class</th>
<th>LOE</th>
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<tbody>
<tr>
<td>Continuous Waveform Capnography to verify ETT placement</td>
<td>I</td>
<td>C-LD</td>
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<tr>
<td>Capnography as a measure of CPR quality</td>
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<tr>
<td>Capnography as an indicator of ROSC</td>
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<tr>
<td>Low PEtCO₂ (&lt; 10 mmHg) after 20 minutes in intubated patients is strongly associated with failure of resuscitation</td>
<td>IIb</td>
<td>C-LD</td>
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<tr>
<td>Should not be used in isolation or in non-intubated patients as a marker to terminate resuscitation</td>
<td>III</td>
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<tr>
<td>Ventilation rate 10 breaths per minute with an advanced airway</td>
<td>IIb</td>
<td>C-LD</td>
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### When to use Waveform Capnography?

- Gold standard for endotracheal tube placement
- Moderate to deep sedation
- High risk patient on PCA
- Fluid responsiveness & resuscitation
- Cardiac arrest
  - Quality indicator of compressions
  - Information helpful to determine cessation of resuscitation efforts
  - Post arrest
Carbon dioxide

There's what you exhale
Normal: 35 – 45 mmHg
\((V = \text{ventilation})\)

There's what you measure in the arterial blood
Normal: 35 – 45 mmHg
\((Q = \text{Perfusion})\)

The relationship between them is \(V/Q\)

Continuous Waveform Capnography

- **Waveform Capnography**
  - Endotracheal tube verification
  - Level 1A recommendation from AHA/ILCOR

- Normal \(\text{PEtCO}_2 = 35 – 45 \text{ mmHg}\)

- Correlates with \(\text{PaCO}_2\) in **normal** \(V/Q\) relationships
  - < 5 mmHg difference
Waveform Capnography

- Gold standard for confirming endotracheal tube placement
- Used as a marker of perfusion
- Normal is 35 – 40 mmHg
- Goal with compressions is at least 10 mmHg

![Waveform Capnography Graph]

Capnography Case #2

- 38 year old patient has been in PEA Arrest for over 20 min
- Suspicion of hypoxia from a drug overdose
- Ongoing chest compressions
- Intubated without incident
- Capnography (PetCO₂) reading 24 mmHg with CC

ABG obtained with the following results:
- pH: 7.18
- PaCO₂: 82
- PaO₂: 106
- HCO₃: 26
- Base Excess: -6
- O₂ sat: 91%
- Lactate 4.8

You are instructed to ventilate the patient faster to “blow off” the CO₂.

- What should you do?
Case #3  52 year old patient goes into Ventricular Fibrillation

- Chest compressions started
- Defibrillated with 200 j, chest compressions immediately restarted
- Epinephrine 1 mg administered
- Intubated with assisted ventilations with 1 breath every 6 seconds
- Waveform Capnography started initial reading is 20 mmHg

Recommendations?

After 4 minutes...

- Rhythm is assessed, remains in Ventricular Fibrillation
- Defibrillated with 300 joules, new provider begins compressions
- Waveform Capnography reading 9 mmHg
- Recommendation?
  - Compress deeper, assess rate!

- Provider compresses deeper, but PEtCO₂ remains < 10 mmHg
- Recommendations?
  - New provider!
3 minutes later (7 min into the arrest)

- Waveform Capnography is reading 38 mmHg
- Recommendations?
  - Go until the end of the 2 minute cycle & assess for a pulse
- At the end of 2 minutes, there is a pulse!!
- Waveform Capnography is currently reading 34 mmHg

Post-Resuscitation started

- Patient is mechanically ventilated
- Capnography has trended from 34 mmHg to 26 mmHg
- BP 80/56, HR 92 bpm, O₂ sat 94%

- What do you think about this?
  - The patient's cardiac output is dropping...assess need for fluid, positive inotrope, vasopressor
Post-Arrest Capnography

- 1.5 liters of fluid administered
- Capnography went from 26 mm Hg to 32 mm Hg
- Recommendations?
  - Consider more fluid, assess LV function

It can be especially helpful to monitor PEICO₂ post arrest!
Downward trends could signify low perfusion & re-arrest
Case #4

- 65 year old patient with sepsis
- Intubated & now hypotensive:
  - HR 102, BP 84/42, vented rate 16, breathing 22, \( \text{O}_2 \text{ sat}\ 94\% 
  - Has a central line in place
  - CVP 12 mmHg
- Treatment: Fluids, pressors or inotrope?

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Passive leg raising

Transfer of blood from legs and abdominal compartment

Semi-recumbent position  \[45^\circ\]  Passive leg raising  \[45^\circ\]

Legs elevated for 1 to 2 minutes
Re-evaluate – ideally stroke volume measure
**EtCO₂ predicts fluid responsiveness in passive leg raising**

- 65 ventilated patients needing volume expansion
- Compared changes in EtCO₂ with arterial pressure to reflect changes in CO
- \( \text{EtCO₂ increase} \geq 5\% \text{ predicted fluid responsiveness} \) (p=0.0001)
  - Increase in the CI \( \geq 15\% \)
  - Sensitivity 71\% (95\% CI 48 – 89\%) and specificity of 100\% (CI 82 – 100\%)
- The changes in EtCO₂ induced by a PLR test predicted fluid responsiveness with reliability, while the changes in arterial pulse pressure did not.

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**Passive Leg Raising**

- Patient – HOB 45 degrees
- Obtain Capnography reading
- Capno: 32 mmHg
  - Lift legs for 1 – 2 minutes
  - Capno reads 38 mmHg after 90 sec
- What does the patient need
  - **Fluids!!!!!!**
Does Capnography predict sepsis?

- ≥ 2 SIRS Criteria
- EtCO₂ < 25 mmHg
- Suspicion of infection

Sepsis Alert activation

Case #4 Exceptions...

- 49 year old female present to the ED with SOB
- Being treated for a LLE DVT she developed after surgery
- C/O shortness of breath with increasing O₂ needs and “impending feeling of doom”
- Goes into PEA Arrest
- Chest compressions started
- Your differential?
- **Pulmonary embolism**
Case #4 continued

- rTPA ordered & given
- Intubated without interrupting chest compressions
- EtCO₂ read 8 mmHg
- CPR quality is incredible!!!

- Why is it only reading 8 mmHg?
- She has a VQ mismatch
- What will happen to serum levels of CO₂?

V/Q Mismatch

- Pulmonary embolism = lots of dead space
- *Dead space* = volume of air inhaled that does not take part in gas exchange
- $V =$ air reaches alveoli, $Q =$ blood reaches alveoli

- If the dead space is $< 30\%$, it is considered normal
- $< 30\%$, not a PE, 100% negative predictive value

Calculation:

$$(\text{PaCO}_2 - \text{EtCO}_2) \div \text{PaCO}_2$$
Case continued  \((\text{PaCO}_2 - \text{PetCO}_2) \div \text{PaCO}_2\)

- EtCO₂ up to 11 mmHg and we achieved ROSC
- rTPA completed
  - 2 hours later EtCO₂ was 15 mmHg, PaCO₂ 56, on FiO₂ 100%
    - Dead space = 73%
  - 6 hours later EtCO₂ was 24 mmHg, PaCO₂ 48, on FiO₂ 80%
    - Dead space = 50%
  - 12 hours later EtCO₂ 30 mmHg, PaCO₂ 40, on FiO₂ 70%
    - Dead space = 25%
- Prognosis?
  - Good! The rTPA lysed the blood clot
  - This is evidenced by the improvement in the V/Q mismatch!

In conclusion:

- Capnography is a Level 1A recommendation for verification of endotracheal tube placement

- Capnography can be helpful in monitoring ventilation, fluid responsiveness, V/Q matching, CPR quality and termination of resuscitation efforts