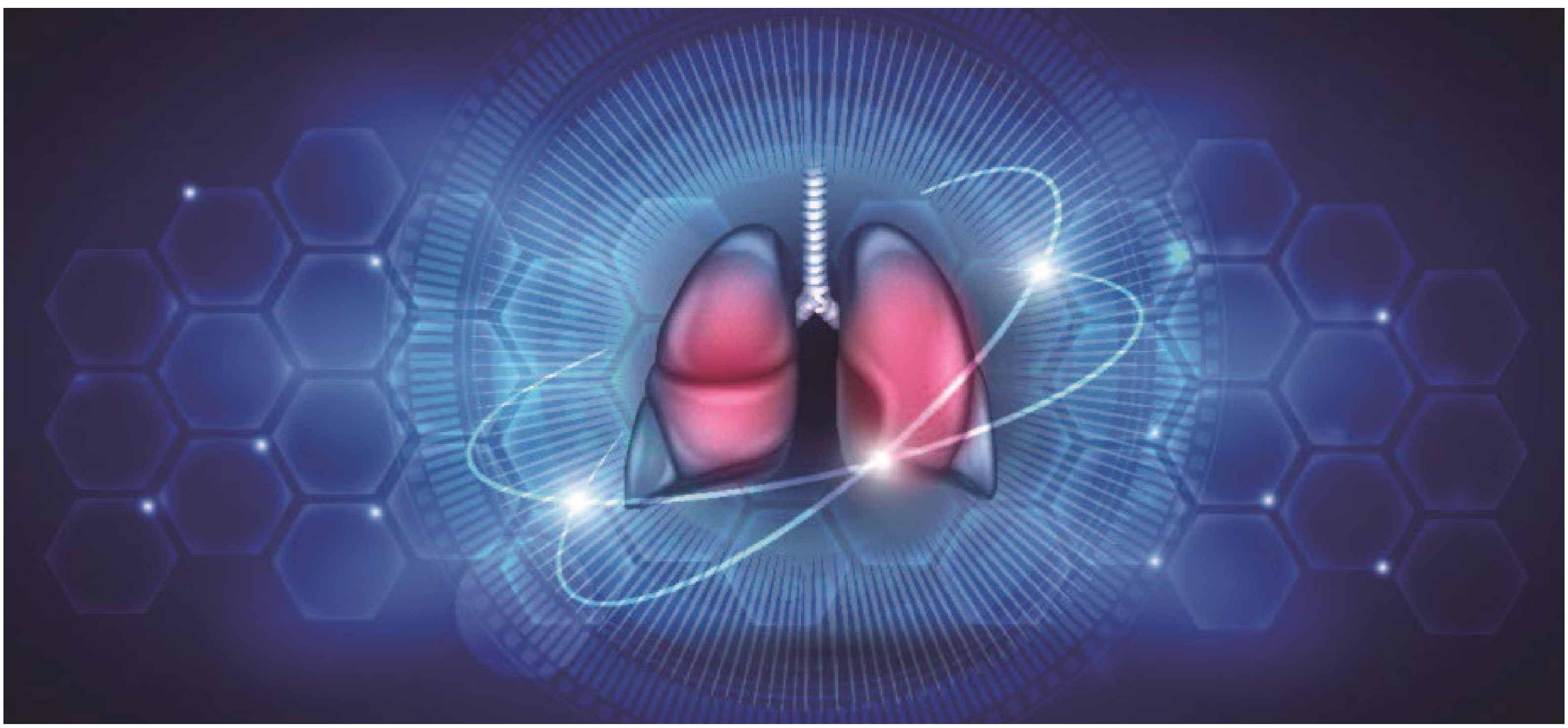
April 2023 CE Handout

Airway | Respiration | Ventilation



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Quick Take: Capnography in EMS: Tube verification is only the beginning

Robert Murray Jr, NRP, MS, shares the components of a waveform and common capnography pitfalls

Apr 16, 2020

After seeing a number of inquiries about the potential uses for CPAP in COVID-19 treatment, we reached out to EMS1 contributors from the Montgomery County Hospital District, Robert Dickson, MD, FAAEM, FACEP, FACEM, MCHD medical director; and Casey Patrick, MD, MCHD assistant medical director, to get their take.

"The bottom line is to avoid all nebs in patients who are not in frank respiratory failure – and, if you have to give them – do it "in line" with NIV, only if you have the proper kit with filter," Dr. Dickson noted. Read more: Airway management adjustments in the era of COVID-19

Robert Murray Jr., NRP, MS, deputy director of operations for Sussex County EMS in Delaware, and Medtronic consultant, presented a webinar titled "Capnography in EMS: Tube verification is only the beginning" as part of the PACE Medtronic Webinar Wednesdays series.

Murray discussed the main uses for capnography in the field and common capnography mistakes, and provided case examples his EMS group has experienced in the field.

TOP QUOTES ON PREHOSPITAL CAPNOGRAPHY

Here are a few quotes from Robert Murray on using capnography in EMS:

"Regardless of how much technology we put in front of you, we can't forget about the patient and actually taking a look at them."

"It's imperative that when we are monitoring CO2, we must have the waveform in our face. The number can give us a false sense of security."

"Capnography allows us to be proactive and get ahead of the proverbial eight ball."

TOP TAKEAWAYS ON CAPNOGRAPHY USE IN EMS

Here are 4 takeaways from Murray's presentation on capnography.

1. Components of a CO_2 waveform

Three things are needed to have a capnography waveform:

- **Perfusion.** Heart needs to be circulating blood
- **Ventilation.** Air needs to be moving in and out
- **Metabolism.** Cells need to performing aerobic respiration

If you aren't seeing a CO_2 waveform, check ventilation and perfusion first, then start thinking about metabolism (sugars, bicarb, etc.). $EtCO_2$ measures the amount of CO_2 leaving the body. If blood isn't circulating or air isn't moving, then cells can't get rid of CO_2. If proper perfusion and ventilation is present, and $EtCO_2$ is still low, aerobic respiration (metabolism) isn't occurring.

2. Know your waveform

Murray described the components of a capnography waveform.

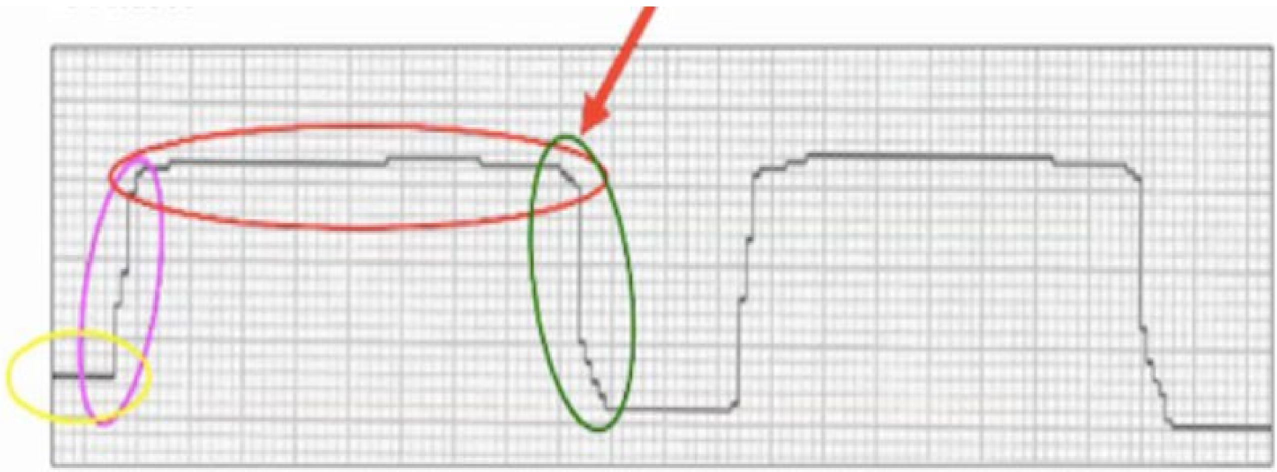


Image courtesy of Robert Murray Jr

- **Phase 1.** Dead space ventilation (yellow) – patient isn't exhaling or inhaling therefore air isn't moving
- **Phase 2.** Beginning of exhalation (pink) – patient is exhaling alveolar CO_2 rich air, the line should be almost vertical because CO_2 is rapidly exiting the lungs
- **Phase 3.** Alveolar Plateau (red) – patient is continuing to exhale, an even flat line means that the alveoli are being evenly emptied
- **Red Arrow.** $EtCO_2$, the maximum amount of CO_2 that is exhaled
- **Phase 4.** Inhalation (green) – CO_2 decreases as the patient inhales oxygen

3. Look at your waveform, not just your numbers

If you're only watching your CO2 number, you may miss something. For example, a COPD patient may have an adequate EtCO2, but their waveform may display a "sharkfin" pattern. This pattern shows a flatter phase 2 and uneven phase 3 indicating that CO2 is taking longer to escape and that the alveoli aren't emptying equally.

Image courtesy of Robert Murray Jr

4. Moving in and out of a vehicle is risky for the ET tube

The most common time for an ET tube to become displaced is when you're moving a patient into or out of your vehicle. Make sure that you keep an eye on your capnography before and after you make the move to ensure that your airway is still intact.

Bob Sullivan
The Practical Medic. Published by ems1.com

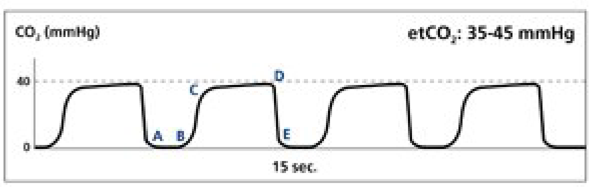
5 things to know about capnography

Understand the importance of monitoring end-tidal carbon dioxide and the valuable information it provides for patient assessment and treatment

Jul 8, 2020

This article, originally published April 27, 2015, has been updated with new information.

Waveform capnography is used at all EMS provider levels to better assess patients in respiratory distress, cardiac arrest and shock. Capnography offers reliable feedback about the severity of a patient's condition and how they respond to treatment.



A typical capnography waveform. (Courtesy/Covidien)

Here are five things you should know about waveform capnography.

1. CAPNOGRAPHY PROVIDES BREATH-TO-BREATH VENTILATION DATA

Waveform capnography represents the amount of carbon dioxide (CO2) in exhaled air, which assesses ventilation. It consists of a number and a graph. The number is **capnometry**, which is the partial pressure of CO2 detected at the end of exhalation. This is **end-tidal CO2 (ETCO2)** which is **normally 35-45 mm Hg**.

The **capnograph** is the waveform that shows how much CO2 is present at each phase of the respiratory cycle, and it normally has a rectangular shape. Capnography also measures and displays the respiratory rate. Changes in respiratory rate and tidal volume are displayed immediately as changes in the waveform and ETCO2.

Two sensors can be used to measure capnography. In patients who are breathing, nasal prongs can be applied that capture exhaled air. Those prongs can also be used to administer a small amount of oxygen, or applied underneath a non-rebreather or CPAP mask. In patients who require assisted ventilation, another adapter can be attached to a BVM and advanced airway device.

Capnography assesses ventilation, which is different from oxygenation. Ventilation is the air movement in and out of the lungs, while oxygenation is the amount of oxygen inhaled by the lungs that reaches the bloodstream. Pulse-oximetry assess oxygenation, and works by measuring the how much of each red blood cell is bound with oxygen. It is expressed as a percent, or SPO2. A normal SPO2 is 92-96%.

2. ETCO2 PROVIDES CLUES ABOUT RESPIRATORY EFFORT

In people with healthy lungs, the brain responds to changes in CO2 levels in the bloodstream to control ventilation. We assess this by observing chest rise and fall, assessing respiratory effort, counting respiratory rate, and listening to breath sounds. ETCO2 adds an objective measurement to those findings. The patient's respiratory rate should increase as CO2 rises, and decrease as CO2 falls.

Waveform capnography is a useful tool to identify when patients with an altered mental status need assisted ventilation with a bag valve mask. When the brain does not respond appropriately to CO2 changes, such as from overdose, head injury or seizure, excess CO2 accumulates in the lungs, though the ETCO2 reading may be low or high. Some causes of respiratory failure present with adequate tidal volume but slow respiratory rate, and in these cases ETCO2 would be high (above 45 mm Hg) and continue to rise if not addressed. Other causes of respiratory failure present with inadequate respiratory rate and depth, and since little exhaled air would reach the sensor on the capnography circuit, the ETCO2 reading would be low. Once ventilation is assisted with a bag valve mask, ETCO2 would spike until the excess CO2 is washed out of the lungs.

While a rise in CO2 should stimulate someone to breathe, no effort should be needed to exhale it. Patients with asthma, COPD, CHF, and pneumonia must often exert themselves to exhale with accessory muscles. It is important to understand that patients in respiratory distress may inhale enough oxygen and have a normal pulse-ox reading, but still struggle to get air out, and progress to respiratory failure from fatigue. In this group of patients means that their effort is not effectively eliminating CO2 **(hypercarbia)**, and ETCO2 may rise or fall depending on tidal volume.

3. CAPNOGRAPHY HELPS DIAGNOSE THE CAUSE OF RESPIRATORY DISTRESS

Correctly diagnosing the cause of respiratory distress can be difficult, and treating the wrong condition may cause harm. A number of conditions can cause diminished breath sounds, wheezing may be heard with both asthma and pulmonary edema, and crackles may be heard with pulmonary edema and pneumonia. Adding waveform capnography to history and physical exam findings can help with treatment decisions.

The capnography waveform represents air movement in the lungs, similar to how complexes on an ECG represent electrical conduction through the heart. The waveform starts at the beginning of exhalation, and senses air from dead space in the upper airway and bronchi. There is normally no CO2 present in dead space, and the graph should be at baseline. A sharp spike is normally seen when exhaled air from the alveoli reaches the sensor, and plateau's when all of the exhaled air detected came from the alveoli. A sharp downward spike is then seen during inhalation. The height of the waveform depends on the amount of CO2 detected, and the length of the waveform depends on the time of exhalation.

In cases of bronchospasm, air is is trapped in the alveoli and inconsistently released. This creates a curve in the initial spike and plateau, or "shark fin" appearance. The worse the bronchoconstriction, the more pronounced the curve on the waveform. If the waveform is upright and “crisp,” there is no bronchospasm and respiratory distress must be from another cause.

Increased work of breathing from pulmonary edema may lead to fatigue and respiratory failure. This would cause a rise in ETCO2, but the waveform will remain upright. Hyperventilation causes excess CO2 to be exhaled, which would present with a crisp waveform and low ETCO2, or **hypocapnea**. Causes of hyperventilation include diabetic ketoacidosis, pulmonary embolism, and anxiety.

4. CAPNOGRAPHY PROVIDES REAL-TIME FEEDBACK ON HOW WELL TREATMENT IS WORKING

Imagine a wheezing patient whose respiratory rate and work of breathing decrease after receiving albuterol. If their shark-finned capnograph shifts upright after receiving albuterol and ETCO2 shifts towards 35 - 45 mm Hg, this means the patient is responding well to treatment. If the shark fin waveform becomes more pronounced and ETCO2 trends further away from the normal range, they are progressing to respiratory failure. Treatment plans can be quickly adjusted when capnography is used to monitor trends.

When providing positive pressure ventilation with a bag valve mask, it can be difficult to track how often the bag is squeezed and how much air reaches the lungs. When capnography is used to assist ventilating patients with a pulse, a waveform will be seen after each squeeze when air reaches the lungs. Ventilation is not effective if there is no waveform, and troubleshooting is needed. Consider repositioning the head, suctioning the mouth, placing an adjunct, having a second person hold the mask, and reassess.

Capnography can also help guide how fast to ventilate the patient. Harm is associated with hypo and hyperoxia, as well as hypo and hyperventilation. Oxygenation should be titrated to achieve SPO2 of 92%, and ventilation should be titrated to achieve ETCO2 between 35 and 45 mm Hg.

Capnography is the most reliable method to confirm correct advanced airway placement, and provides documentable proof. If an ET tube is outside the trachea, or if air from a supraglottic device is not directed into the glottic opening, no waveform or end-tidal reading will appear. If a correctly placed airway device is dislodged, the capnography waveform will immediately be lost.

5. CAPNOGRAPHY ALSO DETECTS SHOCK

Capnography has a ventilatory and circulatory component. Cells use oxygen and glucose to make energy, and release CO2 into the bloodstream to be carried to the lungs. The amount of exhaled CO2 depends on the adequacy of circulation to the lungs, which provides clues about circulation to the rest of the body. Low ETCO2 with other signs of shock indicates poor systemic perfusion, which can be caused by hypovolemia, sepsis or dysrhythmias.

Cardiac arrest is the ultimate shock state; there is no circulation or metabolism and no CO2 production unless effective chest compressions are performed. Capnography provides feedback on the quality of compressions and when a compressor change is needed. An ETCO2 less than 10 mm Hg indicates that compressions are not fast or deep enough. If circulation is restored, a spike in ETCO2 often appears before a pulse is detected. Sometimes it can be difficult to determine if a patient has a pulse, but circulation must be present if ventilation produces a waveform without compressions.