Carbon Dioxide - It's not just a gas

Part 2: Resuscitation

In this article, Martin Betzer of Falck Denmark explains how end-tidal carbon dioxide monitoring might guide you in your clinical judgement of the critically ill and why you should never resuscitate without it. This article is the second of three in a special series on Carbon Dioxide monitoring.

The basics

The capnography fundamentals were reviewed in the previous edition of *Ambulance Today*. To sum up the highlights: capnography provides you with a visual, continuous and real-time, breath-to-breath insight to your patient's airway, respiratory, circulatory and metabolic state – with reference intervals within the range of 4.0-5.7 kPa or 35-45 mmHg[1]. A variety of factors might influence the end-tidal carbon dioxide (EtCO2) readings, and inequalities within ventilation and perfusion might lead to a so-called ventilation/perfusion mismatch (V/Q mismatch) challenging the clinician in capnography interpretation[2]. This article reviews and discusses the usability and application possibilities of capnography during resuscitation of patients in cardiac arrest.

What you need to know

Positive-pressure ventilation during cardiac arrest enables you to control ventilation

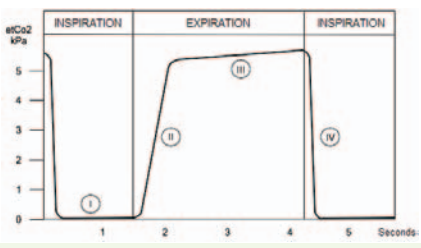

Figure 1: The normal capnogram curve. I: pause/inspiration, II: expiration of dead-space mixed gasses, III: expiration of CO2, IV: pause/inspiration.

rates and tidal volumes. Human factors play an important role in this intervention

because we as professionals tend to excessively ventilate patients in cardiac arrest[3]. This will not only result in hyperinflation induced hypotension leading to decreased survival[3] but also, in the interests of this article, falsely low and unusable EtCO2 readings. The more the rate and volume, the lower the EtCO2 and vice versa.

To correctly interpret capnography, you need to provide continuous, regular ventilations with consistent tidal volumes within normal limits for the patient at hand[4]. You should equip your patient with an advanced airway such as a supraglottic (SGA) or endotracheal (ET) tube making it possible to provide one ventilation with every ten chest compressions[4] – without entering the discussion on ET tubes in cardiac arrest, that is... In the absence of an advanced airway, deliver two ventilations every 30 compressions to the adult patient using a bag-valve mask ventilator (BVM). If you ensure these calm, regular, consistent ventilations, and if high-performance chest compressions are being performed simultaneously, capnography will be your best friend. Why? Let us have a look.

Airway patency

The EtCO2 levels will be displayed on your monitor through a special sampling device connected to your BVM, SGA or ET tube[4,5]. A vital part of any initial patient approach is to ensure a clear airway, and any EtCO2 reading accompanied by a box-shaped capnogram curve as showed in figure 1, provides evidence of just that. Knowing this, you can also be sure that your airway device is correctly placed – which means a dislodged ET tube during resuscitation will be immediately identified, and if your SGA is leaking a little, a box-shaped capnogram can calm you; ventilations are still adequate[6].

Biography: Martin Betzer

Martin Betzer is a Danish ALS-Paramedic with 12 years of experience working in different areas of the ambulance service. Furthermore, Martin has worked 6 years as instructor at the Danish ambulance technician education. Martin has a bachelor of honour's degree in Prehospital Emergency Care from Coventry University, and is currently studying at the University of Stirling on the Master of Research in Health Research programme. Martin is full-time employed with Falck Emergency in the Zealand Region of Denmark as an operational leader and clinical supervisor. Further to this, Martin is also a research assistant at Falck Research.
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Optimising chest compressions

With the airway evaluated and continuously monitored by the capnograph, it is time to focus on optimising the ongoing chest compressions. Remember, you must maintain regular ventilation rates and consistent tidal volumes. Do you have a mechanical ventilator to connect to your advanced airway? Great! Let us use it. Now, the better the chest compressions the higher the EtCO2 values [7]. And that is what we want – better chest compressions and higher EtCO2 values. Use the reading to guide your partner. Push hard, push fast, in the centre of the chest, and consider provider fatigue when EtCO2 is dropping.

Identifying return of spontaneous circulation

Our immediate treatment aim in cardiac arrest is return of spontaneous circulation (ROSC). Common ways to identify ROSC is through palpable pulses, normal breathing or through a rise in coma scores. However, none of these might be present initially in ROSC, and once again, human factors might deceive us. A sudden rise in EtCO2 levels however is an objective and trustworthy parameter, reflecting a rise in perfusion and thereby a rise in cardiac activity [8]. This sudden rise in EtCO2 has actually been found to be the first sign of life in patients regaining ROSC [9]. "Whatever!" You might think. "I am only performing rhythm analysis and looking for signs of life every two minutes anyway, and a rise in EtCO2 would not have me interrupt the ongoing cycle." And you are right, it should not. But could this "early-warning" rise in EtCO2 in the middle of a cycle come in handy? Read on…

Withholding adrenaline

Although not scientifically supported, European Guidelines for Resuscitation 2015 recommend adrenaline every 3-5 minutes in cardiac arrest [4]. Adrenaline is pushed during ongoing, high-performance chest compressions, with no evaluation of signs of life before administration. So, what if… next time you are about to empty that one milligram of adrenaline into the veins of a patient receiving chest compressions, you threw your eyes at the monitor and evaluated the EtCO2 levels first. Are they suddenly high? Maybe that 360 joule DC shock a minute ago worked then, and maybe you should not send them back into ventricular fibrillation with an overdose of vasopressor. Let the EtCO2 guide you on whether to withhold adrenaline until the next rhythm check.

Optimising resuscitation cycles

With the abovementioned knowledge fresh in our minds, capnography can be used as a means of optimising our resuscitation cycles. Towards the end of each 2-minute cycle, notice the EtCO2 value – no sudden increase in EtCO2 equals no ROSC, no ROSC equals no need for pulse check. During ongoing chest compressions charge your defibrillator, pause compressions briefly, analyse, shock or discard, commence compressions immediately.

With capnography, you will never need two pauses in compressions for rhythm analysis/pulse checks and shock again, you will only need one very short pause for a simultaneous rhythm check and possible shock. Capnography tells you what you need to know!

Support in resuscitation termination

Okay, maybe that sudden rise in EtCO2 never came. This is despite your best efforts in ensuring regular ventilations and tidal volumes and your partner being the champ at performing chest compressions. In 2001, Ahrens T. et al. found that after 20 minutes of advanced life support resuscitation, EtCO2 levels below 1,33 kPa/10 mmHg predicted a 0,8% chance of survival[10]. Extremely low EtCO2 levels should therefore be one part of your decision to terminate resuscitation – but never the only one.

Summary

This article has reviewed and discussed the usability and application possibilities of capnography during resuscitation of patients in cardiac arrest. To interpret EtCO2 values during resuscitation, ventilations need to be regular and tidal volumes need to be consistent. Thereafter, capnography might be used as a guide in airway placement confirmation, in optimising chest compressions and cycles, in identifying ROSC, when to withhold adrenaline and as a decision tool in when to terminate resuscitation efforts.

Conversion table

mmHg	kPa	mmHg	kPa
5	0.67	45	6.00
10	1.33	50	6.67
20	2.67	60	8.00
30	4.00	70	9.33
35	4.67	80	10.67
40	5.33	90	12.00

Sources

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In the next edition…

In the next edition of *Ambulance Today*, the application possibilities of capnography in the spontaneously breathing patient will be discussed in the third and last article on EtCO2 monitoring.

The bottom line

- Capnography interpretation during resuscitation calls for regular, consistent ventilations through a clear airway to ensure valid EtCO2 readings

- Capnography can guide you in airway placement, performance, identifying ROSC, when to withhold adrenaline and as an aid in when to terminate resuscitation

- Capnography should be your best friend during cardiac arrest!