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REVIEW

Clinical applications of capnography

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ABSTRACT

This article gives a short review of the basic definitions of capnography and its use. The introduction gives an overview of the historical development of this procedure. Technical features of the method are presented, followed by several definitions for understanding the basic terms needed to realize the applications of capnography. The last section is a descriptive part that explains the most important clinical applications of capnography, the strengths and limitations of this method. This article distinguishes capnography applications as a single procedure and its benefits as a complimentary procedure.

Key words: capnography, monitoring, ventilation, end-tidal CO_2

Introduction

Capnography is a simple method of monitoring the concentration or partial pressure of carbon dioxide (CO_2) in the respiratory gases. The fundamentals of capnography use were established in 1943 by Luft who discovered that CO_2 could absorb infrared (IR) radiation. (1) Capnography was first used in Holland in 1978, and subsequently its usefulness was approved for monitoring during anesthesia. Nowadays, capnography is a standard of care for monitoring patient safety in anesthesia, but it has not yet been accepted for routine use in emergency department procedural sedation and analgesia. (1)

Several procedures are available for monitoring airway CO_2. The first procedure is by using a side stream sample measured through a rapidly responding infrared CO_2 analyzer or measured through a mass spectrometer. The second procedure is direct measurement of CO_2 values through an infrared analyzer at the end of the endotracheal tube. These procedures correspond to the term capnography or airway CO_2 monitoring. (2)

Basic terms

Capnography is a graphic display of CO_2 concentration during the respiratory cycle, while capnometry is a numerical display of CO_2 concentration during the respiratory cycle.

This method of monitoring directly shows the elimination of CO_2 by the lungs and indirectly reflects the production of CO_2 by tissues and CO_2 circulatory transport to the lungs. Capnography is a non-invasive and accurate method. The need for arterial blood sampling can be significantly reduced. (3)

Clinical applications

An extensive Pubmed search lists 46 clinical applications of capnography overall, and can be divided into six major categories: Airway, Breathing, Circulation, Anesthetic Delivery Apparatus, Homeostasis and Non-perioperative. (4)

Information obtained through capnography includes: CO_2 production; lung perfusion; alveolar ventilation; respiratory patterns and elimination of CO_2 from the anesthesia breathing circuit and ventilator. The illustration that follows clearly demonstrates how

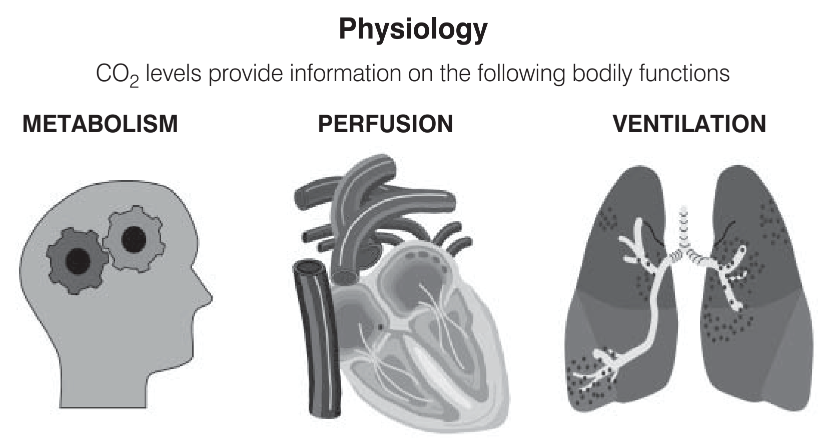

Figure 1. Capnometry is a method applicable for overall assessment of the body's physiology and the crucial parameters of the vital functions.

capnometry, as a method, can be applied to reflect the body's overall physiology and the crucial parameters of the vital functions (figure 1).

Capnography directly measures the ventilatory performance of the lungs and indirectly presents measurements on the performance of metabolism and circulation. For example, an increased metabolism will increase the production of carbon dioxide increasing the $ETCO_2$. A decrease in cardiac output will lower the delivery of carbon dioxide to the lungs, decreasing the $ETCO_2$. (5) Thus, it gives us a rapid and reliable method to detect life-threatening conditions such as malposition of tracheal tubes, ventilatory failure, circulatory failure and defective breathing circuits.

An important use of capnography is as a non-invasive assessor of proper endotracheal tube placement. (6) An advantage of capnography is that it provides an immediate picture of patient apnea, while pulse oximetry is delayed for several minutes. Pulse oximetry is insufficient for postoperative respiratory monitoring. (7) It is better to use capnometry for postoperative patients because it is easy to use and useful for monitoring patients' breathing. However, capnometry must be improved in its wearability and detection capability. Therefore, it is not used often for postoperative patients as a respiratory monitor. Capnography and pulse oximetry, used in conjunction, could have helped in the prevention of 93% of avoidable anesthesia mishaps according to the American Society of Anesthesiologists (ASA). So, capnography and pulse oximetry should be used as complimentary procedures for preventive purposes. Also, as a complementary procedure to arterial blood gas analyses, capnography provides estimates of the inefficiency of ventilation. The American Heart Association (AHA) affirmed the importance of using capnography to verify tube placement in their 2005 CPR and ECG Guidelines. (8) The AHA also notes in their new guidelines that capnography, which indirectly measures cardiac output, can also be used to monitor the effectiveness of CPR and as an early indication of return of spontaneous circulation. (9) The figure below presents the response of cardiac output under the influence of epinephrine administration as one of the CPR procedures measured through the $ETCO_2$ (figure 2).

During resuscitation, exhaled CO_2 is a better guide to the presence of circulation than an electrocardiogram, pulse or blood pressure. Exhaled concentrations are helpful in determining which patients are likely to be successfully resuscitated. The patient is more likely to be resuscitated if the concentration of exhaled CO_2 is greater than 10-15 mmHg.

Finally, it has been suggested that capnography can help in weaning patients off mechanical ventilation, but the prospective value of airway CO_2 monitoring in this clinical situation is unclear. (10)

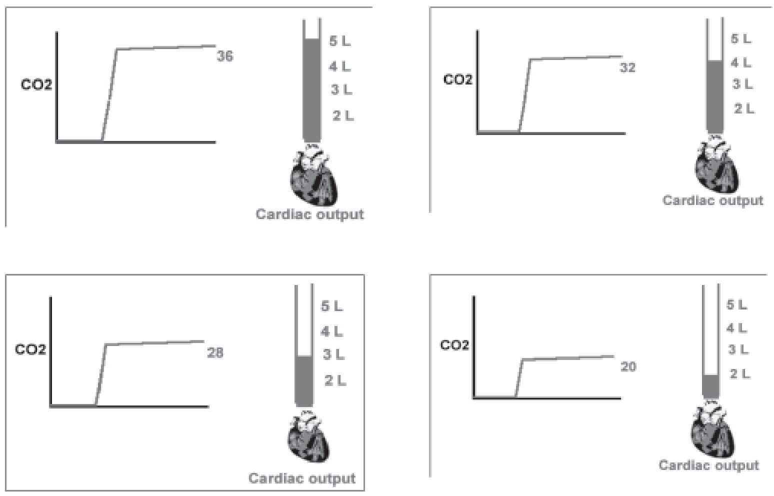

Figure 2. Response of cardiac output under the influence of epinephrine administration as one of the CPR procedures measured through the ETCO2.

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