EXPANDING THE KNOWLEDGE BASE

New Applications of Capnography

by Susan Blonshine, BS, RRT, RPFT

Research continues to explore new applications for capnography while expanding on the current knowledge of current applications. Monitoring the end-tidal carbon dioxide tension (PetCO₂) is a reliable estimate of arterial carbon dioxide tension (PaCO₂) under conditions of stable cardiovascular function and constant body temperature with a normal capnograph waveform. The data can be misleading because each of these components varies. Although capnography may potentially decrease the number of arterial blood gas samples needed, it does not replace the need for arterial blood gas analysis.

A standard of care
Capnography has become a standard of care in surgical departments for airway and ventilation assessment. The continuous monitoring of alveolar ventilation may be applied in patients without lung disease or hemodynamic instability. Examples include apnea monitoring and healthy surgical patients undergoing general anesthesia. In order to gain the maximum benefit for the anesthetist and patient, the capnograph waveform must be examined systematically.

Determining the presence of a waveform is the first step. The absence of a measured PetCO₂ may indicate esophageal intubation, accidental tracheal extubation, disconnection of the breathing circuit, complete obstruction of the endotracheal tube or conducting system of the breathing circuit, apnea, and cardiac arrest.

The next step is to analyze the shape of the waveform. The initial phase or inspiratory baseline should be zero. The second or expiratory upstroke is nearly perpendicular to the inspiratory baseline. The third phase occurring during expiration is the alveolar plateau, which is a straight, nearly horizontal line. The last phase or inspiratory downstroke is nearly perpendicular to the inspiratory baseline.

Dead space Ventilation
Lung disease, pulmonary embolism, and changes in cardiac output cause alterations in dead space ventilation. These alterations result in P(a-et)CO₂ changes. The changes in alveolar emptying patterns cause a change in the shape of the capnograph waveform. When both of these alterations are
observed, the cause is generally an increase in deadspace. A study published in 1998 compared the area under the capnograph waveform from patients with a pulmonary embolus (PE) and those without a PE. The mean capnogram area from patients with a PE (n=19) was $28 \pm 10$ mm Hg × sec, significantly less than for patients without a PE. The authors concluded that the capnograph waveform might be considered as a screening tool for a PE in the emergency department. However, this will need further research.

**Application in the Emergency Department**

The use of PetCO$_2$ monitoring in the emergency department has become increasingly common. Its main use has been as an aid to confirm endotracheal intubation. It has also been used for monitoring cardiopulmonary resuscitation as well as the ventilatory and hemodynamic status of intubated and nonintubated patients. Other proposed uses include using PetCO$_2$ as an adjunct to monitor asthma treatment and to measure cardiac output noninvasively.

**Monitoring Conscious Sedation in Children**

A study published in 1997 outlined the benefit of capnography for monitoring methods of conscious sedation in children undergoing painful procedures in the emergency department. Conscious sedation regimens used in pediatric patients have been extensively studied. The continued improvements in technology and capnography allow increased accuracy in the assessment of respiratory depression in spontaneously breathing sedated children than may have been previously possible.

In this study, vital signs, oxygen saturation, and PetCO$_2$ were monitored continuously; and pain, anxiety, and sedation scores were recorded every five minutes.

**Acute changes in cardiac output may also be detected with capnography.**
An increase in only PetCO$_2$ was observed in six of the eight patients who manifested respiratory depression. Capnography monitoring provided an earlier indication of respiratory depression than pulse oximetry and respiratory rate alone.\textsuperscript{3}

### Additional Applications

Acute changes in cardiac output may also be detected with capnography due to the acute decreases in PetCO$_2$, which occur concurrently with a sudden decrease in cardiac output.

Cardiopulmonary resuscitation is another area where researchers have applied capnography. Again, the sudden decrease in cardiac output results in a decreased PetCO$_2$, while successful resuscitation results in an increased PetCO$_2$ correlating with improved cardiac output. This has also been studied in the non-hospital setting. The survival rate after cardiac arrest occurring outside the hospital averages less than 3 percent. In a prospective observational study of 150 consecutive victims of cardiac arrest outside the hospital, an end-tidal carbon dioxide level of 10 mm Hg or less after 20 minutes of standard advanced cardiac life support successfully discriminated between the survivors and nonsurvivors. Investigators used this data as a screening test to predict death; the sensitivity, specificity, positive predictive value, and negative predictive value were all 100 percent. All of these patients had electrical activity but no pulse.\textsuperscript{4}

Other researchers have suggested an end-tidal carbon dioxide level of greater than 15 mm Hg indicates that aggressive resuscitation efforts should continue.

Capnography has been studied in other applications, as well, that include monitoring for respiratory status during pediatric seizures and during jet ventilation for laryngoscopy. Other proposed applications may need further study, such as capnography as a neuromuscular blockade monitor or as an aid to wedge pressure measurements.

### Continuously assess data

Multiple applications of capnography have been studied with positive outcomes. Even with positive outcomes, the therapist must continue to be vigilant when assessing the data. Misleading end-tidal carbon dioxide tensions do occur. The P(a-et)CO$_2$ gradient may increase in patients with systemic disease, those placed in the lateral position, or with hemodynamic instability. This gradient may also vary widely in different surgical procedures. The changes observed in PetCO$_2$ do not always accurately reflect the change in P$a$CO$_2$ in direction or amplitude.

Susan Blonshine is the director of TechEd, a diagnostics consulting service in Michigan. She is the AARC’s official representative to the National Committee for Clinical Laboratory Standards, and she chaired the Association’s Diagnostics Section from 1995 to 1997.

### references


### additional reading
