Reducing Deaths in ICUs: A Mandate for Capnography

About Capnography
Today, every hospital in the country is using capnography in the operating room, where it is the American Society of Anesthesiologists’ standard of care to prevent respiratory distress for patients under general anesthesia. Outside the OR, capnography also addresses the specific needs of patients who are not intubated.

When the body fails to eliminate carbon dioxide from the blood, this can lead to respiratory distress or failure, and even death. By monitoring adequacy of ventilation through the release of carbon dioxide (CO₂), capnography detects changes in cardio-respiratory function, alerting clinicians to potential problems before the onset of respiratory distress or failure. A capnograph measures CO₂ in exhaled breath—called end-tidal CO₂ or etCO₂—producing a waveform, or capnogram, showing carbon dioxide concentration throughout ventilation. This enables clinicians to continuously measure the quality of breathing and exchange of oxygen and CO₂ during the respiratory cycle.

Capnography is recognized as the fastest method for detecting changes associated with ensuing respiratory failure.¹

Background
A landmark British study has shown that the use of capnography can significantly reduce airway-related deaths and brain damage in intensive care units (ICUs). Researchers in the year-long prospective study concluded that the absence of capnography contributed to an overwhelming majority of airway-related deaths in ICUs, and that the use of capnography would have identified problems at an earlier stage and prevented deaths and traumatic brain injury.

As a result, the authors now recommend the use of capnography for all intubated patients in ICUs, as well as for all intubated and anaesthetized patients in emergency departments (EDs). This is an important study in a growing body of evidence establishing capnography as the standard of care for patient ventilation monitoring.

The Study²
From 2008-2009, the Royal College of Anaesthetists (RCoA) and the Difficult Airway Society (DAS) monitored reports of all major complications of airway management during anesthesia in the operating room, ICUs and emergency departments across all National Health Service hospitals throughout the United Kingdom (UK).

The study, which identified that 2.9 million general anesthetics are administered to patients in the UK each year, defined major complications as those events leading to death, brain damage, emergency surgical airway, or unanticipated admission to an intensive care unit. An expert panel assessed inclusion criteria, outcome, and airway management.

Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society (NAP4)—was published online in two parts in the British Journal of Anaesthesia on March 30, 2011.

Major Findings³
Of 184 reports of airway-related complications reported during the study, 38 resulted in a death. Sixteen of these deaths occurred while the patients were under general anesthetic in the operating room, 18 occurred in ICUs and four in EDs.
The absence of capnography contributed to a majority of airway-related deaths in ICUs and EDs.

"The absence of a breathing monitor (capnograph) contributed to 74% of airway related deaths and persistent neurological injury reported from ICUs. The use of capnography would have identified problems at an earlier stage and prevented at least some of the deaths."

"Capnography, or rather the failure to use it, likely contributed to 17 outcomes of death or brain damage on ICU, including four oesophageal intubations and 14 inadvertent tube displacements: these account for 82% of events leading to death or brain damage in ICU."

"Failure to use, or misinterpretation of, capnography also led to two fatal unrecognized oesophageal intubations in the ED. Correct use and interpretation of capnography would have prevented half of the deaths in the ED."

At least one-quarter of major complications of airway management in hospitals are likely to occur in the ICU and ED. These complications are more likely to lead to permanent harm or death than events in anesthesia.

"Although ICU was the setting for fewer than 20% of notified events almost half of deaths occurred there. Of the events reported from ICU, 61% led to death or brain damage, compared to 14% of events during anaesthesia … Airway problems were more likely to result in death in patients sedated on ICUs (50%) than if they occurred during anaesthesia for surgery (12%)."

"Obesity"
Obese patients are twice as likely as non-obese patients to develop serious airway problems during a general anesthetic. Given the trends in population obesity in developed countries, the number of patients at risk of such problems due to obesity is almost certain to increase.

"Intubation"
The use of capnography in both ICU and the ED could have prevented deaths due to tracheal obstruction or tube misplacement. Six cases of unrecognized esophageal intubation led to five deaths.

"In the cases of tracheal obstruction or tube misplacement, capnography and correct interpretation may have led to a change in clinical management and outcome. Each of the cases serves to remind us that the absence of expired carbon dioxide indicates lack of ventilation."

"Recommendations"
Dr. Tim Cook, a consultant in Anesthesia and Intensive Care at the Royal United Hospital, Bath (Bath, UK), and one of the report authors, says: "The report makes several recommendations to improve the safety of airway management in the ICU. The single most important change that would save lives is the use of a simple breathing monitor, which would have identified or prevented most of the events that were reported. We recommend that a capnograph is used for all patients receiving help with breathing on ICU; current evidence suggests it is used for only a quarter of such patients. Greater use of this device will save lives."

Specifically, the report recommends the use of capnography in ICU for intubation of all critically ill patients and in all patients with tracheal tubes who are intubated and ventilator-dependent, citing, "This project has shown that full implementation would save lives."
While the report focuses on potential improvements in the ICU, it also notes opportunities to improve care in anesthesia (recovery) and the ED, including consistent availability, use, and understanding of capnography during airway placement and maintenance.

**Capnography: Growing Body of Evidence**

This study joins a growing body of evidence establishing capnography as the standard of care for patient ventilation monitoring. Multiple clinical studies have validated the effectiveness of capnography over pulse oximetry and respiratory rate as a method to detect respiratory depression. As a result, a growing number of leading patient safety organizations worldwide recommend that patients be monitored for adequacy of ventilation through continuous ventilation monitoring. In 2010-2011:

- New guidelines from the American Heart Association (AHA) and the European Resuscitation Council (ERC) for cardiopulmonary resuscitation (CPR) emphasize the use of capnography for adults and pediatrics, expressly validating the value and significance of waveform capnography in saving lives.

- The AHA and ERC guidelines stress the critical importance of waveform capnography to confirm and monitor endotracheal tube placement, assess the quality of CPR, and detect return of spontaneous circulation (ROSC).45

- In response to the increasing risks associated with infusion pumps, the U.S. Food and Drug Administration recommended capnography monitoring of etCO2 within their strategy to “reduce risk to patients” administered opioids through infusion pumps.6

- In a Veterans Health Administration (VHA) analysis of 69 patient safety incidents related to PCA pumps, the agency determined that more than 60% of the adverse events could have been prevented by etCO2 monitoring. As a result, the VHA now recommends that PCA pumps with integrated etCO2 monitoring be the pump of choice.7

**Summary**

A year-long prospective study in the UK concludes that the use of capnography could have prevented a majority of airway-related deaths and brain injury in ICUs. The authors recommend continuous capnography for all intubated patients in ICUs. The authors also join a growing number of patient safety organizations worldwide that recommend intubated patients be monitored with continuous capnography, regardless of their location in the hospital.
References
4. Highlights of the 2010 American Heart Association Guidelines for CPR and ECC. American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC).