About Capnography
Carbon dioxide (CO₂) is a waste product formed during energy production for the body’s vital functions. When the body fails to eliminate CO₂ from the blood, it can lead to respiratory distress or respiratory failure; without intervention, it can be fatal. By monitoring adequacy of ventilation through the release of CO₂, capnography detects changes in cardio-respiratory function, alerting clinicians to the onset of respiratory problems.

A capnograph measures CO₂ in exhaled breath—end-tidal CO₂ or etCO₂—producing a waveform that displays a continuous measurement of the quality of breathing. The waveform combined with resulting numeric values, allows clinicians to visualize and interpret CO₂ concentration levels throughout the respiration cycle.

Without capnography, physicians and nurses must rely on pulse oximetry and respiratory rate, which reflect only the patient’s oxygenation status and number of breaths per minute. Neither measurement provides continuous monitoring of the adequacy of ventilation.

Capnography is the only real-time measurement of adequacy of ventilation and meta-analysis data does not support substituting oximetry for capnography when monitoring respiratory depression and some investigators have concluded it would be dangerous to do so.¹

Capnography, already the standard of care in hospital operating rooms, is quickly becoming recognized as the standard of care in monitoring postoperative patients receiving opioid pain management. Heightened concern over the risk of respiratory depression in postoperative patients recently led the Anesthesia Patient Safety Foundation (APSF) to strengthen its recommendations regarding continuous ventilation monitoring using exhaled CO₂/capnography. APSF now recommends that continuous electronic monitoring of ventilation be available and considered to “reduce the likelihood of unrecognized clinically significant opioid-induced depression of ventilation in the postoperative period.”²

Background
According to the most recent HealthGrades report, postoperative respiratory failure is the third most common type of patient safety incident in hospitals each year, affecting an estimated 600,000 patients at a cost of $1.9 billion. The frequency of postoperative respiratory failure, now occurring in 17.2 of every 1,000 patients, is higher than sepsis (16.09) and more than triple the cost.³

According to APSF, clinically significant drug-induced respiratory depression (oxygenation and/or ventilation) in the postoperative period is a “serious patient safety risk that continues to be associated with significant morbidity and mortality.”⁴

The APSF addressed this patient safety issue on June 8, 2011, when 136 stakeholders (physicians, nurses, industry representatives, family representatives, scientists, pharmacists, hospital administrators, insurers, and regulators) reviewed data, clinical studies, and case studies to ascertain the most effective strategies to reduce adverse outcomes in postoperative patients. The result was published as the Essential Monitoring Strategies to Detect Clinically Significant Drug-Induced Respiratory Depression.

APSF Recommendations⁵
Among the recommendations, it was recognized that:

“Future technology developments may improve the ability to more effectively utilize continuous electronic monitoring of oxygenation and ventilation in the postoperative period. However, maintaining the status quo while awaiting newer technology is not acceptable. Intermittent ‘spot checks’ of oxygenation (pulse oximetry) and ventilation (nursing assessment) are not adequate for reliably recognizing clinically significant drug-induced respiratory depression in the postoperative period.”
Specific to monitoring ventilation, it was recognized that, “Continuous electronic monitoring of oxygenation and ventilation should be available and considered for all patients and would reduce the likelihood of unrecognized clinically significant opioid-induced depression of ventilation in the postoperative period. Capnography or other monitoring modalities that measure the adequacy of ventilation and airflow is indicated when supplemental oxygen is needed to maintain acceptable oxygen saturations.” The APSF also observed, “APSF is aware of hospital system experiences that support the effectiveness of alternative continuous respiratory monitoring technologies, such as capnography, in lieu of pulse oximetry.”

**Risk Stratification Can Fail to Protect All Patients**

It is not sufficient to use electronic monitoring only for patients considered at increased risk of respiratory depression.

“Although careful preoperative screening for conditions that portend an increased risk of postoperative respiratory insufficiency (obstructive sleep apnea, obesity, chronic opioid therapy) is recommended and may be part of a graduated continuous monitoring adoption plan, applying electronic monitoring selectively based upon perceived increased risk is likely to miss respiratory depression in patients without risk factors.”6

The 2011 APSF recommendations further validate the growing call for capnography in postoperative patients, particularly those receiving opioids through patient controlled analgesia (PCA). Recent clinical studies and professional recommendations have demonstrated the serious risk of respiratory depression in postoperative patients and the role of capnography as an early indicator.

**Return on Investment**

St. Joseph's/Candler Health System, a 644-bed tertiary care “magnet” hospital system in Savannah, GA, in 2004 replaced its existing IV pumps with “smart” IV safety systems, including pulse oximetry and noninvasive capnography modules.

“These purchases were based on the recognition that patient response to opioid administration is highly variable, even with recommended dosages, and it is important that all patients receiving PCA therapy for opioid-related complications be monitored.”8

The new system resulted in financial benefits, improved safety, improved quality of care, and increased nursing satisfaction. Using these smart systems over five years reduced high-risk medication errors and PCA-related undesired outcomes, helped avert at least 471 preventable adverse drug events, and provided a five-year return on investment (ROI) of $1.87 million, with an internal rate of return of 81%. Feedback from the nursing staff indicates that nurses feel more able to aggressively manage patients' pain now that they have insight into the patient's respiratory response to PCA and can ensure “right programming, right response.” Capnography is now required for all patients receiving PCA, not only those at heightened risk of toxicity.9

“Continuous-pulse oximetry and capnography monitoring during PCA therapy may allow clinicians to identify unforeseen risk and undiagnosed clinical conditions that predispose patients to respiratory complications from IV opioids. Continuous monitoring allows earlier detection of hypventilation and obstructive apnea. In particular, the use of continuous capnography provides information about diagnosed and undiagnosed OSA.”10

**Capnography Valued Over Pulse Oximetry**

St. Joseph's/Candler Health System (SJCHS) experience revealed that capnography demonstrated benefits over pulse oximetry for respiratory monitoring. SJCHS's initial plans for PCA implementation included use of pulse oximetry for all patients and capnography reserved for limited deployment. This approach was changed, based on the results of their clinical evaluation. Capnography is now required for all patients receiving PCA, not only those at heightened risk of toxicity. Pulse oximetry is used selectively for patients at high risk of oxygenation problems.
Clinical Evidence

In a study of 634 patients to determine the most effective method of monitoring postoperative patients receiving patient-controlled opioid therapy, McCarter et al found that capnography was more effective than pulse oximetry in providing early warning of respiratory depression in patients receiving supplemental oxygen. Researchers concluded that relying on pulse oximetry alone is potentially dangerous.

“Capnography monitoring and automatic pausing of patient-controlled analgesia improved postoperative outcomes in situations that could have otherwise been fatal.”

The American Society of Anesthesiologists (ASA) has established new guidelines recommending that post-anesthesia patients be monitored for ventilation, and that all patients sedated with neuraxial opioids be monitored for depth of respiration, not only pulse oximetry and respiratory rate.

The Joint Commission has recommended the use of capnography for patients receiving patient-controlled analgesia (PCA).

“Carefully monitor patients. Even at therapeutic doses, opiates can suppress respiration, heart rate and blood pressure, so the need for monitoring and observation is critical. Oximetry and/or capnography monitoring may be appropriate in some cases.”

The Institute for Safe Medication Practices (ISMP) advises that hospital staff should not rely on intermittent pulse oximetry readings or respiratory rate alone to detect opiate-induced respiratory depression, saying capnography should be used for patients at a heightened risk.

“Do not rely on pulse oximetry readings alone to detect opiate toxicity. Use capnography to detect respiratory changes caused by opiates, especially for patients who are at high risk (e.g., patients with sleep apnea, obese patients). Establish guidelines for appropriate monitoring of patients who are receiving opiates, including frequent assessment of the quality of respirations (not just respiratory rate) and specific signs of oversedation.”

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, they now recommend that PCA pumps with integrated etCO2 monitoring be used.

Conclusion

Drug-induced respiratory depression in postoperative patients is a serious patient safety risk facing hospitals today. In addressing this risk, the Anesthesia Patient Safety Foundation now recommends that capnography (etCO2) monitoring be available and considered for all postoperative patients receiving opioid pain management therapy. The APSF recommendations support and further validate growing evidence establishing capnography as a standard of care for postoperative patient monitoring.
References


5. ibid

6. ibid


