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Economic and Clinical Outcomes Associated With Capnography Monitoring During Procedural Sedation

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Introduction

Adequate and safe sedation and analgesia are critical aspects for successful endoscopic examination and intervention to ensure patient comfort and to avoid distress. However, response to sedatives and analgesics can vary from person to person, which contributes to a risk for over- or undersedation and serious associated complications and adverse events (AEs) such as hypotension, apnea, hypoxemia, respiratory failure, or procedure termination.¹⁻³

Although prior studies have expressed concerns about the financial burden of adding capnography monitoring during procedural sedation, a collection of more recent publications discusses the favorable use of capnography during procedural sedation and analgesia (PSA) to help prevent AEs, reduce procedure time, and facilitate successful and safe gastrointestinal endoscopy.^{1,4}

Strategies To Mitigate Risks of Sedation and Analgesia During Endoscopy

PSA can account for up to 75% of the time and 40% of the cost associated with endoscopy.^{5,6} Monitoring of cardiopulmonary

status during PSA is mandatory, because there is a risk of patients progressing into deeper, unintended levels of sedation with associated loss of protective autonomic physiologic responses. Although some monitoring, such as pulse oximetry, is considered standard of care, other types of monitoring, such as capnography, often are not used despite recommendations from multiple professional organizations and societies.^{4,7,8}

American Society of Anesthesiologists (ASA) standards for basic anesthetic monitoring specify that one clinician be specifically tasked with monitoring the respiratory and hemodynamic status of the patient during PSA.¹ At a minimum, monitoring of vital signs, airway, oxygen saturation, and carbon dioxide in expired gas using capnography should be done before the procedure starts, after administration of sedative–analgesic agents, at regular intervals during the procedure, during initial recovery, and just before discharge from the endoscopy unit.⁷ Furthermore, many guidelines, including the Society of Gastroenterology Nurses and Associates, suggest inclusion of capnography as part of routine monitoring.⁸

Randomized controlled trials have reported that the incidence of all minor and major AEs (eg, apnea, desaturation, and hypotension) during PSA for endoscopic procedures ranges from 13% to 69%.⁹⁻¹¹ The wide variability in this range may be at least partially attributed to undetected events in cases in which monitoring for AEs is suboptimal.¹² Although major AEs (eg, respiratory failure, severe hypotension) are not common, their potentially catastrophic effects magnify their significance. In addition to serious consequences to patients, the occurrence of these major AEs increases the costs and health care utilization required to manage their complications.¹

Identification of patients who are at higher risk for complications while undergoing PSA during gastrointestinal endoscopy might help guide choice of appropriate drugs or decisions to use more rigorous monitoring. In this regard, several groups of investigators

have described factors that can predict a higher risk for such complications. For example, Coté and colleagues reported that airway complications in patients undergoing propofol sedation could be predicted by ASA scores of 3 or higher, longer endoscopy times, male sex, and high body mass index (BMI).² An Italian study investigated a sample of 17,542 patients sedated during endoscopy and found variables that predicted the occurrence of any complication: female sex, advanced age (median age, 65 years), higher BMI, higher ASA score, higher Mallampati score, emergent nature of the procedure, and longer duration of the procedure.³

An analysis of 20 years of data from the ASA Closed Claims Project suggested that over 60% of respiratory-related PSA AEs could have been prevented with improved patient monitoring.^{13,14} Standard-of-care monitoring for PSA includes pulse oximetry, visual assessment, and blood pressure measurement, with adjunct monitoring with capnography.^{7,8,15} Capnography evaluates carbon dioxide in exhaled air and provides a measure of patient ventilation as an indirect measure of level of sedation. Randomized controlled

trials have demonstrated that capnography in addition to pulse oximetry can reduce the occurrence of specific AEs in pediatric patients undergoing moderate sedation and in adults receiving propofol-mediated deep sedation.^{9-11,16} Furthermore, 2 studies published in 2015 indicated that capnography leads to earlier identification of respiratory compromise and a reduced need for intervention.^{17,18} Neither of these series, however, involved gastrointestinal endoscopy.

Modeling the Cost Benefit of Capnography in Endoscopy

The addition of capnography to PSA guidelines has been controversial due to limited evidence regarding the cost benefit. However, recently published models have specifically investigated the effect of capnography on procedure costs. For example, Jopling and colleagues created a gastroenterology cost-avoidance model to determine the net economic effect of capnography monitoring during sedation procedures for a typical hospital-based endoscopy

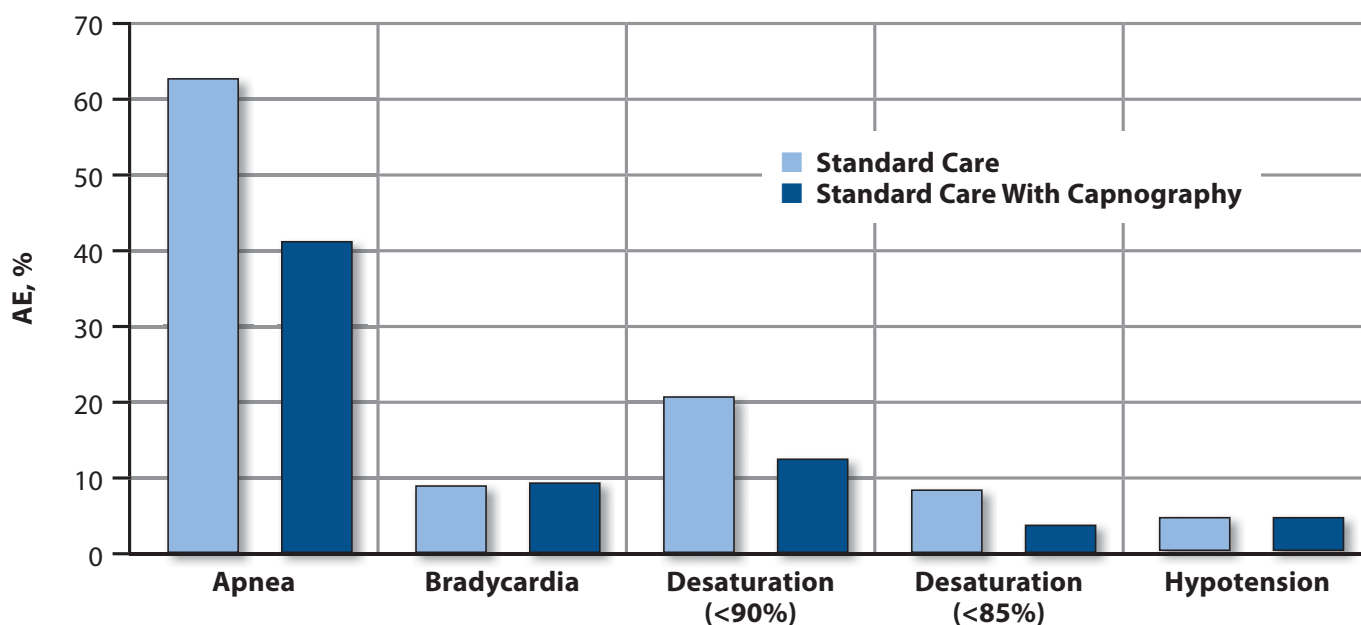


Figure 1. AE rates reported in randomized controlled trials comparing capnography with standard-of-care monitoring.

AE, adverse event

Based on references 1, 9, and 11.

suite. The data model was based on a 240-bed reference hospital with 8,000 instances of procedural sedation in 10,000 of the annual endoscopic procedures used in combination with rates and costs of AEs derived from peer-reviewed publications. The investigators reported that the median annual cost avoidance with routine capnography monitoring for the reference facility was \$304,234 and concluded that capnography may improve patient safety while also decreasing overall costs.¹³

In another analysis, capnography used in combination with pulse oximetry in an inpatient population (285,262 inpatients; 3,807,151 outpatients) undergoing gastrointestinal endoscopy with PSA was associated with a 47% reduction in the odds of

mortality (odds ratio [OR], 0.528; 95% CI, 0.401-0.696; $P < 0.0001$), and a 10% reduction in the odds of naloxone and/or flumazenil administration (OR, 0.905; 95% CI, 0.645, 1.271; $P = 0.5661$) compared with patients using pulse oximetry alone. In an outpatient population undergoing gastrointestinal endoscopy with PSA, use of capnography in combination with pulse oximetry was associated with an 82% reduction in the odds of mortality (OR, 0.178; 95% CI, 0.016-1.990; $P = 0.16$), and a 62% reduction in the odds of naloxone and/or flumazenil use compared with patients with oximetry monitoring alone (OR, 0.385; 95% CI, 0.286-0.520; $P < 0.0001$).¹⁹

Further, Saunders and colleagues established a comprehensive model to examine the cost benefit of the addition of capnography

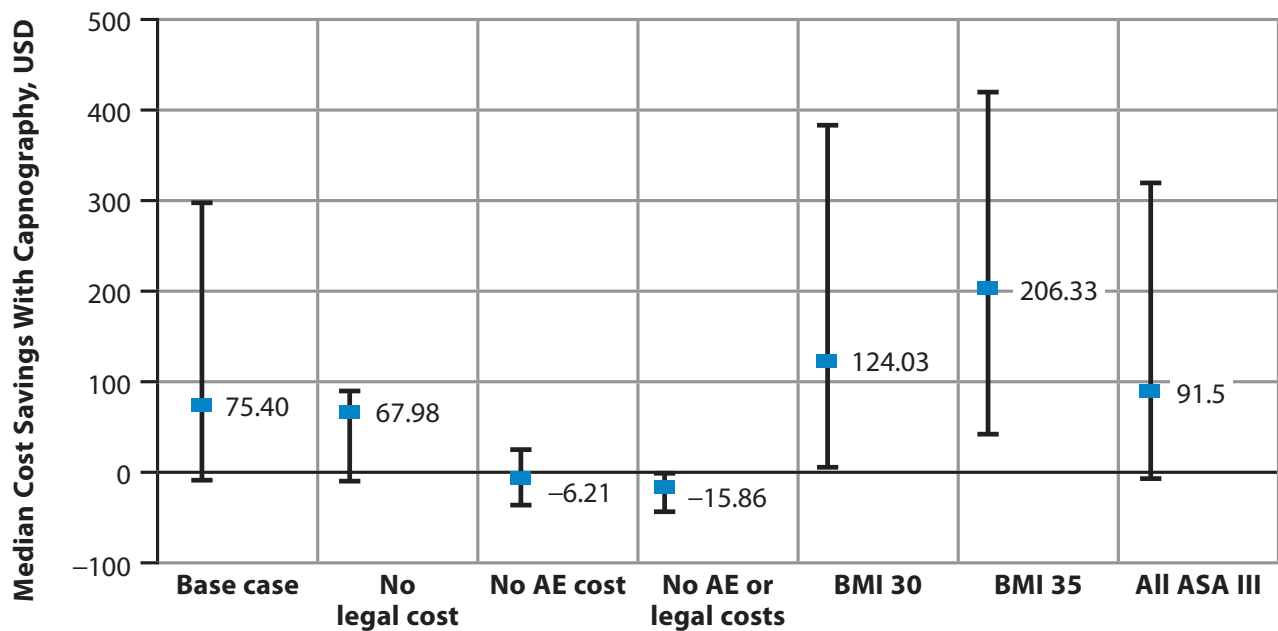


Figure 2. Predicted median cost savings associated with capnography monitoring under different scenarios.

Median (95% CI) cost savings associated with capnography monitoring under different scenarios (n=5,000 simulations for each). Negative cost savings reflect a cost increase.

AE, adverse event; **ASA**, American Society of Anesthesiologists; **BMI**, body mass index; **USD**, US dollars

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to standard pulse oximetry monitoring for patients undergoing PSA during gastrointestinal endoscopy.¹ The model population was taken from randomized controlled trials and large-scale studies, and included 8,000 participants (mean age, 55.5 years; mean BMI, 26.2 kg/m²; 45.3% men). Pulse oximetry was assumed to carry no cost due to the near-universal existence of appropriate equipment, whereas capnography was calculated to cost approximately \$4,000 per monitor and \$16 per procedure for disposables. Training for capnography was assumed to be 2 hours per month per trained staff member, while maintenance and calibration were assumed to require 2 hours of time per month from one technician. The costs of AEs were estimated based on data from 2012-2013 in a literature review and Premier database analysis.¹⁰

Using their model, the investigators reported that the addition of capnography to pulse oximetry monitoring during PSA resulted in an overall reduction in AEs. The most commonly avoided AE with capnography was apnea; in total over 1,134 AEs were reportedly avoided across the whole cohort. Desaturation events also were greatly reduced in the cohort with capnography monitoring (Figure 1).^{1,9,11} In terms of patients experiencing AEs, the percentage of those with AEs was 34.18% with pulse oximetry monitoring and 24.89% with capnography (absolute reduction, 9.29%; relative reduction, 7.18%).⁴ When stratifying according to level of PSA, the addition of capnography resulted in a 27.2% and an 18.0% reduction in the proportion of patients experiencing an AE during deep and moderate PSA, respectively. The median number needed to treat to avoid any AEs was 8 for deep hypoxia and 15 for apnea. Furthermore, the reduced incidence of AEs resulted in cost savings that accounted for the additional up-front purchase cost. Specifically, capnography was estimated to reduce the cost per procedure by \$85 for deep PSA and by \$35 for moderate PSA (Figure 2).¹

Based on these data, the investigators concluded that capnography is cost-effective and possibly carries cost savings during PSA for gastrointestinal endoscopy. Savings were driven by improved patient safety, suggesting that capnography may have an important role in the safe provision of PSA. Furthermore, although capnography was associated with an up-front cost burden in terms of both acquisition costs and staff training time (>1 year), these costs were completely offset by cost savings associated with the reduction of AEs.¹

Conclusion

AEs related to PSA for gastrointestinal endoscopy are associated with serious complications and costs. Identification of patients at risk for complications may enhance patient safety while avoiding the cost associated with treating complications. The inclusion of capnography in the anesthetic protocol appears to be a cost-effective and possibly a cost-saving approach with an estimated cost savings of \$85 per patient.

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