

The emerging role of capnographic monitoring of ventilation during deeper levels of sedation

Patients undergoing procedural sedation often present with multiple comorbidities that can have an impact on their respiratory reserve, making the use of capnography to ensure their safety even more important than it was when first recommended by the Canadian Anesthesiologists' Society in 2012.

ABSTRACT: Procedural sedation, called conscious sedation in the past, is the administration of sedative agents that have the ability to depress ventilation as well as consciousness. This form of sedation often relies on opioids and is used during procedures that may cause temporary pain or anxiety, such as dental surgery and endoscopy. The Canadian Anesthesiologists' Society and other leading medical societies and organizations have identified opioid-related adverse events as a major patient safety concern and recommend the use of capnographic monitoring during procedural

sedation, particularly when the patient cannot be observed directly. Numerous studies have shown that capnographic monitoring during deeper levels of sedation allows an early rescue intervention and prevents desaturation, although these studies fall short of showing that capnography saves lives. Clinicians using capnography for patients undergoing procedural sedation should remain aware that they play a vital role in ensuring patient safety and must not be lulled into a false sense of security or think that the use of capnography can replace a vigilant sedation provider.

After the Canadian Anesthesiologists' Society (CAS) published revised anesthesia practice guidelines in 2012,¹ we wrote an editorial for the *Canadian Journal of Anesthesia* titled "Yesterday's luxury—today's necessity: End-tidal CO₂ monitoring during conscious sedation."² The editorial addressed what is now commonly referred to as procedural sedation and explained the rationale for requiring that deeply sedated patients be monitored by capnography—previously required only for patients when intubated or with a laryngeal mask airway.

Procedural sedation is the administration of sedative agents (often including opioids) that have the ability to depress ventilation as well as consciousness, and is used during procedures that may cause temporary pain or anxiety, such as dental surgery, bone or joint realignment, and endos-

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copy for gastrointestinal problems. Over that past 5 years the use of procedural sedation has increased, and so has the medical complexity of the patients being sedated. Many present with multiple comorbidities that can have an impact on their respiratory reserve, making the use of capnography to ensure patient safety even more important than it was in 2012 when we wrote the editorial.

While the CAS guidelines apply to anesthesiologists, they also contain important information for any provider of deeper levels of sedation.

Adverse events concern

The Canadian Medical Protective Association (CMPA) has identified opioid-related adverse events as a major patient safety concern:

Preventing opioid-related events is a leading patient safety concern. Although there is increased focus on improper use and management of opioids in the community, the hospital setting is also where many patient safety incidents involving these drugs occur. These events take place across different settings within the hospital and involve various members of the healthcare team.³

The concern expressed by CMPA is also seen in the United States, where the Joint Commission Patient Safety Advisory Group reminds us of patient risks associated with administering opioids:

While opioid use is generally safe for most patients, opioid analgesics may be associated with adverse effects, the most serious effect being respiratory depression, which is generally preceded by sedation. Other common adverse effects associated with opioid therapy

include dizziness, nausea, vomiting, constipation, sedation, delirium, hallucinations, falls, hypotension, and aspiration pneumonia. Adverse events can occur with the use of any opioid; among these are fentanyl, hydrocodone, hydromorphone, methadone, morphine, oxycodone, and sufentanil.⁴

In 2009 the CMPA reported on 49 medicolegal cases involving physician-prescribed opioids that closed between 2000 and 2007. The report identified the following clinical outcomes:

- In 44 of 49 cases, the principal event was respiratory insufficiency, which led to 27 deaths, 5 cases of hypoxic brain injury, and 12 cases of respiratory depression that responded to treatment.
- In the remaining 5 of 49 cases, one patient suffered a seizure, one suffered hypotension and renal tubular necrosis, one fell down stairs, and two were involved in motor vehicle crashes.⁵

In analyzing monitoring and treatment in these cases, CMPA found the following issues:

- Insufficient monitoring of vital signs, respiratory status, pulse oximetry, and/or level of consciousness in patients at high risk of respiratory depression.
- Failure to order additional treatment and more intensive monitoring in

patients with sleep apnea.

- Failure to admit high-risk patients to a specialized unit.
- Early transfer from the recovery room to the ward of a postoperative patient who was not fully alert and had just received a large dose of opioid.
- Too-early cessation of monitoring after a procedure done under sedation.
- Failure to recognize respiratory depression during endoscopy.
- Failure of nurses to notify physicians of decreased respiration, apneic spells, confusion, or decreasing level of consciousness.
- Failure of physicians to appreciate signs of impending respiratory arrest, and to react appropriately by securing an airway and/or administering an opioid antagonist.

Similarly, the Controlled Risk Insurance Company (CRICO) in the US found monitoring and management during routine procedures accounted for 55% of errors in outpatient cases and 46% of errors in inpatient cases (Table).⁶

While many of the adverse events reported above involved patients who did not undergo a minimally invasive procedure under deeper levels of sedation at the time of the respiratory compromise, the message remains the same: early detection of impending respiratory compromise in sedated patients with capnographic monitoring of ventilation can permit an early

Table. Errors in medication process of care during routine medical procedures for cases analyzed by the Controlled Risk Insurance Company (CRICO), 2007 to 2011.

| | Outpatient cases (% of total*) | Inpatient cases (% of total) |
|---------------------------|-----------------------------------|---------------------------------|
| Ordering | 18 | 23 |
| Pharmacy dispensing | 2 | 3 |
| Provider administration | 10 | 13 |
| Monitoring and management | 55 | 46 |
| Other | 16 | 15 |

*Percentages do not add up to 100 due to rounding.

Source: CRICO⁶

rescue intervention and prevent progression to respiratory arrest.

Support for monitoring

In the operating room, it has been a standard of practice for intubated patients or patients with laryngeal mask airways to have their oxygenation monitored with pulse oximetry and their ventilation monitored with

dergoing endoscopic procedures with intravenous sedation. They found that capnography detected 57% of adverse respiratory events (defined as apnea lasting 30 s or at least 30 s in any 45-s period), while pulse oximetry detected only 50% of these events and did so with a mean delay time of 45 s. Visual observation alone detected none of the events.

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capnography. These monitoring modalities have generally been embraced by medical practitioners over the years, even though no study has yet proven conclusively that the use of these modalities saves lives. This lack of evidence, however, is solely a statistical problem since the number of patients required to perform such a study (given the relatively small mortality) simply does not make the research feasible.

Likewise, while numerous studies have been able to show that capnographic monitoring during deeper levels of sedation allows an early rescue intervention and prevents desaturation, these studies fall short of showing that capnography actually saves lives.

Studies that support capnographic monitoring for deeper levels of sedation include that of Patel and colleagues,⁷ who studied patients un-

dergoing endoscopic procedures with intravenous sedation. They found that capnography detected 57% of adverse respiratory events (defined as apnea lasting 30 s or at least 30 s in any 45-s period), while pulse oximetry detected only 50% of these events and did so with a mean delay time of 45 s. Visual observation alone detected none of the events.

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ciation for Radiologic and Imaging Nursing (ARIN) addresses this situation directly:

ARIN endorses the routine use of capnography for all patients who receive moderate sedation/analgesia during procedures in the imaging environment. This technology provides the critical information necessary to detect respiratory depression, hypoventilation, and apnea, thus allowing the timely initiation of appropriate interventions to rescue the individual patient. Capnography use is associated with improved patient outcomes. Capnography should be used at all times, regardless of whether sedation is administered by an anesthesia provider or a registered nurse credentialed to administer moderate sedation/analgesia medications.¹²

Similarly, the Association of peri-Operative Registered Nurses has issued guidelines for the care of patients receiving moderate sedation and analgesia (www.aorn.org/guidelines/guideline-implementation-topics/patient-care/care-of-the-patient-receiving-moderate-sedation-analgesia). These recommendations include the use of end-tidal CO₂ to monitor patients when ventilation cannot be observed directly during procedures.

Role of the clinician

Clinicians using capnography for patients undergoing procedural sedation should remain aware that they play a vital role in ensuring patient safety. They must not be lulled into a false sense of security or think that capnography can replace a vigilant sedation provider. Reliance on monitoring technology may lead a practitioner to be more liberal in the administration

of sedatives or less alert to risks. It is important to keep in mind that capnographic monitoring of ventilation during deeper levels of sedation provides an added level of safety but is no substitute for good clinical judgment and vigilant care. As the CAS guidelines remind us:

The only indispensable monitor is the presence, at all times, of a physician or an anesthesia assistant who is under the immediate supervision of an anesthesiologist and has appropriate training and experience. Mechanical and electronic monitors are, at best, aids to vigilance. Such devices assist the anesthesiologist to ensure the integrity of the vital organs and, in particular, the adequacy of tissue perfusion and oxygenation.¹

Cost considerations

Capnographic monitoring is now a robust and mature technology as are other more recently developed respiratory monitoring devices. In 2016 the ECRI Institute reported on the devices available¹³ regarding machine issues such as reliability and provided an analysis of costs, albeit from an American perspective. In Canada, capital costs vary depending on contracts but capnography monitors are not expensive, particularly when included as components of other multi-function devices. In addition, the required disposables are inexpensive, costing approximately \$8 per patient in our hospitals.

By contrast, the sequelae of respiratory complications can be very expensive, both in terms of liability claim costs and human suffering. In 2009 Metzner and colleagues¹⁴ conducted an analysis of closed claims that found median payments for injuries related to sedation complica-

tions totaled \$460 000. In a review of pediatric tonsillectomy claims in which the circumstances differed from procedures under sedation but the injuries did not, Subramanyam and colleagues¹⁵ found opioid-related claims had the largest median monetary awards for both fatal injury (\$1 625 892) and nonfatal injury (\$3 484 278).

Prevention versus cure

Capnographic monitoring of ventilation during deeper levels of sedation is a good example of an ounce of prevention being worth a pound of cure. The Anesthesia Patient Safety Foundation's vision is that "no patient shall be harmed by anesthesia."¹⁶ This is a goal that has, for the most part, been achieved in the operating room whenever general anesthesia is administered.

However, with the growing use of procedural sedation and the increasing complexity of cases, the same goal is needed for procedures involving deeply sedated patients, especially whenever deep sedation might lead to respiratory depression. In addition, it is essential that the attending anesthesia provider be trained to recognize respiratory compromise and be skilled enough to manage the patient's airway. The use of monitoring technology and the presence of adequately trained personnel are required to achieve greater patient safety and ensure no patient is harmed during procedural sedation.¹⁷ **BCMJ**

Competing interests

None declared.

References

1. Merchant R, Chartrand D, Dain S, et al.; Canadian Anesthesiologists' Society. Guidelines to the practice of anesthesia revised edition 2012. *Can J Anaesth* 2012; 59:63-102.

2. Kurrek MM, Merchant RN. Yesterday's luxury—today's necessity: End-tidal CO₂ monitoring during conscious sedation. *Can J Anaesth* 2012;59:731-735.
3. Canadian Medical Protective Association. Safe use of opioid analgesics in the hospital setting. Accessed 21 September 2018.

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www.cmpa-acpm.ca/en/advice-publications/browse-articles/2016/safe-use-of-opioid-analgesics-in-the-hospital-setting.

4. Joint Commission Patient Safety Advisory Group. Safe use of opioids in hospital. Sentinel Event Alert 49. Accessed 21 September 2018. www.jointcommission.org/assets/1/18/SEA_49_opioids_8_2_12_final.pdf.
5. Canadian Medical Protective Association. Adverse events—physician-prescribed opioids. Published 2009. Accessed 21 September 2018. www.cmpa-acpm.ca/en/advice-publications/browse-articles/2009/adverse-events-physician-prescribed-opioids.
6. Controlled Risk Insurance Company (CRICO). Malpractice risks in routine medical procedures: 2013 CRICO Strategies national CBS report. Accessed 21 September 2018. www.rmhf.harvard.edu/Malpractice-Data/Annual-Benchmark-Reports/Risks-in-Routine-Medical-Procedures.
7. Patel S, Vargo JJ, Khandwala F, et al. Deep sedation occurs frequently during elective endoscopy with meperidine and midazol-

am. *Am J Gastroenterol* 2005;100:2689-2695.

8. Lightdale JR, Goldmann DA, Feldman HA, et al. Microstream capnography improves patient monitoring during moderate sedation: A randomized, controlled trial. *Pediatrics* 2006;117:e1170-1178.

9. Qadeer MA, Vargo JJ, Dumot JA, et al. Capnographic monitoring of respiratory activity improves safety of sedation for endoscopic cholangiopancreatography and ultrasonography. *Gastroenterology* 2009;136:1568-1576.
10. Deitch K, Miner J, Chudnofsky CR, et al. Does end tidal CO₂ monitoring during emergency department procedural sedation and analgesia with propofol decrease the incidence of hypoxic events? A randomized, controlled trial. *Ann Emerg Med* 2010;55:258-264.
11. Practice guidelines for moderate procedural sedation and analgesia 2018: A report by the American Society of Anesthesiologists Task Force on Moderate Procedural Sedation and Analgesia, the American Association of Oral and Maxillofacial Surgeons, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, and Society of Interventional Radiology. *Anesthesiology* 2018;128:437-479.
12. Green KL, Brast S, Bland E, et al. Association for Radiologic and Imaging Nursing

position statement: Capnography. *J Radiology Nursing* 2016;35:63-64.

13. ECRI Institute. Evaluation background: Monitors for detecting respiratory depression—recommended for patients on opioids. Health Devices. October 2016.
14. Metzner J, Posner KL, Domino KB. The risk and safety of anesthesia at remote locations: The US closed claims analysis. *Curr Opin Anaesthesiol* 2009;22:502-508.
15. Subramanyam R, Chidambaran V, Ding L, et al. Anesthesia- and opioids-related malpractice claims following tonsillectomy in USA: LexisNexis claims database 1984–2012. *Paediatr Anaesth* 2014;24:412-420.
16. Anesthesia Patient Safety Foundation. Mission and vision statement. Accessed 21 September 2018. www.apsf.org/about-apsf/mission-and-vision-statements.
17. Physician-Patient Alliance for Health and Safety. Capnography monitoring: Yesterday's luxury, today's necessity during conscious sedation. Podcast. 16 November 2017. Accessed 21 September 2018. www.youtube.com/watch?v=rnr4L46SwDw&feature=youtu.be.