Procedural sedation: Capnography’s heightened role

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Outside the OR, it has become increasingly common for nurses to administer procedural sedation. Now, with capnography, you can monitor patients’ respiratory status more closely and accurately.

Thanks to pharmacological advances in procedural sedation—formerly called “conscious sedation”—we’re now able to make patients more comfortable during invasive procedures and tests that generate pain or high levels of anxiety. The result has been improved care. For example, we can medicate children so they’ll comfortably remain still for medical imaging studies like CT scans, MRIs, and complex radiographs. This leads to better diagnostic test results.

Along with the pharmacological developments, improvements in monitoring these patients have enhanced the safe use of procedural sedation. As a result, it’s become commonplace for med/surg, critical care, and pediatrics nurses—as well as those who work in the ED, a GI lab, or interventional radiology—to provide procedural sedation for a wide range of tests and procedures.

If you are asked to perform or assist in procedural sedation, it’s essential that you understand the standards for its administration and what can be done to optimally monitor these patients so that you can detect the early warnings of respiratory depression and intervene before the patient gets into serious trouble. While frequent blood pressure measurements and pulse oximetry are standard monitoring tools, capnography has the potential to significantly improve patient safety by offering the earliest possible detection of hypoventilation during sedation.1

Why pulse oximetry alone is not sufficient

Capnography monitors ventilation, while pulse oximetry monitors only oxygenation. Capnography thus provides breath-to-breath feedback, and changes in breathing, like apnea, are reflected immediately. Changes in pulse oximetry can lag behind breathing changes.2

A study of 80 patients who received procedural sedation while undergoing colonoscopy demonstrated this important difference between the two monitoring tools.3 Patients were monitored with EKG, pulse oximetry, and capnography. However, clinicians could see only the EKG and pulse oximetry, in addition to their own physical observations of the patients.

Researchers who reviewed the capnography on a strip recording with simultaneous EKG and pulse oximetry tracings looked at the number of apnea episodes (there were 96). They compared the care given to patients who received supplemental oxygen during the procedure with the care given to those who did not. (Many nurses will administer a few liters of oxygen by nasal cannula during procedural sedation for an added measure of safety.)

The findings revealed that adding oxygen not only didn't prevent apnea, it actually masked its detection by keeping pulse oximetry readings high during apnea episodes.

In fact, 39 of the 49 apnea episodes in the supplemental oxygen group (80%) were followed by administration of additional sedation within three minutes. Patient restlessness resulting from apnea was misinterpreted as discomfort, and the lack of change in pulse oximetry readings supported that bedside assessment. Among patients who didn’t receive supplemental oxygen, 25 of the 47 apnea episodes (53%) were followed by administration of additional sedation within three minutes.

While there was less sedation following apnea in patients not receiving supplemental oxygen, it’s still sobering to realize that more than half of all patients who had apnea were re-sedated when the procedural sedation team did not have access to capnography readings.

Procedural sedation: What's involved

Before we take a more detailed look at capnography, it’s important to review a few things about the procedural
sedation process itself. Common procedural sedation medications for both children and adults include the sedatives diazepam (Valium) and midazolam HCl (Versed) and the opioids morphine sulfate and fentanyl citrate (Sublimaze).4 Other sedatives, such as chloral hydrate (Noctec), mehoexital sodium (Brevital Sodium), and thiopental sodium (Pentothal), and the dissociative agent ketamine HCl (Ketalar), are used primarily in children; the opioid meperidine HCl (Demerol) is typically used only for adults. Reversal agents such as naloxone HCl (Narcan), nalmefene HCl (Revex), and flumazenil (Romazicon) need to be readily accessible.

The use of sedating agents is indicated for a number of tests or procedures, including bronchoscopy, upper or lower endoscopy, cardioversion, thoracentesis, and burn or decubitus debridement—along with others for which a child might be frightened.

According to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), which in January 2001 revised its standards for monitoring patients sedated for procedures, clinicians who provide moderate to deep sedation must be competent to \textit{manage} the level of sedation deeper than the one intended.5 (See "Levels of sedation", as defined by JCAHO.) This is because drug metabolism in a given patient cannot be precisely predicted, and some patients may become more heavily sedated from a standard dose than others.

In addition, those who administer sedation must be competent to \textit{monitor} the patient at a level deeper than the one intended. Physiologic monitoring—such as pulse oximetry and capnography—is often the only reliable source of quantitative assessment data in patients with a depressed level of consciousness.1

JCAHO’s standards, which apply across practice settings, also describe how a patient should be evaluated before a procedure. This includes taking a history and looking for conditions or factors that may affect drug metabolism (such as liver or kidney disease) or airway patency (such as dentures that could move if an artificial airway were placed in the mouth). Patients should also be assessed for other factors that may affect the administration of sedation, such as a history of cardiovascular or lung disease, the last time the patient had something to eat (for emergency situations, such as fracture reduction or cardioversion), or any previous adverse experiences with sedation and anesthesia.

Typically, the nurse administering the sedating drug(s) monitors the patient during the procedure and stays with him during recovery. JCAHO standards specifically require that heart rate and oxygenation are continuously monitored by pulse oximetry, and that respiratory rate and adequacy of pulmonary ventilation are also continually monitored.5

As we’ve already mentioned, one way to monitor the adequacy of pulmonary ventilation is with capnography, which provides breath-to-breath data about the elimination of carbon dioxide (CO2) from the lungs. Simply watching for the rise and fall of the chest provides very little information about the effectiveness of the chest wall movements.

\textbf{New technology makes capnography easier}

Capnography provides a graphic representation of exhaled CO2 levels in the form of a tracing called a capnogram. Just like an EKG tracing in which each heartbeat results in a distinct complex, each breath results in an individual waveform. The highest point of the curve is called the end-tidal CO2 point, or \textit{EtCO2}.6

Until recently, capnography was a complicated technology that could be used only with adapters that attached to endotracheal or tracheotomy tubes. Today, a type of capnography called Microstream allows you to monitor exhaled CO2 levels on spontaneously breathing patients with a nasal cannula-like device. There are three options for the patient interface:

- Nasal prongs that transmit exhaled gas to the monitor only
- Nasal prongs that allow administration of oxygen and transmit exhaled gas to the monitor
- A nasal-oral device (nasal prongs with a small piece of tubing that collects gas from the mouth, as well) that allows administration of oxygen through nasal prongs and transmits exhaled gas to the monitor, whether gas is exhaled through the nose or mouth.

The monitors themselves can be handheld; integrated into bedside monitoring systems; or part of a monitor-defibrillator system. Thanks to this flexibility, capnography is easily integrated into routine monitoring of patients undergoing procedural sedation.

\textbf{How to properly interpret capnograms}

In the past, clinicians haven’t always trusted capnography because they weren’t taught how to properly interpret the values. Capnography may or may not correlate with arterial blood gas results. That’s because exhaled CO2 is affected by perfusion to the lungs. There must be enough blood flow to bring CO2 back to the alveolar-capillary membrane so that gas exchange can take place and CO2 can be exhaled.
If a patient has low cardiac output, his EtCO₂ will be lower than his arterial CO₂ levels because less CO₂ is carried to the lungs from the tissues. Think of EtCO₂ as correlating with alveolar CO₂ levels, not necessarily arterial CO₂ levels. Once you understand this, you'll be more likely to rely on capnography values when monitoring patients sedated for procedures.

Capnography interpretation is essentially straightforward if the patient's cardiopulmonary status is stable before sedation. (For a detailed explanation of capnography waveforms, see "Respiratory Monitoring," RN, May 1999.)

Prior to sedation, you'll need to establish a baseline waveform and make sure that the pulse oximetry is working. Then, once you've administered the sedative medication, you'll need to watch the shape of the waveform's curve, which is as important as the EtCO₂ point.

The patient's capnogram should have a normal shape and configuration, as depicted in Fig. 1. The top shows individual breaths; the bottom shows a 30-minute trend tracing.

A patient's respiratory rate may be increased slightly if he is anxious. Still, the EtCO₂ level should be consistent; it may be a little below the normal reading of approximately 38 mm Hg if the patient is anxious and hyperventilating. This reading can also be expressed as a percentage, depending upon the device being used.

Watch for abnormal tracings, like the one shown in Fig. 2. This tracing is from a patient whose breathing is impaired by sedation. Note that the tracing begins with two normal breaths. With the next breath, the waveform loses its characteristic squared shape, the top of the waveform is below the baseline, and eventually the line flattens out. The flattened line represents apnea.

When the patient resumes breathing, the squared waveform returns, but this time, the peak is above the baseline. That's because during the apnea episode, blood flow past the alveoli continued, but the gas was not exhaled. So CO₂ built up in the lung, and when the patient resumed breathing, the excess CO₂ was exhaled. The waveforms then returned to baseline as the patient continued to breathe normally.

Another common abnormality you may see when a patient's breathing is impaired by sedative drugs is shown in Fig. 3. In this tracing, the waveform has a normal configuration but the peak is above the baseline. This represents hypoventilation.

If you see either of these abnormal waveforms, do a quick visual check to see if the patient is breathing while you call his name and tell him to take a few deep breaths. At the proper level of sedation, the patient should respond to your verbal commands and the waveform should return to normal. If not, be prepared to support ventilation with a manual resuscitation bag and call for help—the patient may need intubation or reversal of the sedative agent(s).

**Capnography is still only one part of monitoring**

While capnography and other monitoring technology help enhance the safety of procedural sedation, don't underestimate the importance of other aspects of nursing in this setting.

Keys to successful monitoring include having a thorough knowledge of the pharmacology of the medications used and a nursing assignment that includes no other responsibilities that would leave the patient unattended or compromise continuous monitoring—a policy backed by many nursing organizations and state Boards of Nursing. (See the "Know your duties in procedural sedation" box.)

Assessing your patient before the procedure is similarly important. For example, if your patient ate a meal just before an injury occurred, you might need to delay the procedure until his stomach has emptied.

Honing your skills in the early detection of changes in a patient's breathing pattern and performing appropriate interventions for airway obstruction, significant hypoventilation, or apnea is also essential. This is true whether the intervention required is simple, such as asking the patient to take deep breaths or repositioning him to open the airway, or more involved, such as preparing for emergency intubation.

And of course, you will need to frequently assess the patients' noninvasive blood pressure measurements and pulse oximetry readings. The value of these standard monitoring tools should in no way be underestimated when you're providing procedural sedation.

With the advent of new, easy-to-use technology, expect capnography to soon become the undisputed standard of care for procedural sedation of all patients. Understanding how to use it competently will help you to ensure that your patients receive safer sedation and the appropriate standard of care.

**REFERENCES**


Levels of sedation

Minimal sedation (anxiolysis)

Patients respond normally to verbal commands. Cognitive function and coordination may be impaired. Ventilation and cardiovascular function are unaffected.

Moderate sedation/analgesia (procedural sedation)

Patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No airway interventions are needed. Spontaneous ventilations are adequate. Cardiovascular function is maintained.

Deep sedation/analgesia

Patients cannot be easily aroused. Patients respond purposefully to repeated or painful stimulation. Ventilation may be impaired. Patients may need assistance to maintain an airway and adequate breathing. Cardiovascular function is usually maintained.


Know your duties in procedural sedation

The American Nurses Association’s position on the nurse’s role and responsibilities during procedural sedation states that the nurse “shall have no other responsibilities that would leave the patient unattended or compromise continuous monitoring.” This statement, which is endorsed by 23 additional nursing organizations, forms the foundation of positions taken by many state nursing boards regarding the actions permitted, or restricted, under their Nurse Practice Acts.

If you fail to follow rulings and statements made by your Board of Nursing (BON) when administering procedural sedation, your license could be in jeopardy. Of course, your facility’s policies and procedures should be consistent with the rulings and statements from your state BON. If there’s a discrepancy, notify your nurse manager immediately so that your facility’s policies and procedures can be brought into line. Although the current nursing shortage may tempt some facilities to try to give additional responsibilities to nurses who...
administer procedural sedation, you must insist on the standard of care in your state.

You can view a summary of each state board's position statements on procedural sedation on the Web site of the National Council of State Boards of Nursing at www.ncsbn.org/public/news/state_sedation.htm.