Virtua: Implementing Capnography in Low Acuity Settings
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Introduction
While the acuity level of patients on medical-surgical units is increasing, the current standard of care for monitoring ventilation in non-intubated patients is falling behind. Obtaining intermittent vital signs and visual assessments of the patient at prolonged intervals represents the current standard of care in most non-critical care environments. These intermittent or “spot check” patient assessments may miss early signs of respiratory depression. The number of Patient Controlled Analgesia (PCA)-related deaths in the United States continues to rise. The Anesthesia Patient Safety Foundation (APSF) first brought attention to these preventable sentinel events in a 2006 workshop on hypoxic brain injury and preventable death from PCA use. In 2011, APSF convened a second conference to discuss monitoring strategies for early detection of critical drug-induced respiratory depression. The following year, The Joint Commission issued Sentinel Event Alert #49, “Safe Use of Opioids in Hospitals,” to address the issue. Since then, further research has revealed the serious risks associated with insufficient monitoring of patients receiving narcotics. A 2013 survey conducted by Robert Stoelting MD, president of APSF, estimated that “between 20,000 and 676,000 PCA patients will experience opioid-induced respiratory depression every year.”

Efforts to improve the standard of care for monitoring ventilation status of patients are emerging at both the national and grass roots levels. At the national level, the AAMI Foundation has organized the National Coalition to Promote Continuous Monitoring of Patients on Opioids to gather data-driven evidence on improved outcomes and share strategies for overcoming barriers to implementing continuous respiratory monitoring. At the grass-roots level, several hospital organizations, including the Virtua in New Jersey, have implemented strategies to identify high risk patients and streamlined ways to offer continuous respiratory monitoring of patients on opioids.

Introducing Non-invasive Capnography at Virtua
In 2013, the Virtua (1,009 beds across three hospitals) prioritized narcotic safety. The hospital system responded by implementing non-invasive capnography monitoring and continuous pulse oximetry monitoring on medical-surgical units. Capnography is used to measure exhaled end-tidal carbon dioxide (EtCO₂) and inhaled carbon dioxide (FiCO₂) to determine a patient’s respiratory rate and generate waveforms (i.e., capnograms) of exhaled carbon dioxide over time. However, unlike conventional capnography, which requires patients to be intubated to sample a patient’s inhalations and exhalations, thus restricting its use to critical care areas and operating rooms, non-invasive capnography uses nasal or oral-nasal sampling tubing that is worn over the nose (and sometimes mouth) to collect respiratory data, making it practical for use anywhere in a hospital.
This paper details Virtua’s journey of implementation of non-invasive capnography, highlighting how barriers were overcome, sharing key factors for success, and describing the ongoing challenges of effectively monitoring patients receiving intravenous opioids for pain management.

Virtua’s commitment to a culture of safety led the organization and senior leadership to identify and implement an enhanced patient monitoring system for patients treated with opioids.

To begin, a project committee was created that included physicians and nurses, as well as staff from respiratory therapy, anesthesia, risk management, quality, support services, central supply, information technology, and finance. Two important criteria in selecting the committee members were that they represent a broad, multidisciplinary group of stakeholders, and include an anesthesia physician champion with knowledge and strong interest in implementing capnography monitoring on the medical units.

The committee’s first task was to conduct an evidence-based gap analysis that compared current practices to alternative practices and to identify opportunities for improvement. The gap analysis identified the following solutions: increasing the frequency of vital sign checks, monitoring pulse oximetry continuously, and monitoring using non-invasive capnography. Although non-invasive capnography is the most expensive of these three options* and the most time and resource intensive to implement, it was chosen by the committee because it provides the earliest indication of respiratory depression, thus allowing the most time for non-invasive interventions (e.g., reducing the dose, temporarily pausing the medication).† Based on the literature, decreasing vital sign monitoring intervals and using continuous pulse oximetry do not reliably detect respiratory depression early enough to prevent painful or expensive medical intervention, such as administering a reversal agent (e.g., Narcan), escalation of care (e.g., intubation and transfer to a critical care environment), or a code situation.

Another factor that influenced the selection of non-invasive capnography monitoring was the support for this technology by APSF, The Joint Commission’s Sentinel Event Alert #49, and the Institute for Safe Medication Practices (ISMP).

Selecting a Non-invasive Capnography Monitor

The project committee,† comprised of a multidisciplinary group, worked with the purchasing department to identify suitable products to evaluate. The Medtronic monitor was ultimately selected based on the fact that it was a pioneer in the field of non-invasive capnography and had the most advanced and reliable sampling technology. An additional advantage of this monitor was its ability to communicate a patient’s respiratory status, using a single value called the Integrated Pulmonary Index (IPI). This number, ranging from 1-10, provides a quick reference about the patient’s stability, employing an algorithm that integrates the capnography data (EtCO₂ and respiration rate) with the pulse oximetry data (pulse rate and blood oxygenation).

Developing a Screening Monitoring Process

The biggest hurdle to implementing non-invasive capnography on medical/surgical units was designing a process that included all of the following:
- identifying patients at risk
- minimizing false alarms and alarm fatigue
- effectively and reliably communicating with the appropriate clinician if the patient’s respiratory status is declining.

* Due to equipment acquisition, IT investment, education across the spectrum of healthcare providers, and the need to develop ongoing education and competency assessments.
† A project committee included physicians, nurses, respiratory therapists, risk managers, quality, support service staff, central supply staff, information technology personnel, and finance employees.
• providing clear directions to responders on how to mitigate the respiratory depression

The project committee carefully designed the new monitoring process using a six-sigma process improvement method called, DMADV (Define, Measure, Analyze, Design, Verify). The workflow was outlaid through careful evaluation of the required steps in the process – from selecting a patient to discontinuing the capnography – considerations included the maintenance, repair, cleaning and transportation of the system.

The tasks associated with each step were developed using the following approach:
1. Review current practice.
2. Review the evidence-based best practice data.
3. Discuss any gaps between current practice and best practice data.
4. Reach consensus on how to address the gap.
5. Define the new practice.

Once the project committee achieved consensus on the task, the new screening and monitoring process was sent to a multitude of additional medical committees across the organization for review and approval. Any feedback from the committees was discussed by the project team and used to revise the proposed process before redistributing it for review and approval.

To ensure successful implementation, the project team believed it was important to conduct face-to-face meetings to garner support and the buy-in needed from all stakeholders. This process took roughly one year to complete. A high-level summary of the new monitoring process is shown in Figure 1. Capnography Algorithm.

Virtua developed and tested the new monitoring process and education as a pilot initiative on two post-surgical units—a bariatric unit and an orthopedic unit—for two weeks. The technology has now been implemented in 22 medical/surgical units across all three Virtua hospitals.

**Patient Screening**
Nurses in the Pre-admission Testing (PAT) Department were trained and involved in the screening process to identify patients who were most at risk for opioid-induced respiratory depression. Specific capnography screening criteria (see Figure 2) were provided to the PAT Department and assessed using information from the nursing admission history.

Patients who had an order for a PCA pump or IV parenteral opioids with a dose frequency of every two hours or less, even if they did not meet the screening criteria for high risk, were placed on continuous capnography or pulse oximetry monitoring.

**Orders**
A team of anesthesiologists, nurses, respiratory therapists, and quality nurses established new order sets for SPO₂ and EtCO₂ for initial monitoring and for monitoring after a respiratory event has occurred.

**Alarm Notification**
The capnography monitors were connected via telemetry to the central telemetry station. Telemetry technicians were responsible for notifying the patient’s nurse if capnography readings met alarm criteria (Figure 3); if the IPI was less than five or if a depressed waveform was present, indicating hypercapnia, deoxygenation and respiratory depression.

During the pilot, there were many “false-alarms” that frustrated the telemetry technicians and registered nurses. A delay was added to the monitoring algorithm so the alarm would trigger only after the IPI remained continuously low for a specified amount of time, and the alarm settings were modified (Figure 4) to reduce alarm fatigue.

**Post-Pilot Settings**
The new alarm settings decreased the frequency of false alarms. Virtua is currently working on an algorithm to

‡ A respiratory event is defined as patients who experienced episodes of desaturation while on remote pulse-oximetry or episodes of hypopnea/apnea while on opioid therapy when capnography monitoring was ordered.

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differentiate between “nuisance alarms” and “actionable alarms”. These algorithms were tested through Virtua’s Institutional Review Board (IRB) and approved for clinical trial. Virtua is also focused on setting alarms that are triggered by a patient’s overall trend, rather than by a single indicator (which could easily occur if a patient is moving, sitting up, or eating).

Initially, Virtua believed that direct nursing notification would be preferable to telemetry technician interphase, as that option was considered to be more cost effective. However, when the additional costs for telemetry licenses and space for the stations were factored, this option was not deemed to be more cost effective. Therefore, Virtua decided to implement Nuvon’s Vitals Charting Server product, an automated remote notification system, which automatically sends the capnography alarms to a nurse’s phone or pager. The procurement and implementation of the complex technology and work processes needed to support this are currently being developed. During the interim, the telemetry technicians remain removed from the process, and the capnography alarms are audible in the patients’ rooms.

**Protocol for Responding to an Alarm**

In the event of potential respiratory compromise, the nurse must assess the patient and identify the appropriate set of actions based on the patient’s condition. Criteria for notifying the patient’s physician or a respiratory therapist, decreasing or stopping the patient’s medication, administering a reversal agent, and/or using supplemental oxygen were established by a clinical team, developed into a policy, and included in the training protocol prior to the capnography monitoring implementation. A policy was developed which included a training protocol that was to be implemented prior to the capnography monitoring implementation.

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**Figure 1. Capnograpy Algorithm**
Prior to implementing capnography monitoring, training was provided to all nurses on the pilot units, as well as respiratory therapists and rapid response nurses. A vendor trainer and a Virtua clinical educator developed and delivered the training. The focus of education and training included the significant clinical differences between monitoring a patient’s oxygenation (via pulse oximetry) and monitoring ventilation (via capnography). The education team expanded on the clinical uses of the capnography monitor, waveform discrimination, and manipulation of the equipment, including “hands-on” practice. Clinical “super-users” were trained as local experts to support staff through the implementation. They received one-hour classes included additional trouble shooting techniques and parameter options on the capnography monitor.

During the pilot implementation on the first two units, there was a daily meeting on each of the two units where staff shared their stories of how capnography monitoring contributed to improved patient outcomes. The nurses went on to include these stories in their education to patients and their patients’ families. Not only did the story-based education create a strong awareness of capnography, but it also created an acute realization about saving...
patients' lives and the role of the patient and their family in supporting patient safety. Family members asked that their loved ones be monitored by capnography, as did the patients in the room.

Results
Since 2014, capnography monitoring for all medical/surgical patients who met the capnography screening criteria (Figure 1) has been required. In the 19-month period since implementation of capnography monitoring according to established criteria, Virtua has not had a single patient that experienced a respiratory event resulting in a serious outcome (e.g., intubation, transfer to ICU, death/brain damage).

Although apprehensive at first, nurses have become strong advocates for the technology, because it has successfully identified early respiratory depression and prevented potentially painful, high-risk interventions and escalations of care.

An example is the case of Mr. W. K., a 72-year-old male who was admitted for total joint replacement. This patient was retired, lived alone, and presented to the pre-operative area with two adult daughters. During preadmission evaluation, W.K. was found to meet the B, A and G categories of the “STOP-BANG” (Figure 2) for hypertension, advanced age, and gender. Upon further questioning on the day of surgery, his daughters confirmed that W.K. also snores (a fourth qualifier). He denied that he had ever been advised to have sleep testing. Patient education was provided to the patient and his family, and they agreed to the use of capnography monitoring post-operatively. In the early post-operative period, W. K. exhibited multiple episodes of low EtCO₂ and apnea. Continuous positive airway pressure treatment (C-PAP) was ordered immediately post-op, and the patient was referred for a follow-up sleep study after discharge. The early recognition and intervention prevented harm from reaching the patient.

Challenges, Solutions, Strategies, and Lessons Learned
In reviewing implementation efforts, Virtua identified several challenges that arose during the implementation, as well as effective solutions to those challenges.

Physician Support
Physicians who were unfamiliar with capnography were uncomfortable with the technology. They had concerns about being bombarded by calls from nurses about alarms and uncertainty about which interventions to prescribe in response. To gain physician support for the project, it was important for anesthesia to educate medical/surgical physicians early in the process. The key to engaging physicians in...
training and education was strong buy-in and advocacy from the chief medical officer, and subsequently the physician leadership of each medical/surgical area. These clinical leaders encouraged the participation of all physicians, not only in the training activities, but also in sharing their opinions, concerns, and ideas for how to support the implementation. This was done early in the process by having project committee members attend physician meetings and inviting them to be part of the process. Another strategy the project team used to ensure they had physician support was inviting the apprehensive physicians who resisted capnography monitoring to be part of the team developing the implementation process. Providing an opportunity for their concerns to be heard and for them to influence the processes had a very positive effect on gaining physician support.

**Bulky Equipment**

Capnography monitoring equipment can be cumbersome. The technology purchased by Virtua required an attachment to an IV pole with a wider base. In newer clinical units, this was easily accommodated, but in some of the medical/surgical rooms at one of the older facilities, nurses had to adjust the room setup to accommodate the equipment. This created some frustration among the nurses early on, but once they experienced the benefits of the improved monitoring technology, these issues became irrelevant.

**False Alarms**

The primary concern with implementing capnography was alarm fatigue. During the pilot, this proved accurate. Fortunately, this did not overshadow staff enthusiasm for the technology for two reasons. First, nurses and physicians witnessed their patients benefiting from the technology. Soon after the implementation, the capnography monitor identified several patients who were trending towards respiratory depression, and the nurses were able to respond by turning off the medication without requiring any further intervention. Second, the project team has since minimized false alarms and alarm fatigue and

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<tr>
<th>Sedation Scale/ Monitoring</th>
<th>Description</th>
<th>Interventions</th>
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<tbody>
<tr>
<td>S</td>
<td>Sleep, easy to arouse</td>
<td>Acceptable; no action necessary; may increase opioid dose if needed (as per order)</td>
</tr>
<tr>
<td>1</td>
<td>Alert and awake</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Slightly drowsy, easily arousable</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Frequently drowsy, arousable, drifts off to sleep during conversation</td>
<td>Unacceptable; immediately stop opioid, stimulate patient, encourage deep breathing, administer oxygen, Call RRT if deemed appropriate. Keep PCA Pump off for a minimum of one hour. Monitor respiratory status and sedation level closely until sedation level is stable at less than 3 and respiratory status is satisfactory. After one hour, may restart PCA when the patient is at an acceptable sedation level. NO increase in PCA dose without physician evaluation.</td>
</tr>
<tr>
<td>4</td>
<td>Somnolent, minimal or no response to verbal or physical stimulation</td>
<td>Unacceptable; immediately stop opioid; stimulate patient, encourage deep breathing, administer oxygen, Give naloxone (narcan); notify Physician STAT &amp; RRT; monitor respiratory status and sedation level closely until sedation level is stable at less than 3 and respiratory status is satisfactory*</td>
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*Items in italics have been added to the original Pasero Opioid-induced Sedation Scale (POSS) with Interventions
has included staff in these efforts. They have launched an Institute Review Board approved study to investigate optimal alarm settings to minimize false alarms.

**Noise**
Nurses were initially concerned about alarms disturbing patients and their roommates and the potential negative impact on patient satisfaction. In response to this, patients, families, and roommates received story-based education on the importance of capnography monitoring and its ability to save lives. Additionally, patients, and roommates were provided with earplugs.

**Evaluating outcomes**
Implementing capnography is both an ongoing process and an evolving process. The project sponsor needs to communicate to all staff involved that the implementation is a journey and not a project with a defined end-date. The protocols will continue to change and require flexibility on the part of the staff and a willingness to contribute ideas and solutions throughout the journey.

It is important to assign key stakeholders the task of evaluating outcomes, barriers, and challenges that arise post-implementation. Different stakeholders will have different metrics that reflect their role in the process. For example, IT is concerned with downtime and monitoring communication issues, while nurses are concerned with detection of respiratory depression; anesthesia is concerned with compliance to notification and intervention protocols. Therefore, a member of each stakeholder group should be assigned to the task of collecting relevant metrics and reporting back to the project team to ensure that implementation continuously moves towards an optimized state.

**Final Thoughts**
The capnography monitoring implementation experience at Virtua provides a prototype of how a team, through persistent advocacy, can influence their organization to change practice and leverage its best asset—staff across all disciplines—to improve the quality of patient care. Because of technology’s role in healthcare, implementing new technology is complex; implementing capnography monitoring is no exception. Redesigning processes, developing and delivering education, and integrating technology into the existing electronic infrastructure require strong commitment on the part of leadership. Considerable effort is also required from clinical, IT, and biomedical engineering staff, as well as patient engagement. What makes this all possible is a passion for improving the safe delivery of parenteral opioids, so lives are saved.
Thank you to our Premier Industry Partners for Supporting the AAMI Foundation’s National Coalition to Promote Continuous Monitoring of Patients on Opioids!

To learn more about the coalition’s efforts click here.
To read the AAMI Foundation’s Opioid Safety and Patient Monitoring Compendium click here.
If your hospital has successfully utilized a strategy to implement continuous electronic monitoring in a low-acuity setting for patients on opioids and you would like to share your story, please contact Sarah Lombardi, program director at slombardi@aami.org.

References


