Overview:
Radiology and Imaging Nurses provide procedural sedation to a variety of patients. The administration of procedural sedation in the interventional radiology and diagnostic imaging suites presents a unique set of circumstances that can be challenging for the procedural sedation nurse. These include
- high acuity patients
- inaccurate/incomplete patient assessment
- limited visualization due to imaging equipment
- impaired visualization due to sterile drapes
- awkward patient positioning
- complex, lengthy procedures
- providers who must step into a separate room to limit exposure to radiation (Anderson et al., 2007)
- hyper-oxygenated patients

Advancements in technology such as capnography, the monitoring of the partial pressure of expired carbon dioxide (PetCO₂), provide nurses with a means to ensure the improvement of care delivery, provide a safe environment, and effectively achieve successful procedural sedation.

- The use of pulse oximetry as a surrogate measure for ventilation fails to adequately identify ventilatory effort by the virtual of its intended measurement.
- Capnography can detect almost immediate ventilatory changes, and in an apneic patient this will appear as a flat line. This can be especially useful when visual assessment of a patient during a procedure is limited or obscured.
- The addition of capnography along with standard monitoring during procedural sedation can greatly enhance the procedural nurses’ ability to safely monitor and sedate a patient and decrease the incidence of adverse respiratory events (ARE) within this unique and evolving environment.
- Changes from the baseline capnographic waveform should prompt timely interventions by the sedation nurse to avoid the progression to a hypoxic event.

The use of supplemental oxygen during procedural sedation may prolong the recognition of apnea due to hypoventilation/apneic oxygenation. Capnography provides a real-time assessment of ventilation and is superior to the pulse oximetry when assessing hypoventilation/apneic oxygenation. (See www.arinursing.org for the ARIN (2016) Capnography Position Statement.)

Target Audience:
- Radiology and Imaging Nurses engaging in procedural sedation practices.
- Healthcare practitioners administering pharmacotherapies for sedation, analgesia, and anxiolysis.
Nursing Considerations:

The use of capnography aims to decrease adverse events, more specifically adverse respiratory events (ARE), within the delivery of procedural sedation. AREs include, but are not limited to: hypoxemia, hypercapnia, tachypnea, disordered ventilation, apnea, and respiratory failure.

Practice recommendations for the use of capnography are as follows:

1. Pre-procedure

   - In addition to standard assessments prior to procedural sedation: assess patient positioning requirements and/or limitations; orthopnea, sleep apnea, obesity, physical limitations due to orthopedic or surgical issues.
   - Pay particular attention to these contributing co-morbidities which may impact capnography assessment: COPD/asthma, severe cardiac disease, CKD/ESRD, sleep apnea
   - Educate the patient regarding monitoring technology used during their procedure

2. Intraprocedure

   - Position the patient according to procedural needs while maintaining optimal airway access
   - In addition to standard monitoring devices: cardiac monitor, NIBP, SpO2, RR, apply capnometry sampling device and adjust to patient’s requirements i.e. face mask oxygen, tracheostomy/laryngectomy collar, mouth breathing patient
   - Ensure clear visualization of the cardiac monitor with adequate display of vital signs and capnography. Adjust equipment and/or surgical drapes as necessary to ensure visualization of the patient. Maintaining close monitoring of capnography and vital signs is paramount in the early detection of ensuing adverse respiratory events.
   - Optimize capnography sampling device to deliver accurate waveform/capnogram
   - Review monitoring alarm settings* and ensure alarms are audible
     - Low alarm limit: 8
     - High alarm limit: 26
   - Limits need to reflect the patient’s current respiratory rate
   - Capnography Interpretation
     - Is the PetCO₂ waveform present?
       - If absent, check pulse, airway, or for accidental disconnection
     - Does PetCO₂ waveform start and end at the baseline?
       - If not, consider air trapping/breath stacking, moisture in adapter
     - What is the height, width and frequency (quality of respiration) of the waveform?
       - Wide and tall: bradypnea/hypercapnia

Association for Radiologic & Imaging Nursing

www.arinursing.org
Clinical Practice Guideline: Capnography

- Narrow and short: tachypnea/hypocapnia
  - What is the waveform pattern?
    - Waveform returns to baseline (if no, consider air trapping/breath stacking, moisture in adapter)
    - Note shape of waveform: sloping (loss of alpha angle), notching, prolonged (altered beta angle)

- Evaluate respirations, numeric capnographic value and capnograms. Identify and intervene for any impending adverse respiratory events:
  a. Check and adjust capnography sampling device as needed
  b. Encourage deep breaths
  c. Manage pain and/or anxiety
  d. Adjust airway i.e. chin lift or reposition head
  e. Tactile stimulation to increase arousability
  f. Assist ventilations with Bag-Valve-Mask, consider nasal or oral airway
  g. Consult with physician/proceduralist/advanced practice provider regarding use of reversal agents
  h. Consider need for emergent intubation

- Documentation *
  o Preprocedure
    - Baseline vital signs, including respiratory rate
    - Capnogram
    - PetCO₂ value
    - Use of accessory muscles
  o Intraprocedure
    - Note changes in rate and waveform
    - Provide continuous capnographic monitoring
    - Every 5 minutes, document capnometry value/presence or absence of a waveform according to organization policy
    - Evaluate the capnograms and intervene appropriately**
    - Document intervention(s) performed

3. Post procedure

- Monitor patient until discharge criteria is met or transferred to recovery area *
- Provide clear and complete Hand Off on transfer of patient*
- Change capnography sampling device and components per manufacturer recommendation

*Per institution guidelines
Association for Radiologic & Imaging Nursing

Clinical Practice Guideline: Capnography

** refer to article by Brast, Bland, Jones-Hooker, Long and Green (2016).

References


Developing Authors and/or Committee/Task Force Members:

a. Authors:

   Christopher Lambert, MSN, RN, CCRN
   Lisa Pella, BA, RN, CRN
   Carissa West, RN
   Marisol Hernandez, MA, MLS
   Michael Long, DNP, CRNA

b. Reviewers:

   Karen Green, MHA, BSN, RN
   Shawn Brast, MSN, RN, CCRN, NRP
   Mary Sousa, BSN, RN
   Barbara McArthur, BSN, RN, CPN

Review and Revision Dates:

a. Approved by the ARIN Clinical Practice and Research Committee: 03/16/18
b. Approved by ARIN Board of Directors: 03/17/18
c. Revision: (Name[s] and Date)
d. Revision Approval by ARIN Board of Directors: (Date)
## Appendix A

### 5 Step Practical Method for Rapid Capnography Interpretation

<table>
<thead>
<tr>
<th><strong>Question 1:</strong></th>
<th><strong>Waveform Assessment</strong></th>
<th><strong>Rationale</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a PetCO2 Waveform?</td>
<td>If no waveform or loss of waveform, is your patient pulseless or not ventilating due to accidental disconnection or extubation.</td>
<td></td>
</tr>
<tr>
<td><strong>If YES, what is the height, width and frequency (RR)?</strong></td>
<td>The height, width and frequency represent the quality of respiration.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the capnogram wide and tall?</td>
<td>• Bradypnea/hypercapnia</td>
</tr>
<tr>
<td></td>
<td>Is the capnogram narrow and short?</td>
<td>• Tachypnea/hypocapnia</td>
</tr>
<tr>
<td></td>
<td>Is there a pattern to the waveform?</td>
<td>• Loss of airway, • Shock state.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Question 2:</strong></th>
<th><strong>Waveform Assessment</strong></th>
<th><strong>Rationale</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the shape of the waveform? Do you see a steep rise in Phase II with a plateau? Is there any sloping, notching or a prolonged Phase III?</td>
<td>You expect to see a steep rise in Phase II followed by a plateau. If this is altered, the expiratory phase and alveolar gas exchange are altered, and the relationship between ventilation to lung perfusion is changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Sloping</strong> (loss of alpha angle): consider bronchospasm, kinked artificial airway or foreign body. Greater the shark fin appearance, the greater the severity.</td>
<td><strong>Notching</strong>: uncoordinated respiratory effort</td>
</tr>
</tbody>
</table>
as a result of neuromuscular blockade wearing off. The greater the notch, the lighter the neuromuscular blockade and asynchronous the ventilatory effort.

**Prolonged** (altered beta angle): consider leak in the system, normal variant in patient with reduced thoracic compliance (obese patients or late pregnancy) or V/Q mismatch.

<table>
<thead>
<tr>
<th>Question 3: Waveform Assessment</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| Finally, does the waveform have a steep return to the baseline? | Represents the initiation of the inspiratory phase. If Phase IV fails to return to the baseline:  
  a) Air trapping or breath stacking,  
  b) Consider moisture in adaptor,  
  c) Calibration error. |

<table>
<thead>
<tr>
<th>Question 4: Waveform Assessment</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| What is your PetCO2 trend & PaCO2/PetCO2 Gradient? | Evaluating the trend will provide graphic representation of a patient’s ventilatory status over the course of time.  
  a) Do you see a downward stepping trend that will make you suspicious for a shock syndrome?  
  b) Do you see a trend for great quality CPR?  
  c) Do you see an upward stepping trend consistent with an increasing metabolic demand or change in temperature (early sepsis, hypo/normothermia to hyperthermia)?  
  d) Is your PetCO2 reading correlated to an ABG?  
    a. What is the gradient of your PaCO2/PetCO2? |
Question 5:

<table>
<thead>
<tr>
<th>Clinical Correlation</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your capnographic assessment correlate to your clinical assessment? Is there agreement in assessment, or are there assessment disparities between capnographic assessment (PetCO2, RR, waveform, PaCO2/PetCO2 and trending data) and the patient’s clinical assessment or history/presentation?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a standard of practice, multiple subjective and objective assessment criteria is required to confirm endotracheal tube placement due to no single technique having a proven 100% accuracy (Pauze &amp; Burton, 2009).</td>
</tr>
</tbody>
</table>