Title: Capnography (ETCO2) Monitoring

Code: CPC-2012AUG-1.C.35

Title of Responsible Party: Director of Medical-Surgical Services

Origination Date: 5/2009

Effective Date: 8/2012

Review/Revision Dates: 1/2013

Scope: Capnography provides information about CO2 production, pulmonary (lung) perfusion, alveolar ventilation, respiratory patterns, and exhaled elimination of CO2. It offers an immediate picture of patient’s ventilatory status. ETCO2 is more sensitive than pulse oximetry, and can identify hypoventilation and apneic episodes before is is picked up by changes in heart rate and/or pulse oximetry. ETC02 monitoring is for patients who are determined to be at risk for complications due to pain management and/or obstructive sleep apnea. ETCO2 monitoring should be initiated prior to start of pain management interventions and pre-procedural moderate sedation induction. ETCO2 monitoring may be initiated by a physician’s order and/or based on the discretion of the RN.

Key Words: @ETCO2, @Capnography, @Sedation, PCA, @Pain management

Purpose: The purpose of this document is to outline the indications and procedure for end tidal carbon dioxide (ETCO2) monitoring. ETCO2 monitoring is used to obtain non-invasive measure of the ETCO2 and is an early detection of the clinical indicators for respiratory depression evaluated through monitoring airway patency, CO2 removal (ETCO2 level) and respiratory rate. This policy is not for patients receiving epidural PCA or those who are receiving palliative care receiving intravenous medications per PCA.

1 Clinical applications:
   1.1 Patients with pain management issues requiring high dosages of narcotics
   1.2 Patients receiving epidural or intrathecal pain management
   1.3 Patients who are difficult to arouse
   1.4 Patients with a history of respiratory distress or sleep apnea
   1.5 Patients who easily desaturate
   1.6 Patients requiring procedural sedation

2 Equipment:
   1.1 ETCO2 monitor
   1.2 Oridion Capnography monitor or Alaris “brain” with ETCO2 module or Capnostream monitor
1.3 Oridion Smart CapnoLine®

Text:

1 Set – Up
1.1 Obtain ETCO₂ monitor from central supply
1.2 Obtain Smart CapnoLine® from clean supply room
1.3 Attach Smart CapnoLine® into the ETCO₂ monitor port
1.4 Explain the purpose of ETCO₂ monitor and alarm feature to the patient
1.5 Apply Smart CapnoLine® to patient to allow sampling from either nose or mouth
1.6 Change tubing set every twenty-four hours or more often as needed to ensure accurate measurements
1.7 Turn ETCO₂ monitor on. The machine will run a self-test.
1.8 Recommended default alarm limits for the following settings:
   1.8.1 ETCO₂ High - 60 mmHg
   1.8.2 ETCO₂ Low - 10 mmHg
   1.8.3 Respiratory rate High – 48 breaths per minute
   1.8.4 Respiratory rate Low – 7 breaths per minute
   1.8.5 No breath delay – 30 seconds
1.9 The Smart CapnoLine® last for up to 72 hours and must be changed when the ETCO₂ monitor displays a ‘Blockage” or “Occlusion” message

2 ETCO₂ Values
2.1 Normal: Adults: ETCO₂ 35 to 45 mmHg (in normal, healthy adults)
2.2 Abnormal ETCO₂ Values:
   2.2.1 An ETCO₂ less than 35 mmHg indicates an increased respiratory rate or “Hyperventilation/ Hypocapnia"
   2.2.2 An ETCO₂ more than 45 mmHg indicates respiratory depression or "Hypoventilation/ Hypercapnia"
2.3 A sudden loss of ETCO₂ indicates no respiratory activity (apnea).
2.4 Medical conditions that affect reliability of ETCO₂ values include:
   2.4.1 COPD (causing incomplete alveolar emptying)
   2.4.2 ARDS (causing a ventilation-perfusion mismatch)
   2.4.3 Pulmonary embolism and hypovolemia (causing unperfused, but ventilated alveoli)
2.5 For further information on interpreting abnormal ETCO₂ values and waveforms, see “Interpreting ETCO₂ and waveforms” below.

3 General Care and Monitoring
3.1 ETCO₂ monitoring should be used in conjunction with pulse oximetry.
3.2 The Smart CapnoLine® samples CO₂ continuously from both mouth or nose, even for low tidal volumes. The oxygen tubing portion of the Smart CapnoLine® can be attached to an oxygen source if needed. Up to 5L of oxygen can be delivered via the SmartCapnoLine®. For patients requiring greater than 5L of oxygen therapy, it is necessary to add an oxygen mask (the mask can be placed directly over the cannula). Note: Adding oxygen by mask may lower the ETCO₂ reading by 10% or more, and values should not be considered reliable.
3.3 ETCO₂ monitoring may be used with PCA to provide continued assessment of physiological response to pain management by evaluating trends in ventilatory status.
3.4 ETCO₂ measurements should be evaluated over a 1 to 2 minute time frame every four (4) hours or more often as patient condition warrants. Some patients may require more frequent monitoring (for example, pain management patients requiring additional bolus
doses, continuous basal rates, or if other risk factors for respiratory depression are identified).

3.5 Monitoring ETCO₂ trends can be more important than the actual number. A steadily rising ETCO₂ (as a patient begins to hypoventilate) can help medical and nursing staff anticipate when a patient may soon develop respiratory compromise.

3.6 If the alarm limits need to be adjusted, contact MD and report modification.

3.7 Note that monitoring respiratory rate by the assessment of chest wall movement may differ from the respiratory rate displayed on the monitor. The ETCO₂ monitor measures breaths detected from actual airflow.

3.8 If an Alaris PCA is in use, the PAUSE PCA function may be triggered by a respiratory rate < 7. The PAUSE PCA function ceases the delivery of opioids and requires the nurse to re-start the Alaris PCA at the bedside.

3.9 ETCO₂ is NOT used in terminally ill patients for which PCA is utilized and/or indicated for comfort and symptom management.

4 Indications for Interventions

4.1 If ETCO₂ is 45-50 mmHg:

4.1.1 Attempt to stimulate and arouse the patient. If patient is immediately aroused and breathing normally, monitor every 15 minutes x 1 hour.

4.1.2 Assess vital signs for decompensation (O₂ sat, BP, HR, RR, and LOC)

4.1.3 Check patient for normal signs of ventilation, assessing for hypoventilation via assessment of RR, quality and depth.

4.2.2 Assess pain, level of sedation, and consider decreasing narcotic dose and/or frequency.

4.1.4 Reposition the Smart CapnoLine® if necessary.

4.1.5 If EtCO₂ remains > 45 mmHg in spite of interventions, contact physician.

4.2 If ETCO₂ is >50 mmHg or greater (In addition to the above interventions in 4.1)

4.2.3 If ETCO₂ does not return to normal within 5 minutes, call Rapid Response Team and notify MD immediately to report patient condition.

4.2.4 Consider obtaining ABG (RT or RRT can also be consulted during this process).

4.2.5 If the patient does not immediately arouse, evaluate the appropriateness of administering Narcan to partially or completely reverse sedation.

4.2.6 Patients may be referred to an intensive care unit when nursing staff has concerns about possible respiratory compromise.

4.3 If respiratory rate falls below 7 per minute (whether ETCO₂ is normal or not)

4.3.1 Evaluate patient for sleep apnea. Sleep apnea patients are encouraged to remain non-supine.

4.3.2 Patients can potentially have a normal EtCO₂ and low respiratory rate. In these instances it is appropriate to monitor, contact respiratory therapy or RRT if there is any question regarding accuracy of EtCO₂ measurement.

5 Care and Monitoring for Procedural Patients

5.1 When using capnography during sedation, the emphasis should be placed on significant changes from the baseline waveform or numeric ETCO₂ value rather than an absolute number. When capnography is used during administration of procedural sedation, the focus should be on baseline ETCO₂ during the procedure.

5.2 When placing Smart CapnoLine® on patient, use small pieces of tape bilaterally (cheekbone area) to secure cannula in nares and over mouth. This will help to prevent movement of cannula during procedure.
5.3 Document baseline ETCO₂ value and assess waveform so changes can be identified prior to start of procedure and during and post-procedure as per moderate sedation policy.

5.4 With any significant change in ETCO₂ measurement, the first action will always be to assess the patient.

5.5 Common changes from the baseline seen during sedation and that require intervention include:
   5.5.1 A change in the numerical ETCO₂ of greater than 10mm
   5.5.2 A waveform that suddenly becomes erratic in shape and size
   5.5.3 A waveform that becomes flat

5.6 Interventions for changes in ETCO₂ include:
   5.6.1 Ensure airway is open by repositioning head and neck
   5.6.2 Provide gentle stimulation if patient does not respond
   5.6.3 Reposition the Smart CapnoLine® if necessary
   5.6.4 Stop administration of sedation and re-evaluate patient as appropriate
   5.6.5 If patient is immediately aroused and breathing normally, continue to monitor
   5.6.6 Administer O₂ therapy as needed per moderate sedation policy
   5.6.7 If the patient does not immediately respond based on degree of sedation, consider using appropriate reversal agent per moderate sedation policy.
   5.6.8 Inform MD immediately to report unanticipated changes in patient condition.

6 Interpreting ETCO₂ and waveforms

6.1 Interpretation of waveforms/ tracings: Capnography is a graphic representation of exhaled CO₂ levels in the form of a tracing called a capnogram. Just like an EKG in which electrical activity of the heart is reflected in a distinct complex, each breath results in an individual waveform.

6.2 Each waveform represents a single respiratory cycle. The waveform has several components:
   6.2.1 The first segment of the waveform is the flat area before exhalation.
   6.2.2 The second segment is a sharp rise (beginning of exhalation) followed by a curve that then starts to level out. The highest portion of this part of the waveform is called the ETCO₂ point and represents exhalation of alveolar CO₂.
   6.2.3 The third segment is a sharp drop representing inhalation.

Normal
6.3 Indicators of respiratory depression or hypoventilation:
6.3.1 ETCO$_2$ of > 50
6.3.2 No waveform for any period of time
6.3.4 Change in ETCO$_2$ of 10 below or above baseline
6.3.5 Hypoventilation: Decreased RR with an elevated ETCO$_2$. Waveform shape will represent a taller waveform (higher CO2) ETCO$_2$. May have a prolonged flat area (alveolar plateau)

6.4 Shallow Breathing Hypoventilation
6.4.1 RR may or may not change with a decrease in ETCO$_2$.
6.4.2 Waveform shape will be abnormal in shape, shorter and smaller. It may be rounded and choppy in shape.

6.5 Airway obstruction:
6.5.1 RR may or may not change with a decrease in ETCO₂.
6.5.2 Waveform shape will be abnormal with elongated upstroke or down stroke. Waveform will be shorter, rounded, and choppy.

**Airway Obstruction**

![Airway Obstruction Diagram]

6.6 Apnea:
6.6.1 Waveform, ETCO₂ value, and RR will be absent.
6.6.2 No air exchange is taking place due to cessation of breathing or total airway obstruction.

**Apnea**

![Apnea Diagram]

6.7 Rebreathing:
6.7.1 Elevated baseline.
6.7.2 Waveform shape may be normal or abnormal but key is not returning to 0 baseline.

**Rebreathing**

![Rebreathing Diagram]

NOTE: ALWAYS OBTAIN A BASELINE ETCO₂ AND TRACING READING PRIOR TO ADMINISTRATION OF SEDATION

6.8 Interventions if above waveforms noted:
6.8.1 Immediately assess patient
6.8.2 Ensure patent and open airway
6.8.3 Check position of cannula to ensure in nares
6.8.4 Check for secretions obstructing the prongs
6.8.5 Stimulate patient if necessary. Ask patient to take a deep breath
6.8.6 Stop drug delivery
6.8.9 Inform physician. Pause procedure if necessary
6.8.10 Administer reversal agents as indicated

7 Documentation
7.1 During acute pain management, monitor and document ETC0₂ every 1 hour until satisfactory pain control is achieved.
7.2 Once patient comfort is achieved, monitor and document ETC0₂ (and displayed respiratory rate) every four (4) hours, and more frequently as patient condition warrants.
7.3 Some conditions may suggest a need for increased monitoring and documentation. Examples of conditions that require increased monitoring are:
  7.3.1 Additional boluses
  7.3.2 Continuous IV or PCA basal rate
  7.3.3 Risk factors for complications associated with narcotic administration such as advanced age or obesity
  7.3.4 Pre-existing conditions including allergies or sleep apnea
  7.3.5 Current medication use
7.4 Document all interventions performed as a result of changes in ETC0₂ and respiratory rate.
7.5 ETC0₂ values should be trended and monitored for changes and monitored and documented more frequently if values fall outside the normal range of 35 to 45mmHg.
7.6 All reports to physicians, respiratory therapy or RRT must be documented in the EMR.

8 Alarm Interpretation
7.1 Disposable disconnected: Disposable cable is removed from module during monitoring activity.
7.2 Clearing disposable: Disposable is blocked preventing adequate gas monitoring. Monitoring data is not available.
7.3 Disconnect occluded disposable: Clearing of blockage failed. Disconnect and then reconnect the disposable.
7.4 AutoZero in process: EtC0₂ module AutoZero feature is active and monitoring will be available momentarily.
7.5 Low ETC0₂: Patient has a low carbon dioxide content in the blood.
  7.5.1 Causes:
   7.5.1.1 Disposable not correctly attached to patient
   7.5.1.2 Disposable not securely attached to monitoring module
   7.5.1.3 Low alarm limit may not be optimal for this patient
7.6 High ETC0₂: Patient has a high carbon dioxide content in the blood.
  7.6.1 Causes:
   7.6.1.1 Respiratory depression
   7.6.1.2 Fever
   7.6.1.3 Hypermetabolic state
   7.6.1.4 Disposable is not properly attached to patient

9 Changing ETC0₂ Options
9.1 Waveform Height: entire waveform of respiratory cycle should be viewable.
9.1.1 Press “Channel Select” on EtC02 module
9.1.2 Press “Options” (hard key) on the PC unit
9.1.3 Select “Waveform Height” and scale to appropriate size

9.2 Waveform Time Scale: Options are 5 or 10 seconds. If RR is rapid, the 5 second option will provide better waveform detail for viewer. If RR is normal or slow, 10 second waveform may provide better detail.
9.2.1 Press “Channel Select” on EtC02 module
9.2.2 Press “Options” (hard key) on the PC unit
9.2.3 Select “Waveform Time Scale” and select desired time scale

9.3 To view the Trended Data:
9.3.1 Press “Channel Select” on EtC02 module
9.3.2 Press “Trend” on main display. View will contain “maximums” and “minimums” and “averages” of EtC02 values and respiratory rates
9.3.3 To view more values, press “Page Up” or “Page Down”.
9.3.4 To change time period for data collection, select “Zoom” in bar above prompt display for the desired time period. Press “Zoom” to cycle through the choices

9.4 To view PCA and EtC02 Trend Data:
9.4.1 Press “Channel Select” on EtC02 module
9.4.2 Press “Options” (hard key) on the PC unit
9.4.3 Select “PCA/ETC02 Trend Data”
9.4.4 The “Total Dose” column includes all infusion data being monitored by the PCA module during that specific time frame. This includes all PCA doses, bolus doses, loading doses and continuous infusion.

9.5 Silencing Alarms: Alarms can be silenced for 2 minutes
9.5.1 Press “Silence” on the PC unit
9.5.2 To cancel silencing prior to the 2-minutes lock-out, press “Cancel Silence” on the PC unit

10 Definitions
10.1 Capnography: Graphic display of CO2 concentration (FCO2) or expired volume during a respiratory cycle
10.2 End Tidal CO2 Monitoring: Continuous measurement of exhaled and inhaled carbon dioxide
10.3 EtC02 Waveform (Capnogram): Monitor depiction of breathing pattern
10.4 Respiratory Rate: Breaths per minute
10.5 Trend Data: data is stored and trended for 24 hours and is available in a table format

11 Discontinuation
11.1 ETC02 monitoring may be discontinued when:
11.1.1 PCA pump is discontinued
11.1.2 6 hours after continuous epidural infusion is discontinued
11.1.3 IV narcotics discontinued
11.1.4 Per moderate sedation monitoring policy
11.2 Once ETC02 monitoring is discontinued, remove ETC02 monitor from the room and take to the soiled utility room to be picked up for cleaning. The cannula FilterLine® is discarded in the same manner as regular medical waste.

12 Patient and Family Education: Patients should be informed that they are connected to a special nasal cannula that monitors breathing more accurately than a visual assessment. It measures carbon dioxide (C02) with each exhalation and monitors the respiratory rate. Some pain medications can
affect the breathing rate, possibly slowing it down. From time to time, patients should expect to hear an alarm and wake up. Instruct patients to think of the monitor as an alarm clock reminding them to breathe deeply.

**Committee Review:** Surgical Executive committee, Medical Executive committee, Anesthesia Executive Committee, Collaborative Practice Committee

**References:**


3. Practice guidelines for sedation and analgesia by non-anesthesiologists, an updated report by the American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists.

4. www.Capnography.com

5. www.ovidion.com