SCOPE:
All Poudre Valley Health System Facilities.

PURPOSE:
To provide guidelines for patient selection and capnography monitoring for the non-ventilated patient.

GENERAL INFORMATION:
The rise and fall of the chest provides very little information about the effectiveness of the chest wall movements, while capnography gives continuous measurement of CO₂ content throughout the respiratory cycle. In spontaneously breathing patients, hypoventilation, hyperventilation, and apnea can all be promptly detected by capnography. Any questions about capnography monitoring should be directed to the Rapid Response Team, Respiratory Therapist, or Clinical Nurse Specialist.

DEFINITIONS:
Capnograph: a graphic representation (waveform) of exhaled CO₂ levels in the form of a tracing.
Capnography: non-invasive method for monitoring the level of CO₂ in exhaled breath (ETCO₂) to assess a patient’s ventilatory status. It is the combination of the numeric measurement (capnometry) with the waveform (capnography).

a. A normal capnograph has the following components:

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CO₂
38
A B EXHALATION E
0
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- Zero Baseline A-B
- Rapid, sharp upstroke, beginning of exhalation B-C
- Plateau as flow velocity slows with exhaled CO₂ C – D
- End-tidal CO₂ point, max ETCO₂ D – this is where the ETCO₂ measurement takes place
- Rapid down stroke, inspiration D-E
NOTE that the POSITIVE deflected limb occurs with EXHALATION. The NEGATIVE deflected limb occurs with INHALATION.

DEFINITIONS:
Capnometry: The numeric measurement of the concentration of CO₂ in the airway during inspiration and expiration. Age, smoking, general anesthesia, and major systemic disease can cause decreased ETCO₂ levels.
ETCO₂/End-tidal CO₂: Also known as PetCO₂. Measurement of CO₂ concentration at the very end of expiration is termed end-tidal CO₂.
Capnoline: A nasal cannula-like device that allows sampling of the CO₂ and can also deliver oxygen to the patient.

PATIENT SELECTION AND ASSESSMENT:

AN ORDER IS NOT NEEDED FOR NURSES TO USE ETCO₂ MONITORING

I. MODERATE SEDATION/ANALGESIA PATIENTS with one or more of the following criteria will have capnography monitoring:
   1. ASA Class 3 or more.
   2. Sedation procedures that have the potential to exceed 30 minutes, including endoscopic retrograde cholangiopancreatography (ERCP) and radiofrequency ablation.
   3. Children under 6 years of age (Exclusion: neonates)
   4. Any patient with obstructive sleep apnea.
   5. Any non-intubated critically ill patient.
   6. Post bronchoscopy procedures, during the recovery process.

II. PATIENTS WITH OPIOID USE, via PCA or continuous neuraxial opioid infusion with one or more of these diagnoses will have capnography monitoring (excluding pregnant or post-partum see criteria below):
   1. Diagnosis of sleep apnea (Not applicable while the patient is on a CPAP or BiPAP machine).
   3. History of neurological disorder/neurological compromise affecting chest wall function, nerve innervation, or respiratory drive such as Multiple Sclerosis or Myasthenia gravis.
   4. BMI of 40 or more.
   5. Anatomical/structural abnormalities that compromise the respiratory system, such as kyphosis or achondroplasia (dwarfism).
III. **PREGNANT OR POST-PARTUM PATIENTS** (excludes the active labor patient)
   Any patient not in active labor with two or more of the following require capnography monitoring:
   1. PCA
   2. Continuous neuraxial infusion
   3. Magnesium sulfate infusion
   4. BMI of 40 or more (calculated by the pre-pregnancy BMI)

IV. Capnography monitoring may also be initiated at the nurses' discretion or per provider order for concerns about ventilatory status or a change in patient condition. Examples include the patient with:
   - Alcohol withdrawal protocol
   - A change in level of consciousness
   - Respiratory distress
   - An episode of respiratory failure during the present hospitalization
   - Decreasing respiratory rate or depth or a combination of both
   - End Stage Renal Disease and receiving opioids
   - Age over 65 and decreased muscle mass, decreased liver or renal function, decreased protein and albumin levels, or multiple co-morbidities
   - Current diagnosis of unstable or progressive angina
   - New brain stem CVA and receiving opioids

V. Patients requiring EMERGENCY return to the Operating Room or CCL, with a provider present, may be excluded from the monitoring requirements.

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**PROcedure:**

I. **Procedure for patients receiving moderate sedation/analgesia in The Emergency Department and procedural units.** Follow moderate sedation policy and:
   1. Include information about capnography in education given to patient, family and significant others.
   2. Attach Capnoline to patient and capnography monitor.
   3. Obtain and document baseline ETCO₂ values before the procedure. To obtain the baseline Capnography information, observe the patient in a non-stimulated environment (patient should lie quietly without speaking or moving) for 2 minutes then document the baseline vital signs with ETCO₂ and place a baseline waveform strip in the patient record.
   4. Alarm values for ETCO₂ monitoring are:
      a. Default alarm limits for ETCO₂ are set at 10 and 50.
      b. Default alarm limits for airway respiratory rate (awRR) are set at 9 and 30.
5. Assess ETCO₂ waveform, and awRR continually throughout the procedure and document the ETCO₂ and awRR at least every 15 minutes and PRN for significant changes.

   Exception: ETCO₂ monitoring is not required during bronchoscopy, however monitoring is to be resumed when the procedure is complete. Refer to #7 for discontinuing monitoring post procedure.

6. Capnography monitoring is done by evaluating trends of the awRR and ETCO₂ value and they should be assessed together. Therefore if the awRR and ETCO₂ values are both changing, the patient should be assessed and interventions initiated as needed. If the awRR is stable while the ETCO₂ monitor is alarming, then the situation can be observed for one minute for a possible equipment malfunction or transient reading, and then the patient is assessed if the alarms continue to be abnormal.

7. The capnography monitoring can be discontinued when the procedure is complete and the ETCO₂ is within +/- 20% of the baseline value for at least one minute. Document ETCO₂ and include a recorded waveform in the patient record at the time that capnography is discontinued.

II. Procedure for patients receiving moderate sedation/analgesia on inpatient units and any outpatients in the Pediatric Plus Unit. Follow moderate sedation policy and:
   1. Include information about capnography in education given to patient, family and significant others.
   2. Attach Capnoline to patient and capnography monitor.
   3. RN to observe patient prior to drug administration in a non-stimulated environment (patient should lie quietly without speaking or moving) for 2 minutes then document the baseline vital signs with ETCO₂ and place a baseline waveform strip in the patient record.
   4. Alarm values for ETCO₂ monitoring are:
      a. Default alarm limits for ETCO₂ are set at 10 and 50.
      b. Default alarm limits for airway respiratory rate (awRR) are set at 9 and 30.
   5. Assess ETCO₂, awRR, and waveform continually throughout the procedure and record the ETCO₂ and awRR at least every 15 minutes and PRN significant changes.
   6. Capnography monitoring is done by evaluating trends of the awRR and ETCO₂ value and they are assessed together. Therefore if the awRR and ETCO₂ value are both changing, the patient is assessed and interventions done as needed. If the awRR is stable while the ETCO₂ monitor is alarming, then the situation can be
observed for one minute for a possible equipment malfunction or transient reading, and then the patient is assessed if the condition remains.

7. Discontinue capnography monitoring when the procedure is complete and the ETCO₂ value is within +/- 20% of the baseline value for at least one minute. Document ETCO₂ and include a recorded waveform in the patient record at the time the capnography is discontinued.

III. Procedure for patients receiving PCA or neuraxial opioid infusion, on inpatient units with telemetry/central station monitoring capability.
   1. Include information about capnography in education given to patient, family and significant others.
   2. Attach Capnoline to patient and capnography monitor.
   3. RN to observe patient before drug administration in a non-stimulated environment (patient should lie quietly without speaking or moving) for 2 minutes, then document the baseline vital signs with ETCO₂ and place a baseline waveform strip in the patient record.
   4. Alarm values for ETCO₂ monitoring are:
      - Default alarm limits for ETCO₂ are set at 10 and 50.
      - Default alarm limits for airway respiratory rate (awRR) are set at 9 and 30.
   5. Inform telemetry technician that patient is on a capnography monitor so the patient is monitored at the central station for ETCO₂ and awRR while on the PCA. Cardiac telemetry is not needed unless this has been ordered by the provider.
   6. Capnography alarms are to be on at the central telemetry station at all times.
   7. Include ETCO₂ assessments with vital signs at the frequency directed by the PCA policy or as indicated by the patient status.
   8. Capnography monitoring is done by evaluating trends of the awRR and ETCO₂ value and they should be assessed together. Therefore if the awRR and ETCO₂ values are both changing, the patient should be assessed and interventions initiated as needed. If the awRR is stable while the ETCO₂ monitor is alarming, then the situation can be observed for one minute for a possible equipment malfunction or transient reading, and then the patient is assessed if the condition remains.
   9. The ETCO₂ and a waveform is documented with every significant ETCO₂ change.
   10. Change ETCO₂ Capnoline every 24 hours or as indicated by the monitor with the message "CO₂ OCCCLUSION".
   11. Capnography monitoring may be stopped one hour after the PCA has been discontinued and the ETCO₂ value is within +/- 20% of the baseline value for at least one minute. Document ETCO₂ and include a recorded waveform in the patient record at the time that capnography is discontinued.
12. If the patient is on the inpatient unit and has already received sedating/opioid/anesthetic medication (e.g. in the ED or OR, etc), before the PCA has been started; obtain and record the current EtCO2 value and waveform and continue to monitor EtCO2 and awRR while the PCA is infusing. When the PCA is stopped, the capnography monitoring can be ended after one hour, as long as the patient trends of ETCO2 values is not moving up, and the current value is below 50.

IV. Procedure for patients requiring capnography monitoring on units without telemetry/central monitoring capability.
   A. Patients who meet the criteria for capnography monitoring shall be cared for in an area that has the capability to perform telemetry/central monitoring.

   CAPNOGRAPHY INDICATORS OF RESPIRATORY DEPRESSION, APNEA, OR HYPOVENTILATION
   • No waveform for any period of time.
   • Change in EtCO2 of 20% above baseline.
   • Hypoventilation: Decreased respiratory rate with an elevated EtCO2. Waveform shape will have a taller waveform (higher CO2). May have a prolonged flat area (alveolar plateau).
   • Shallow Breathing Hypoventilation: Shallow breathing often involves such low exhaled volumes that the gas deep inside the lung, may not flow all the way to the mouth and some of the gas in the trachea, or dead space gas that doesn’t contain CO2 may mix with the alveolar gas and dilute it. Therefore the waveform shape will be abnormal in shape, shorter and smaller. The respiratory rate may or may not change and the EtCO2 may appear to decrease.
   • Airway obstruction: Respiratory rate may or may not change with a decrease in EtCO2. Waveform is erratic with loss of the alveolar plateau.
   • Apnea: Waveform, EtCO2 value, and respiratory rate will be absent. No air exchange is taking place due to cessation of breathing or total airway obstruction.
   • Rebreathing EtCO2: Elevated baseline. Waveform shape may be normal or abnormal but the baseline is not returning to zero.

   INTERVENTIONS IF RESPIRATORY DEPRESSION, APNEA, OR HYPOVENTILATION NOTED
   • Immediately assess patient.
   • Ensure patient has an open airway.
   • Stimulate patient if necessary. Ask patient to take a deep breath.
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- If adequately breathing, check capnoline to ensure it is positioned in the nares and check connections to monitor.
- Stop drug delivery if previous interventions do not sustain and improve sedation level.
  - Continue with the following interventions if respiratory depression, apnea, or hypoventilation occurs during a moderate sedation procedure:
    - Inform provider and pause the procedure if necessary.
    - Use reversal medications as directed by provider or protocol.
    - Continue monitoring until patient is at pre-procedure sedation level and respiratory rate and EtCO₂ are within +/- 20% of the baseline values for at least one minute.
    - Document all interventions.
    - Document EtCO₂ and include a recorded wave form in the patient record indicating the incident of abnormal EtCO₂.
  - Continue with the following interventions if respiratory depression, apnea, or hypoventilation occurs during use of PCA or neuraxial opioid:
    - Initiate the respiratory algorithm and use reversal medications as directed by protocol.
    - Utilize the excessive sedation algorithm if ordered with the PCA.
    - Continue monitoring until patient is at pre-procedure sedation level and respiratory rate and EtCO₂ are within +/- 20% of the baseline values for at least one minute.
    - Document all interventions.
    - Document EtCO₂ and include a recorded wave form in the patient record indicating the incident of abnormal EtCO₂.
REFERENCES: