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End Tidal Carbon Dioxide Monitoring (Capnography) in the Cardiac Intensive Care Unit

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Purpose: Capnography monitoring will be used to obtain a continuous, noninvasive measurement of the end tidal carbon dioxide ($EtCO_2$) on selected patients. The purpose of this policy is to provide guidelines for patient selection and capnography monitoring for patients in the cardiac ICU.

Background: Carbon dioxide levels can be monitored throughout the respiratory cycle via capnography. In this way, capnography allows healthcare professionals to follow a number of respiratory factors in real-time, including respiratory depression, apnea, and hypercapnia. It can be done for a short period of time or continuously, both in mechanically ventilated and non-ventilated patients. Postoperative patients are subjected to significant harm or death while receiving sedating medications without appropriate monitoring and intervention. Some studies have found that up to 14.2% of all surgical patients experience postoperative pulmonary complications, particularly those with open upper abdominal procedures.[1] Earlier detection of alterations to ventilation status will better enable providers to more accurately dose medications during procedures, especially in high-risk patient populations.

Definitions

Capnograph = a graphic representation (waveform) of exhaled CO_2 levels in the form of a tracing; often in conjunction with numerical reading in a clinical setting. See attached waveforms for additional information.

$EtCO_2$ = a numeric measurement of CO_2 concentration at the very end of expiration.

Normal values:
$EtCO_2$ 35-45 mmHg.

Abnormal values:
$EtCO_2 < 35$ mmHg = Hyperventilation/Hypocapnia
$EtCO_2 > 45$ mmHg = Hypoventilation/Hypercapnia

Capnoline = a nasal cannula-like device that allows sampling of the CO_2 and can also deliver oxygen to the patient.

Integrated Pulmonary Index (IPI) = a value which calculates and quantifies $etCO_2$, respirations, SpO_2 and pulse rate.

Methods:

Patient Selection/Clinical Applications

I. Patients receiving moderate sedation/analgesia 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.
   3. Children under 6 years of age, excluding neonates.
   4. Any patient with obstructive sleep apnea.
   5. Any non-intubated critically ill patient.
   6. Post-bronchoscopy procedure, during the recovery process.

II. Patients receiving high doses or high frequencies of opioids with one or more of these diagnoses will have capnography monitoring:
   1. Sleep apnea
   2. A chronic respiratory disease with an acute respiratory problem
   3. History of neurological disorder/compromise affecting chest wall function, innervation, or respiratory drive such as multiple sclerosis or myasthenia gravis.
   4. BMI of 40 or more.
   5. Age > 70 years
   6. Anatomical/structural abnormalities that compromise the respiratory system.

III. Patients receiving epidural or intrathecal pain management.

IV. Patients who are difficult to arouse.

V. Patients with a history of respiratory distress, including the high-risk factors of obesity, sleep-disordered breathing, and obstructive sleep apnea.

VI. Patients undergoing resuscitative efforts and/or endotracheal intubation.

Results:

The high-risk target populations above should receive continuous pulse oximetry by telemetry. If supplemental oxygen is used, add continuous $EtCO_2$ monitoring. Pulse oximetry may suggest adequate oxygenation in patients who are actively experiencing respiratory depression when supplemental oxygen is used. Thus, $EtCO_2$ monitoring is added to monitor ventilation in these patients on supplemental oxygen.

For patients with PCA/Epidural Application, capnography can be used as a standard of care for post-op/post-procedural monitoring because it is the most rapid indicator of hypoventilation and apnea. It may also be paused or removed for patients ambulating, eating, or performing therapies and activities that stimulate respiratory effort. The guidelines for PCS/PCEA applications as developed according to the results of this work are described in Table 1. $EtCO_2$ monitoring may be discontinued when the PCA pump is discontinued, 6 hours after continuous epidural infusion is discontinued, when IV narcotics are discontinued, or per moderate sedation monitoring policy. Capnography indicators of respiratory depression include no waveform for any period of time, change in EtCO2 of 20% above baseline, hypoventilation, shallow breathing hypoventilation, airway obstruction, apnea, or rebreathing EtCO2. Definitions and descriptions of waveforms for each capnography indicator is described in Table 2.

Table 1. Guidelines for PCA/PCEA Application

EtCO2	IPI (if available)	Recommendation
30 - 55	7 - 10	Monitor
55 - 60	4 - 6	Requires attention/attempt to stimulate and arouse patient
>60	1 - 3	Requires immediate intervention, consider recommending decreased opioid dosage, notify MD

Table 2. Capnography Indicators of Respiratory Depression, Apnea, or Hypoventilation

Capnography Indicator	Definition of Indicator	Capnography Waveform Description
Hypoventilation	decreased respiratory rate with an elevated etCO_2.	Waveform shape will have a taller waveform (higher CO_2). May have a prolonged flat area.
Shallow Breathing Hypoventilation	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 may mix with the alveolar gas and dilute it.	Waveform will be shorter and smaller.
Airway Obstruction	respiratory rate may or may not change with a decrease in etCO_2.	Waveform is erratic with loss of the alveolar plateau.
Apnea	EtCO_2 value and respiratory rate will be absent.	Waveform will be absent
Rebreathing EtCO2	elevated baseline.	Waveform shape may be normal or abnormal, but the baseline is not returning to zero.

Conclusion:

Capnography is an essential monitoring device for post-operative patients in the intensive care unit that are receiving sedation/analgesia, high dose or high frequency opioids, epidural or intrathecal pain management, patients that are difficult to arouse, patients with a history of respiratory disease, and patients undergoing resuscitative efforts and/or endotracheal intubation. Monitoring carbon dioxide levels will help decrease the morbidity and mortality in high-risk surgical patients who experience postoperative pulmonary complications.

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