San Benito County Emergency Medical Services Agency

NON-INVASIVE GAS MONITORING

Policy : 4040
Effective : May 1, 2014
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I. Purpose

The purpose of this policy is to outline guidelines for monitoring oxygen saturation (SpO2), end tidal capnography (ETCO2), and carbon monoxide (SpCO). Monitoring these gases will allow responders to better evaluate patients in the field, and will also help to diagnose specific problems relative to oxygenation, ventilation, and metabolism.

II. Scope of Practice

Monitoring Sp02 and SpCO are considered both BLS and ALS provider skills; while monitoring ETCO2 is reserved for ALS providers.

III. Monitoring SpO2

Overview/Background

SpO2 measures the percentage of hemoglobin in a patient's red blood cells that have fixed oxygen. Thus, this tool is a rough measurement of a patient's oxygenation. This differs from P02, which is a measure of the actual amount of oxygen dissolved in blood plasma. P02 and SpO2 normally are very closely aligned, though SPO2 readings will lag behind falling P02 numbers as a patient becomes hypoxic.

Factors that decrease SpO2 include decreased pH (acidosis), increased blood levels of CO2, and increased physiologic temperature. Factors that increase SpO2 include increased pH (alkalosis), decreased blood levels of CO2, and decreased physiologic temperature.

Because SpO2 measures the ratio of saturated to unsaturated hemoglobin in arterioles, its accuracy can be impaired by any factor that influences arteriolar blood flow. Conditions that may cause false low readings include a cold environment, hypotension, and vasoconstriction from smoking or vascular disease. Substantial motion, fingernail polish, bright light, and shivering can also falsely lower readings. Carbon monoxide fixed to hemoglobin can cause falsely elevated readings, though this can be mitigated when a multi-gas sensing system is employed.

Monitoring Indications

- All patients in respiratory distress.
- Patients with altered mentation, or in any circumstance where airway or ventilation is impaired or may become impaired.
- Use as a "5th vital sign" to monitor the overall status of a patient in significant physiologic distress.
- May be used to detect blood flow to extremities with compromised blood flow/major injuries by placing the oximeter probe onto tissue distal to a fracture or crush injury.

SpO2 Measurements, Interpretation, and Interventions

SpO2 Reading (%)	Interpretation	Intervention
95 – 100%	Normal	Maintain saturation
91 – 94%	Mild Hypoxemia	Increase 02 delivery to increase saturation
86 – 90%	Moderate Hypoxemia	Increase 02 to increase saturation Assess and possibly increase ventilations
< 85%	Severe Hypoxemia	Increase 02 to increase saturation Increase ventilations

IV. Monitoring ETCO2

Overview/Background

End-tidal CO2 (ETCO2) is a measurement of the maximum amount of exhaled CO2 at the end of respiration. It provides excellent real time information about the effectiveness of a patient's ventilation. ETCO2 can be used to estimate PaCO2 (the partial pressure of carbon dioxide in blood plasma) in patients with normal lungs. Normal PaCO2 and ETCO2 values range from 35 – 45 mmHg.

ETCO2 is very effective at identifying hypo- and hyperventilating patients, as well as those patients who develop sudden apnea. ETCO2 monitoring can help to detect problems with advanced airway adjuncts and positive pressure ventilation. Analysis of a patient's capnographic wave form and trending of this wave form can help responders to identify bronchospasm, increased respiratory depression, inadvertent esophageal intubation, and a host of other issues.

While capnography is a direct measurement of ventilation in the lungs, it also indirectly measures metabolism and circulation. For example, an increased metabolism will increase the production of carbon dioxide, increasing the ETCO2. A decrease in cardiac output will lower the delivery of carbon dioxide to the lungs, decreasing the ETCO2.

Monitoring Indications

ETCO2 monitoring via waveform capnography **must be used** on those patients experiencing the following:

- Respiratory arrest or respiratory distress requiring positive pressure ventilation via BVM, King Tube, or ETI.
- Cardiac arrest

ETCO2 monitoring via waveform capnography should be **considered** in patients experiencing the following:

- Hypoventilation/respiratory insufficiency.
- Respiratory distress of any etiology
- Chest pain with respiratory distress
- Congestive heart failure
- Altered mentation/Overdose
- Patients who have received medications which may alter respirations (narcotics, benzodiazepines)

Note: Colormetric CO2 monitoring may be used in those instances that preclude the use of waveform capnography.

ETCO2 Measurements, Interpretation, and Interventions

SPONTANEOUS RESPIRATION ONLY

ETCO2 Reading	Interpretation	Intervention
35 – 45 mmHg	Normal ETCO2	Maintain ventilation
> 45 mmHg	Hypoventilation	Increase ventilation
< 35 mmHg	Hyperventilation	Decrease ventilation

- **ETCO2 In Cardiac Arrest**
  Monitoring ETCO2 during cardiac arrest measures cardiac output, and is a good way to measure the effectiveness of CPR. Reductions in ETCO2 during CPR are associated with comparable reductions in cardiac output.
  Note: Patients with extended down times may have ETCO2 readings so low that the quality of compressions will show little difference in this number.

ETCO2 may be the first sign of return of spontaneous circulation (ROSC). During cardiac arrest, if the CO2 number increases rapidly, stop CPR and check for pulses. Conversely, rapid drops in ETCO2 in a patient with ROSC may indicate that pulses have been lost and that CPR needs to be resumed.

An ETCO2 level of 10 mmHg or less, measured 20 minutes after the initiation of advanced cardiac life support accurately predicts death in patients with cardiac arrest associated with electrical activity but no pulse. In patients for whom this is the case, resuscitation may be discontinued per County Guidelines.

ROSC patients will usually present with an ETCO2 of 18 or greater and will usually quickly climb to above 30 mm Hg in cases that will ultimately survive to discharge.

- **ETCO2 in Bronchospasm/Asthma**
  Bronchospasm will produce a characteristic "shark fin" capnographic wave form, as the patient has to struggle to exhale, creating a sloping "B-C" upstroke. The shape is caused by uneven alveolar emptying.

  Asthma values change with severity. With mild asthma, the CO2 will drop (below 35 mm Hg) as the patient hyperventilates to compensate. As the asthma worsens, the C02 levels will rise to normal. When the asthma becomes severe, and the patient is tiring and has little air movement, the C02 numbers will rise to dangerous levels (above 60 mmHg).

V. Monitoring SpCO

Overview/Background

Carbon monoxide (CO) is an odorless, colorless, tasteless heavier-than-air gas that is the most common product of combustion. Its affinity for hemoglobin is 250 times greater than that of oxygen, and when enough carbon monoxide is fixed to hemoglobin, hypoxia can occur. High carbon monoxide levels can cause fatal anoxia.

Monitoring Indications

- SpCO monitoring should be included in the medical monitoring conducted at Emergency Worker Rehab. At present (4/1/2012) paramedics are not allowed to monitor CO readings in patients.

SpCO Measurements and Interpretation

SpCO Level	Interpretation	Signs and Symptoms
< 3%	Normal Levels (nonsmokers)	None
4% - 11%	Minimal Levels	Usually none; possibly mild headache, nausea

12% - 20%	Mild exposure	Headache, n/v, dizziness, blurred vision
21% - 40%	Moderate exposure	Confusion, syncope, chest pain, weakness, rapid HR
41% - 59%	Severe exposure	Dysrhythmias, hypotension, MI, respiratory arrest, Seizures, coma, pulmonary edema, cardiac arrest
>60%	Fatal	Death 100% of the time

- Cherry red skin color is not always present in carbon monoxide poisoning, and when present, is often a late finding.
- Smokers often will have a chronic SpCO level of 4 – 10%
- Most non-smokers have a SpCO level less than 2.5%
- County Emergency Worker Rehab Plan endorsed by County Fire Chiefs, sets green (return to duty) level at <6; yellow level (hold and recheck at 20 minute mark) at 6 – 12%; and red level (must be evaluated by MD) at >12%.
- Fetal hemoglobin has a much greater affinity for SpCO than adult hemoglobin. Pregnant mothers may exhibit mild to moderate symptoms, yet the fetus may have devastating outcomes.
- Remember, SpCO poisoning is the great imitator. It can "masquerade" as many other etiologies. When in doubt, check for it.
- Missed SpCO exposure often leads to death and disability.
- ***CO poisoning is a particular risk for firefighters.***

SpCO Treatment

- Treatment is based on the severity of symptoms.
- **Treatment generally indicated with SpCO > 12-15%, but may begin at any level in which the patient is experiencing symptoms.**
- High-concentration O2 should be administered to displace CO from hemoglobin.
- Be prepared to treat complications (e.g., seizures, cardiac ischemia).
- ***Patients with severe poisoning may benefit from hyperbaric chamber therapy. The receiving ED will arrange this.***