It is 3 am and you are called to a local residence for smoke detectors going off. Upon arrival, you determine that it is not the smoke detectors, but the Carbon Monoxide detector that has activated. The resident states that he has had a headache all day and that he started to feel nauseous before bed. He tells you that the detectors were going off before dinner, but he took the battery out of the one by the garage door and it stopped. There is a workshop in the garage and you find a snow blower on a work bench. The resident states that he has been working on the snow blower since this morning, but he always keeps the garage window open a “crack” for fresh air. He says that he can’t keep the snow blower running for more than a couple minutes at a time. He asks if you could look at the snow blower after you get the detector to stop beeping.

**Carbon Monoxide Review**

Carbon monoxide (sometimes referred to as CO) is a colorless, odorless gas produced by burning materials containing carbon. It is the combination of 1 carbon molecule and 1 oxygen molecule. It is caused by the incomplete combustion of a carbon based fuels. Complete combustion converts to $CO_2$ (1 Carbon and 2 Oxygen molecules) and $H_2O$ (2 Hydrogen and 1 Oxygen molecule).

![1 Carbon Molecule and 1 Oxygen Molecule](image)

**Why is Carbon Monoxide so dangerous?**

In the lower airway, oxygen is exchanged at a cellular level in the alveoli. The capillaries that surround the alveoli allow red blood cells to give up carbon dioxide ($CO_2$) and receive Oxygen (O). Hemoglobin is the part of the red blood cell that receives these oxygen molecules. The oxygen is then carried to individual cells and is used for fueling that cell. Carbaminohemoglobin is what the hemoglobin becomes as it transports the $CO_2$ back to the lungs. Carbon Monoxide disrupts this sequence of events. Hemoglobin has a high affinity to oxygen, but an even higher affinity to carbon monoxide. This means that the oxygen will be displaced by carbon monoxide and the carbon monoxide will be carried out to supply the cells. Hemoglobin will also hold onto the carbon monoxide and not allow it to be replaced with new oxygen. (Think of a taxi that can carry passengers from the city to the airport and continue to pick up and drop off as it drives back and forth. Carbon Monoxide would be a passenger that gets in the cab and refuse to get out.) Not only is there no new oxygen being carried to the cells for energy, but no carbon dioxide is not being carried off to the lungs to be exhaled.
How will the patient present that has Carbon Monoxide Poisoning

Signs and symptoms of carbon monoxide poisoning may include: ¹

- Dull headache
- Weakness
- Dizziness
- Nausea or vomiting
- Confusion/Agitation
- Loss of consciousness
- Loss of coordination
- Cyanotic skin coloring
- Bright cherry red skin (late finding)
- Shortness of breath
- Blurred vision

These signs and symptoms will depend on how long the patient has been exposed to the carbon monoxide, what the levels of carbon monoxide are at and the overall health of the patient. The higher the levels and the longer the exposure, the more affected the patient will become. Agencies like the EPA and OSHA look at the exposures that an individual can be exposed to on a daily basis. They determine a Time Weighted Average (TWA) over the course of an 8 hour day. Continuous, low level/long term exposure can be just as deadly as an extremely high level/short term exposure.

There are 3 groups that are more susceptible to the effects of carbon monoxide: children under 14, elderly and those with a history of chronic respiratory issues, anemia and/or chronic heart conditions. Children under 14 have a higher metabolism and faster respiratory rates. For these reasons, their absorption of carbon monoxide is a lot faster. For the same reasons, once they are removed from the toxic environment and given oxygen, their recovery is a lot quicker. For elderly patients, symptoms of carbon monoxide poisoning are nonspecific and can mimic those of other chronic geriatric illnesses. They may not attribute what is going on to carbon monoxide and not seek medical attention. This would lengthen there exposure time. For patients with a history of respiratory issues, anemia and/or cardiac conditions, these patients are already affected at normal oxygen levels. Exposure to carbon monoxide can cause conditions to become worse at a faster rate. There have been cases of carbon monoxide causing an MI in patients.

The patient may initially describe “Flu” like symptoms - very vague. A Red Flag would be no fever associated with the flu symptoms or multiple patients in the same location, with similar complaints. Don’t forget to look at how the pets are acting. (Remember they used to bring birds into below grade mines for this reason.) Carbon monoxide should be ruled out as a cause.

The first step in determining if the patient is having a carbon monoxide problem is to check the area that they have been occupying. This can be done with a carbon monoxide detector. Illinois Code ((430 ILCS 135/) Carbon Monoxide Alarm Detector Act) requires that a carbon monoxide detector be in every residence (single family or multiple occupancy dwelling), but as we know, they may not be working. The detectors are very important because a lot of victims go to sleep not aware that there is a CO problem. They do not wake up. These dwelling detectors will only alert when a certain level is reached. This is how UL determines when the detectors go off. (See BRK Chart) Carbon monoxide levels can be checked by a monitor from the fire department or the gas company.
The next table summarizes some health effects due to prolonged exposure to various concentrations of CO, as well as some government recommended limits, and Pocket CO alarm levels. It has been compiled from various sources, including the NFPA.  

<table>
<thead>
<tr>
<th>Level of CO</th>
<th>Health Effects, and Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 PPM</td>
<td>Normal, fresh air.</td>
</tr>
<tr>
<td>9 PPM</td>
<td>Maximum recommended indoor CO level (ASHRAE).</td>
</tr>
<tr>
<td>10-24 PPM</td>
<td>Possible health effects with long-term exposure.</td>
</tr>
<tr>
<td>25 PPM</td>
<td>Max TWA Exposure for 8 hour work-day (ACGIH). Pocket CO TWA warning sounds each hour.</td>
</tr>
<tr>
<td>50 PPM</td>
<td>Maximum permissible exposure in workplace (OSHA). First Pocket CO ALARM starts (optional, every 20 seconds).</td>
</tr>
<tr>
<td>100 PPM</td>
<td>Slight headache after 1-2 hours.</td>
</tr>
<tr>
<td>125 PPM</td>
<td>Second Pocket CO ALARM starts (every 10 seconds).</td>
</tr>
<tr>
<td>200 PPM</td>
<td>Dizziness, nausea, fatigue, headache after 2-3 hours of exposure.</td>
</tr>
<tr>
<td>400 PPM</td>
<td>Headache and nausea after 1-2 hours of exposure. Life threatening in 3 hours. Third Pocket CO ALARM starts (every 5 seconds).</td>
</tr>
<tr>
<td>800 PPM</td>
<td>Headache, nausea, and dizziness after 45 minutes; collapse and unconsciousness after 1 hour of exposure. Death within 2-3 hours.</td>
</tr>
<tr>
<td>1000 PPM</td>
<td>Loss of consciousness after 1 hour of exposure.</td>
</tr>
<tr>
<td>1800 PPM</td>
<td>Headache, nausea, and dizziness after 20 minutes of exposure; Death within 1-2 hours.</td>
</tr>
<tr>
<td>3200 PPM</td>
<td>Headache, nausea, and dizziness after 5-10 minutes; collapse and unconsciousness after 30 minutes of exposure; Death within 1 hour.</td>
</tr>
<tr>
<td>6400 PPM</td>
<td>Death within 30 minutes.</td>
</tr>
<tr>
<td>12,000 PPM</td>
<td>Immediate physiological effects, unconsciousness. Death within 1-3 minutes of exposure.</td>
</tr>
</tbody>
</table>
The only pre-hospital way to check to see if a patient has an elevated carboxyhemoglobin level (hemoglobin combined with carbon monoxide) is with a CO-oximetry. This is like pulse oximetry, but uses 8 wavelengths instead of 2 wavelengths. Pulse Oximetry can’t distinguish what is being carried by the hemoglobin, only the fact it is carrying something. A patient that has 90% Oxygen and 15% CO will show 95% SpO2 on Pulse Oximetry. A device that is able to distinguish the carbon monoxide will give a SpCO reading. This same patient would show the SpCO at 15%.

The body usually has a small amount of CO in it that is considered normal (1-4%). A chronic smoker can have a normal reading of up to 10%. Patients can have different responses at different levels. You can find a child having moderate symptoms and an adult having mild symptoms.

<table>
<thead>
<tr>
<th>Severity</th>
<th>COHb Level</th>
<th>Signs &amp; Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&lt;15 - 20%</td>
<td>Headache, Nausea, Vomiting, Dizziness, Blurred Vision</td>
</tr>
<tr>
<td>Moderate</td>
<td>21 - 40%*</td>
<td>Confusion, Syncope, Chest Pain, Dyspneea, Weakness, Tachycardia, Tachypnea, Rhabdomyolysis</td>
</tr>
<tr>
<td>Severe</td>
<td>41 - 59%*</td>
<td>Palpitations, Dysrhythmias, Hypotension, Myocardial Ischemia, Cardiac arrest, Respiratory arrest, Pulmonary edema, Seizures; Coma</td>
</tr>
<tr>
<td>Fatal</td>
<td>60%+</td>
<td>Death</td>
</tr>
</tbody>
</table>

**We have identified a symptomatic patient from Carbon Monoxide**

First, remove the patient from the environment. *In fresh air, the half-life of carbon monoxide can be from 4 to 6 hours.* Put the patient on oxygen, a Non-Rebreather mask (NRM) at 12-15L. *Once the patient is put onto 100% oxygen, the half-life time can be reduced down to 45 to 60 minutes.* Check vitals, but remember to use CO-oximetry (like a RAD-57). *Pulse Oximetry can give you a false reading.* This person should be put on to a cardiac monitor. Try to determine the length of time that the patient was exposed. *This may be determined by when the symptoms started.* If a CO reading in the environment can be obtained, relay that to medical control with your report.

**Where to transport**

A stable/low acuity patient can be transported to the nearest hospital. If the patient is (critical) in respiratory/ cardiac arrest or the airway is unsecured, they would also go to the closest facility. The patient that is hemodynamically stable, but severely confused can be best helped by a hyperbaric chamber. By increasing the atmospheric pressure, the half-life is dramatically shortened and so are the symptoms. OLMC would need to be contacted and the order would come from them. Consider aeromedical transport if the facility is beyond your transport range. Lutheran General, in Park Ridge and St. Luke’s Medical Center, in Milwaukee, would be hospitals that could receive these patients.

**The Original Scenario Revisited**

The crew grabs a gas monitor and it shows CO levels are 75 ppm in the house. The garage readings are at 200 ppm. (*There was no window open in the garage.*) As you remove the patient to the ambulance, the fire department ventilates the house. You check the patient’s vitals and put them onto a NRM at 15L. You originally put your patient onto the Pulse Oximetry and it showed 97%. You then grab the RAD 57 and it shows SpCO at 17%. After talking with your patient, you determine that their headache started
around lunch time. You confirm that there is no one else is in the house. You contact OLMC and they request that the patient be transported to a local facility.

Reference used:

1 www.mayoclinic.org/diseases-conditions/carbon-monoxide/basics/symptoms/con-20025444

2 http://www.brkelectronics.com/faqs/oem/what_levels_of_co_cause_an_alarm

3 http://www.detectcarbonmonoxide.com/co-health-risks/
**Carbon Monoxide**

**IMC special considerations:**
- Use appropriate Haz-mat precautions & PPE; remove patient from CO environment as soon as possible.
- O₂ 12-15 L/NRM or BVM; ensure tight seal of mask to face; SpO₂ UNRELIABLE to indicate degree of hypoxemia.
- Vomiting precautions; ready suction; monitor ECG.
- Keep patient as quiet as possible to minimize tissue oxygen demands.
- CO screening per System policy if available. If using CO-oximeter >12% abnormal, <3% CO normal, smokers may have as high as 10%; use manufacturer standard levels if given; carefully assess for clinical correlation due to questionable device sensitivity.
- Transport lower acuity/stable patients to nearest hospital.
- Severely confused/hemodynamically stable: Consider transporting directly to a facility w/ a hyperbaric chamber via helicopter.
- CRITICAL: If in respiratory/cardiac arrest or airway unsecured, transport to nearest hospital.

**Hyperbaric oxygen chambers**
- Advocate Lutheran General Hospital 847/723-5156 24/7
- St. Luke’s Medical Center (Milwaukee) 414/649-6577 24/7

**Cyanide Exposure**

PPE including SCBA; evacuate danger area.
- IMC per Drug OD/Poisoning SOP; decontaminate as necessary. Do NOT direct water jet on liquid.
- Absorb liquid in sand or inert absorbent and remove to a safe place. Remove vapor cloud w/fine water spray.
- Remove contaminated clothing and wash skin with soap and water for 2-3 min.
- Establish OLMC ASAP so receiving hospital is prepared for your arrival.
- If hypotensive or pulseless: IV/IO NS wide open. CPR as indicated.

Illinois Poison Center # 1-800-222-1222
www.illinoispoisoncenter.org
1) Carbon Monoxide means:
   a. 1 Carbon/2 Oxygen
   b. 2 Carbon/2 Oxygen
   c. 1 Carbon/1 Oxygen
   d. 2 Carbon/1 Oxygen

2) All patients in the same environment will present the same with Carbon Monoxide poisoning.
   a. True    b. False

3) What is the best tool to determine how much CO is in the patient’s blood?
   a. Capnography
   b. Litmus Paper
   c. Fruity Smell on their breath
   d. CO-oximetry

4) What part of the blood carries Carbon Monoxide?
   a. White Blood Cells
   b. Hemoglobin
   c. Carbaminohemoglobin
   d. Platelets

5) What signs/symptoms would you expect to find in a patient who is EMERGENT?
   a. Chest Pain, Weakness, Syncope
   b. Dizziness, Headache, Blue Lips/Nail beds
   c. Full Arrest
   d. Expiratory Wheezing, Anxious, Pitting Edema in ankles

6) What patients are more susceptible to the effects of Carbon Monoxide?
   a. Smokers
   b. Extremely Fit 28 year olds
   c. 16 year olds
   d. 10 year olds
7) What could an expected normal SpCO reading be on CO-oximetry for a healthy patient?
   a. 8%
   b. 10%
   c. 2%
   d. 5%

8) What could an expected normal SpCO reading be on CO-oximetry for a chronic smoker?
   a. 9%
   b. 12%
   c. 15%
   d. 21%

9) What group recovers the quickest from exposure to Carbon Monoxide?
   a. Children
   b. Athletic Adults
   c. Smokers
   d. Nurses

10) In the past, what was brought into coal mines to check for poisonous gases?
    a. Dog
    b. Cow
    c. Lemur
    d. Canary

If you are NOT a member of the McHenry Western Lake County EMS System, Please include your address on each optional quiz turned into our office. Our mailing address is: Northwestern Medicine – McHenry Hospital EMS, 4201 Medical Center Drive, McHenry, Illinois 60050. We will forward to your home address verification of your continuing education hours.

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