

ToxicologyTimes

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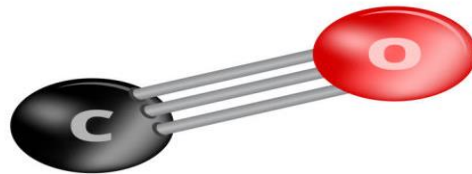
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What has no smell, no taste and no colour but can kill if inhaled?

“The Silent Killer” Carbon Monoxide (CO)



According to Stats Canada between 2000 and 2013, there were 1125 Canadian deaths related to CO with no other underlying causes. As of 2022 there are an estimated 300 deaths and 200 hospitalizations related to CO exposures each year in Canada.

Carbon Monoxide is produced by incomplete combustion of any carbon containing substance. Burning of fuels such as coal, gasoline, natural gas, oil, propane, and wood all emit carbon monoxide fumes. Other sources could include charcoal grills, gas powered cooking appliances, chimney flues and gas-powered dryers. In an enclosed space, with inadequate oxygen to feed a fire, CO is produced instead of carbon dioxide.

As we get into the colder months of the year with snow, ice storms and power outages, the risk of carbon monoxide exposures significantly increases, as does the potential for severe outcomes, including deaths. People use propane heaters, grills, and fires to stay warm indoors. If used incorrectly or in a poorly ventilated confined space, this could result in significant CO poisoning.

Exposures can be both accidental and intentional.



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Case:

After a cold wintery night and loss of power in the neighbourhood, a gentleman checked on an elderly neighbour. He noted that, upon answering the door, the individual was slightly confused and complained of feeling unwell with mild shortness of breath.

On arrival to the Emergency Department (ED) the elderly patient presented awake, but felt “foggy,” complaining of a headache, nausea and mild shortness of breath. The symptoms seemed to have improved a little since leaving his home. After this history and a non-focal physical examination, the ED physician ordered investigations including an acetaminophen and ASA level with routine CBC, electrolytes, renal function tests and a venous blood gas. A CT head and urinalysis were added. The Poison Centre was contacted; the bedside team was inquiring if this presentation could be compatible with a poisoning. Due to the initial history, the Poison Centre staff asked for further information regarding the house and if there was an alternative heat source being used. Upon further discussion with the patient, it was determined that he had started using a propane stove in the house earlier that morning to try to stay warm. There were no other occupants in the house at the time.

Based on this history and symptoms, the Poison Centre recommended starting the patient on 100% O₂ and ensuring that a Lactate and Carboxyhemoglobin were added to the labs. It was recommended the patient also have a baseline ECG.

The ED contacted the Poison Centre with the patients’ lab results, which showed a mild acidosis, and an elevated COHb >10%. It was confirmed that the patient had no loss of consciousness and reported his symptoms improving with the oxygen treatment.

It was recommended to continue with the O₂ therapy for a minimum of 5 half-lives (estimated 5-6hrs while on 100% O₂) and resolution of symptoms. The patient’s symptoms continued to improve. Due to the slight acidosis, the ED physician repeated labs 6 hours after presentation and noted VBG was within normal limits and the COHb improved significantly to 2%. The patient was discharged, following a consult with social work to ensure home safety and the recommendation to follow up with his family doctor.

Carbon Monoxide mechanism:

CO binds to hemoglobin 250 times stronger than O₂ does. It is also believed to bind to myoglobin and affect cellular respiration by binding directly to mitochondrial enzymes, generate reactive oxygen species and peroxidize brain lipids leading to inflammation.

The attachment of CO to hemoglobin forms carboxyhemoglobin, which cannot carry O₂ and therefore decreases the amount of oxygen in the blood. This creates a state of systemic hypoxia. The formation of carboxyhemoglobin also affects hemoglobin’s normal ability to release O₂ into the tissues worsening cellular hypoxia. This is the most notable mechanism of toxicity related to CO. The other mechanisms suggested above will compound these effects.

In pregnancy, these mechanisms affect the fetus. It is estimated the fetus hemoglobin has a 10-15% higher affinity to CO than for the mother’s hemoglobin; this means peak concentrations are higher in the fetal circulation. There is also a significant delay in fetal elimination of CO which prolongs exposure and possible complications and neurological development.

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Preexisting conditions and comorbidities also significantly affect an individual's response to CO exposures. Cardiac, cerebral diseases or hematological disorders may increase severity of symptoms. Age plays a role with younger and older patients experiencing greater effects at lower COHb levels. Correlation of COHb levels to severity of symptoms may not be reliable. COHb levels may be a determining factor regarding the extent and possible duration of the exposure but may not be predictive of symptom severity or outcome.

Clinical presentation:

Although carbon monoxide levels can be measured, a level does not necessarily correspond to a sign or a symptom. Generally, as the exposure is longer or the concentration is higher, a patient will have increasing complaints. Symptoms may be as mild as a general malaise/flu-like symptoms.

Clues for the triage nurse that his/her patient may be suffering from carbon monoxide exposure include:

- The history of the environment (enclosed space, alternate heating device, fire setting, recent renovation work in the furnace/basement area of a home)
- An epidemic (many persons all ill at the same time)
- Symptoms that are episodic (for example, are worse when at home but get better during the day when at the workplace)

Carbon monoxide detector "beeps":

- *4 beeps and a pause are an Emergency. If this occurs, turn off any obvious sources, leave the house and call 911.*
- 1 beep every minute is a warning of low battery.
- 5 beeps every minute is a warning of end of life of the unit.

Remember that the mechanism of carbon monoxide toxicity includes the inability to deliver oxygen to vital organs. This may present as abnormal vitals including depressed GCS, tachycardia, tachypnea, and symptoms as below.

- CNS... headache, lightheadedness, confusion, seizures, coma
- GI... nausea, vomiting
- CVS... chest pain, tachycardia, palpitations, dysrhythmias
- Lungs... shortness of breath, tachypnea
- Muscles... weakness, fatigue

CO can cause delayed neuropsychiatric symptoms including parkinsonism, neuropathies, dementia, psychosis, memory and personality changes. These should be managed on an outpatient basis as they can be delayed 2 to 40 days after the exposure.

Normal Physiological CO levels (Wright & Shephard, 1979): (Chart from Toxin2)

Pregnant women	0.4 to 2.6%
Normal infant	0.5 to 4.7%
Average adult	1 to 5%
Hemolytic anemia	Up to 6%
Cigarette smoker (one pack/day)	3 to 7%
Cigarette smoker (two packs/day)	8 to 9%

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Treatments:

The first step is evacuating people and pets from the area. First responders should use caution if there is a risk of significant CO accumulation. The Fire Department should be called to ensure safety entering the area and measure for gasses. The area should be well ventilated and protective apparatus should be worn.

Once a patient has presented with possible CO exposure, they should be placed on 100% O₂ (via a nonrebreather mask if available).

Initial routine labs should be drawn including a VBG, lactate and carboxyhemoglobin level.

- CO ½ life on room air is approximately 4-6 hours.
- CO ½ life on 100% O₂ at 1 atmosphere is approximately 60-75 minutes.
- CO ½ life on 100% O₂ at 3 atmospheres (hyperbaric O₂) is approximately 20 mins.

O₂ treatment should be continued for a minimum of 5 half-lives and resolution of symptoms.

If patient is pregnant, they may require longer treatment with O₂ therapy.

Be cautious if patients were exposed during a fire as other toxic inhalants may have to be considered, including cyanide.

Hyperbaric might be considered with CO exposures involving loss of or alteration in consciousness, seizures or ongoing chest pain and only in consultation with a toxicologist. Hyperbaric Oxygen treatment could potentially prevent the delayed neuropsychiatric affects, but literature is controversial.

Carbon Monoxide Pearls:

1. Removal from the area and prompt use of high flow oxygen is 1st line treatment.
2. Installation and routine checking of CO and smoke alarms significantly reduces the incidence of severe CO exposures.
3. Fires may produce other toxic gases which need to be considered (i.e. Cyanide)
4. All incidents should be reported to your local Poison Centre, however, any reports of loss of consciousness with a potential or confirmed CO exposure requires toxicological consultation.

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