



# Carbon Monoxide

## General Information

Carbon Monoxide (CO) is an odourless and colourless gas produced by incomplete combustion. Since CO is equally as heavy as air it will diffuse through a space and can build up in confined spaces.

### Sources of Carbon Monoxide:

- Generators, motors, space heaters, furnaces, stoves, BBQs, fireplaces, gas ranges, lanterns, cars, i.e. incomplete combustion of any carbon-containing fuel source (gas, oil, coal, or wood).
- Cigarette smoking; other types of smoking such as hookah, shisha, waterpipes can result in relatively high carboxyhemoglobin (COHb) levels (>30%). Vaping/e-cigarette use is reported to have variable CO emissions related to multiple factors including device, temperature, and e-liquid, with COHb levels ranging from normal to >20%.
- Methylene chloride is a hydrocarbon solvent in products like paint strippers, cleaners, degreasers, adhesives and sealants. It is metabolized in the body via cytochrome P450 2E1 to CO. Exposure to methylene chloride can occur through ingestion, inhalation, or prolonged dermal exposure. Since CO from methylene chloride exposure is a product of endogenous metabolism, the peak COHb levels and effects are delayed with a longer duration of action due to ongoing metabolism in the body (See Treatment: [Special Considerations](#)).

### How to Interpret Carbon Monoxide Alarm Sounds

- See [Appendix](#).

### Measuring Carboxyhemoglobin (COHb) levels:

- Standard pulse oximetry cannot differentiate between oxygenated hemoglobin and carboxyhemoglobin; therefore, pulse (finger) oxygen saturation levels (O<sub>2</sub> Sat %) are not a useful marker of CO levels and will typically be normal even with high COHb levels.
- CO-oximetry with a blood gas (venous or arterial) is the preferred method to measure COHb. This is often an add-on test for a blood gas sample (blood gas + CO-oximetry).
  - COHb values may be reported as a percent (i.e. 15%) or as a decimal value that can be converted to a percent (i.e. 0.15 = 15% (multiply decimal by 100))
- Pulse (finger) CO-oximetry may be available at some centres. This can be used to guide therapy, but may be less accurate than laboratory CO-oximetry measurements, especially when oxygen saturations are low and with dark skin etc.

### Carboxyhemoglobin (COHb) levels:

- Normal COHb levels are typically <2.5% (see normal range table in Toxinz).
- Abnormal COHb levels:
  - >5% abnormal in adults (non-smokers) and children/infants
  - >5% vapers/e-cigarette users
  - ≥10% adult smokers

## Clinical Effects

Severity of symptoms may not correlate to specific COHb levels.

COHb levels are not a reliable predictor of symptoms, course, or outcome.

In addition to maternal risk, CO exposure in pregnancy is a risk for toxicity to the fetus at any gestational age. COHb levels can be 10-15% higher than maternal levels and may rise later than maternal COHb levels (See Treatment).

### Symptoms of CO exposure:

Acute:

- “Flu-like” symptoms: headache, nausea, vomiting.
- Neurological effects- confusion, syncope, loss of consciousness, seizures, ataxia (unsteady gait).
- Cardiovascular effects – tachycardia, chest pain, palpitations, dysrhythmias myocardial ischemia (based on symptoms, ECG, or troponins).
- Respiratory effects – tachypnea, shortness of breath, non-cardiogenic pulmonary edema.

Persistent and Delayed Neurological Sequelae:

- These are secondary complications of CO toxicity and include variable neurological, cognitive, and psychiatric signs and symptoms.
- These may be a continuation of acute toxicity symptoms (Persistent Neurological Sequelae) or develop after a period of improvement (days to weeks later) from acute symptoms (Delayed Neurological Sequelae) and may persist for weeks or months after exposure.
- Neurological sequelae require follow-up with primary care physician and potentially neurology consultation.

## Triage

Medical assessment is required (ED assessment and COHb level measurement by CO-oximetry):

- All potentially significant exposures to CO (symptomatic or asymptomatic):
  - Significant exposures examples include more than a few minutes of potential exposure based on carbon monoxide alarm alert, fire department detector, exposure to a potential source of carbon monoxide i.e. generator in an enclosed space. Clinical judgement will be required.
  - Currently asymptomatic, but decreased level of consciousness at any point.
- All intentional exposures (symptomatic or asymptomatic).

Medical assessment is NOT required:

- *Asymptomatic* patients (including pregnant people) exposed to an environment where a carbon monoxide detector has alarmed do not require medical assessment *if* the exposure time was minimal (less than a few minutes).

## Consult Toxicologist On-call

- Any potential indications for hyperbaric oxygen treatment (see Treatment: [Special Considerations](#)).
- Patients are not improving or worsening with treatment.

## Investigations

- All patients in ED should receive:
  - Cardiovascular, respiratory, and neurological assessment
  - ECG and continuous cardiac monitoring (for duration of treatment for CO)
  - Labs: blood gas with CO-oximetry, lactate, electrolytes, glucose, creatinine, urea, cardiac enzymes (CK, Troponin), BhCG (urine or serum pregnancy test)
  - Toxicology labs if indicated for possible self-harm (ASA, APAP, EtOH, anion gap, osmolar gap, etc.)
  - CXR
  - COHb levels by finger CO-oximetry (if available and no blood CO-oximetry)
  - In patients with neurologic symptoms, a standard, measurable cognitive test is helpful as a benchmark. For example, the [Mini Mental State Exam](#).
  - Pregnant patients should have fetal monitoring arranged (see Treatment: [Special Considerations](#))

## Treatment

**Note:** all patients should receive 100% oxygen therapy while awaiting COHb level results regardless of oxygen saturation levels. **Oxygen supplied by nasal prongs is not sufficient since this cannot deliver 100% oxygen.**

**Oxygen Therapy:** Reduces the half-life of COHb from approximately 4.5 hours to 90 min.

100% oxygen may be administered via:

- Non-rebreather facemask (NRB)
- High flow nasal cannula (i.e. Optiflow™, Airvo™) (at least as (or more) effective than NRB mask to reduce COHb levels)
- Non-invasive ventilation (CPAP or bi-level positive airway pressure)
- 1.0 FiO<sub>2</sub> in an intubated and ventilated patient

All patients should receive 100% oxygen therapy for 6 hours

- IF *asymptomatic* at end of 6 hours treatment, COHb level does not need to be repeated, and patient can be cleared from a CO toxicity perspective.
- IF still *symptomatic* after 6 hours of treatment, repeat the COHb Level. If COHb <5% (<10% in smoker), STOP oxygen therapy and treat symptomatically. Hyperbaric oxygen treatment may be considered in selected scenarios. Consult Toxicologist on-call.
- If COHb levels are not available (and there is a clinical suspicion of CO exposure) treat with 100% oxygen for minimum of 6 hours AND until resolution of symptoms.
- Considerations for requirement to transfer to a larger centre from a remote nursing station are to be made on a case-by-case scenario.

**Hyperbaric Oxygen (HBO):** Although HBO reduces the half-life of COHb to approximately 23 min, the theoretical benefit of HBO is not to clear COHb more quickly, but to reduce neurological sequelae through a reduction in free radical damage and other mechanisms.

- The role of hyperbaric oxygen treatment remains controversial. Consult Toxicologist on-call if there are possible indications for HBO (see below).
- Ultimate decisions about HBO treatment for a specific patient will require the bedside team to pursue further consultation with a Hyperbaric Medicine Physician (See [Appendix](#)).

Indications for possible hyperbaric oxygen treatment:

- Neurological signs or symptoms: altered level of consciousness, coma, ataxia/cerebellar dysfunction, seizures
- Loss of consciousness at any time since exposure
- Persistent neurological signs/symptoms after 6 hours of 100% oxygen therapy
- Cardiac signs or symptoms: chest pain, ECG changes, troponin elevation, dysrhythmias
- Metabolic acidosis
- COHb >25%
- Pregnancy and COHb >15%

## Special Considerations

Pregnant patients

- Should be continued on 100% oxygen for 16 hours (if COHb levels not available) OR 5 x longer than time required to reduce maternal COHb < 5% due to delayed and prolonged binding of CO to fetal hemoglobin.
- When available, COHb levels should be measured q 4 h in pregnant women to help guide duration of oxygen therapy.
- Fetal monitoring should be arranged in all pregnant women.

Methylene Chloride Exposures (all routes of exposure):

- Since CO from methylene chloride is a product of endogenous metabolism, the peak CO levels and effects are delayed with a longer duration of action due to ongoing metabolism in the body, and therefore require longer monitoring time (minimum 12 hours, with serial COHb level measurements q 4 h until there is a peak and decline to normal range).
- Indications for possible hyperbaric oxygen therapy are the same as for other CO exposures.
- NOTE: Methylene chloride has toxicity beyond CO toxicity. See TOXINZ or MICROMEDEX.

### **References:**

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## Appendix

### How to Interpret Carbon Monoxide Alarm Sounds:

#### Carbon Monoxide Detectors:

- CO detectors should be in every household at bedroom level (if there is only one in the house).
- They will sound an alarm if the concentration exceeds 100 ppm for 90 minutes, 200 ppm for 35 minutes and 400 ppm for 15 minutes.
  - 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.

### Contact Hyperbaric Physician on-call:

Emergency referrals via CRITICALL Ontario 1-800-668-4357, ask for closest facility with capabilities for hyperbarics.

<b>Toronto University Health Network</b> <i>(multi-place chamber, mono-place chambers)</i>	<b>Hamilton General Hospital</b> <i>(2 mono-place chambers)</i>	<b>Ottawa General Hospital</b> <i>(dual-place chamber)</i>	<b>Tobermory Hyperbaric Facility</b>
To speak with an on-call hyperbaric physician call locating service: 416-340-3155		Direct Line: 613-737-8966 (M-F:7-3)  Fax: 613-737-8965	Direct Line: 519-596-2306  Back Line (after hours): 519-596-2367
Emergency referrals via CRITICALL Ontario: 1-800-668-4357	Emergency referrals via CRITICALL Ontario: 1-800-668-4357	Emergency referrals via CRITICALL Ontario: 1-800-668-4357	Lion's Head Hospital (for after hours on-call coverage information): 519-793-3424