DIAGNOSIS AND TREATMENT OF

Carbon Monoxide Poisoning

This care process model (CPM) was developed by the Intermountain Healthcare Hyperbaric Development Team to guide emergency department (ED), InstaCare, and primary care staff in assessment, diagnosis, and treatment of carbon monoxide (CO) poisoning, including the use of hyperbaric oxygen (HBO_2) treatment. This CPM is not focused on prevention.

Why Focus ON CARBON MONOXIDE POISONING?

- **CO poisoning is common.** The Centers for Disease Control and Prevention (CDC) estimate that in the U.S. more than 400 people die every year from CO poisoning [CDC] and more than 50,000 people are seen in hospital emergency departments with the condition. [HAM1]
- **CO poisoning is often unrecognized or underdiagnosed in the ED**, and even when correctly diagnosed, the severity of poisoning and potential for complications or long-term neurological sequelae are often underappreciated.
- **Hyperbaric oxygen therapy can reduce cognitive sequelae after CO poisoning** by 46% at six weeks and by 33% at 12 months when compared to normobaric high-flow oxygen treatment. The number needed to treat (NNT) to prevent one case of long-term neurologic sequelae is 5 (NNT=5). [WEA1]
- **Hyperbaric consultation services and facilities are available 24/7 in all Intermountain coverage regions** to address CO poisoning and the possible need for HBO_2 therapy. This service is immediately available and easy to access; see note (g) on page 3. Despite this, a two-year retrospective study indicated that 52% of patients presenting with CO poisoning at Intermountain EDs did not recieve a hyperbaric consultation. [CAB]

Key Points

- **Signs and symptoms of CO poisoning may be nonspecific and in lower doses can be similar to viral gastroenteritis; see note (a) on page 3.**
- **CO poisoning can result in impaired cognitive function, loss of consciousness, seizures, and coma, regardless of severity.**
- **Carboxyhemoglobin (COHb) measurements confirm exposure but do not correlate with severity or outcome. COHb levels can be low or normal in patients with CO poisoning.**
- **Patients who show cerebellar dysfunction need hyperbaric oxygen consultation immediately.**
- **Hyperbaric oxygen therapy reduces cognitive sequelae and is widely available in the Intermountain service area.**

WHAT'S INSIDE?

MEASUREMENT & GOALS

The goal of this CPM is to promote appropriate diagnosis and treatment of CO poisoning in adults, adolescents, and children. To measure outcomes, Intermountain will track the number of:

- Confirmed or suspected cases of CO poisoning referred to HBO_2 specialists for consultation.
- Confirmed CO cases transferred to Intermountain HBO_2 facilities.
- Confirmed CO poisonings due to suicide attempts that are referred to psychiatric care.

Indicates an Intermountain measure

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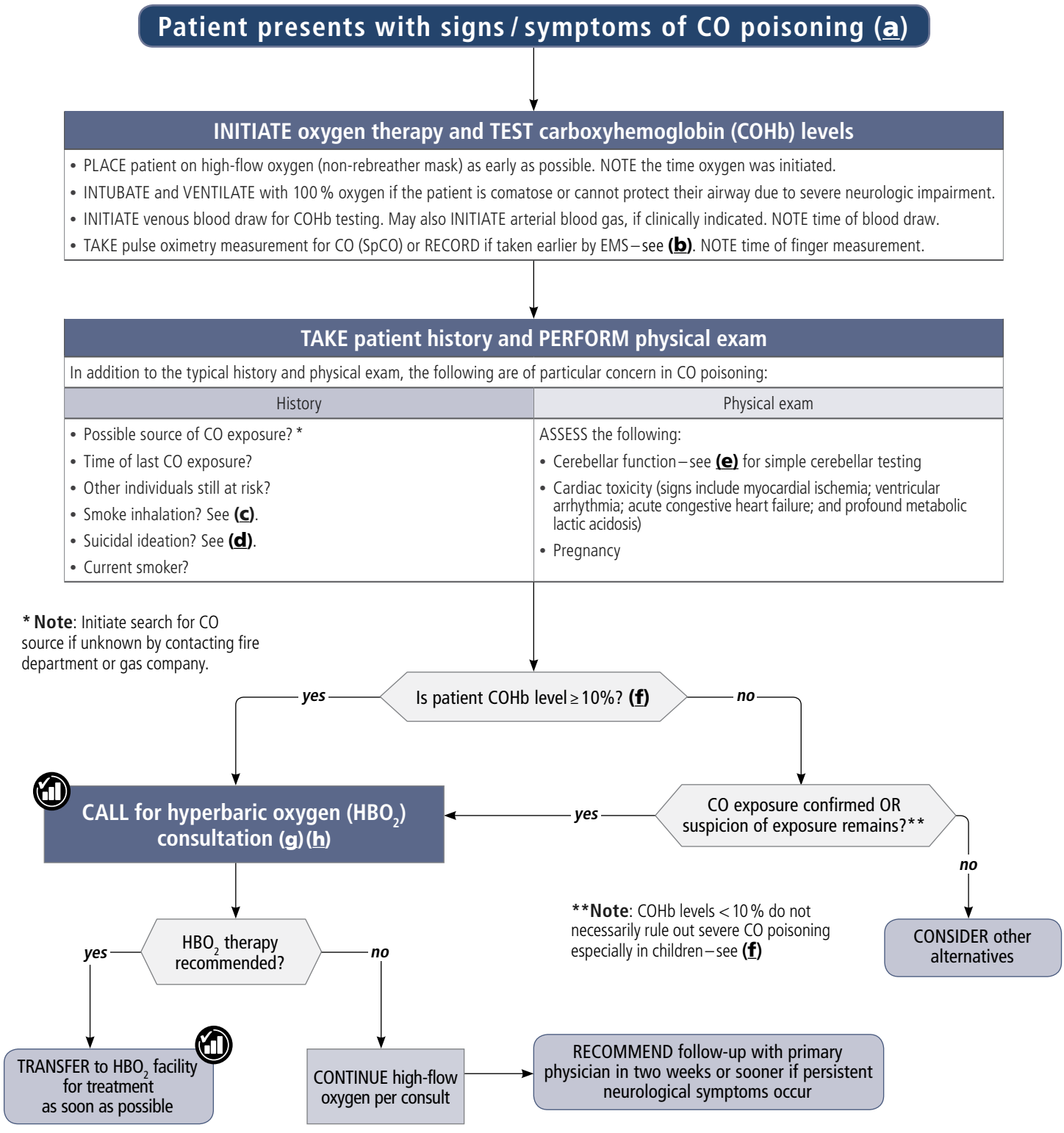
ALGORITHM: DIAGNOSIS AND TREATMENT OF CO POISONING



Note: Patients with confirmed CO exposure should not be allowed to return to environment until CO source has been eliminated.

ALGORITHM NOTES

(a) Signs and symptoms of CO poisoning

Patients with CO poisoning present signs/symptoms which can be nonspecific and can be easily mistaken for viral gastroenteritis. They include:

- Headache
- Nausea/vomiting
- Decreased clarity of thinking
- Difficulties with balance or coordination
- Shortness of breath
- Syncope
- Confusion
- Dizziness
- Weakness/malaise
- Chest pain

Also consider CO poisoning in patients with any of the following conditions:

- Unexplained loss of consciousness
- Inability to give a history of recent events
- Smoke inhalation
- Coma

Symptoms may be present > 24 hours after exposure to CO. The "Classic" symptom, cherry red lips, is not often present.

(b) Pulse Oximetry (SpCO)

When measuring the SpCO using pulse oximetry consider the following:

- A finger SpCO measurement can **rule in** CO poisoning but does not have the sensitivity to **rule it out** on its own**.**
- Many SpCO oximeters have NOT been approved for use in children. Check manufacturer's instructions.
- Generally, a blood draw measurement of COHb is more accurate; however, if there is a long delay, then SpCO measurements near the time of poisoning may present a better reflection of exposure to CO.
- Specific information on SpCO oximeters use at Intermountain on page 4.

(c) Smoke inhalation

If the patient has known smoke inhalation, CONSIDER the following:

- If the patient was exposed to smoke from the burning of plastic materials, CONSIDER concomitant **cyanide** poisoning**.** The emergent treatment of cyanide toxicity is high-dose hydroxycobalamin. HAM2, ROS
- A chest radiograph is helpful if looking for pulmonary edema or aspiration.
- If upper airway thermal injury is present, CONSIDER early intubation.

(d) Suicide assessment

Suicide assessment will help with patient management once the acute medical needs have been met.

- If suicide is suspected, PERFORM urine toxicology. Include salicylate and acetaminophen levels.
- CONSIDER the possibility of a suicide attempt if the reason for poisoning is unknown.
- REFER to Intermountain's ***Suicide Prevention CPM*** for guidance on assessment and referrals. These can be performed on-site or with telecrisis.

(e) Assessing Cerebellar Function

CONSIDER the following assessments for cerebellar function in patients with CO poisoning:

- Difficulty with rapid alternating movements, finger-to-nose movements, or heel-shin movements occur with CO poisoning and are a quick means of assessing cerebellar function.
- The Sharpened Romberg test is a very sensitive cerebellar test. To perform this test, ASK the patient to:
  - Remove their shoes and stand with one foot directly in front of the other (i.e., heel to toe).
  - First stand quietly with eyes open, and then with eyes closed.

Patients with cerebellar ataxia generally cannot maintain balance while doing a Sharpened Romberg test, even with their eyes open.

(f) Carbon monoxide levels (COHb) HAM2, ROS

To help determine the prognostic value of COHb levels, consider:

- COHb measurement is generally more accurate than using SpCO.
- COHb measurement can **rule in** CO poisoning but does not have the sensitivity to **rule it out** on its own**.**
- COHb levels do not correlate well with severity of poisoning or outcomes. People exhibiting normal or near-normal COHb levels in the ED can still have CO poisoning and poor neurological outcomes.
- Using normal COHb levels as an end goal of treatment is not advised, rather, use cognitive improvement and resolution of neurological symptoms. Hyperbaric consultation is recommended for guidance.
- Repeated measurement of COHb is unnecessary.
- COHb levels can be influenced by:
  - Length of time between exposure and measurement (↑ time = ↓ COHb)
  - Length of time high-flow oxygen has been in place (↑ O_2 time = ↓ COHb)
  - Age of the patient (children's COHb levels decrease faster than adults)
  - Smoking status of patient (smoking one pack per day can increase baseline levels by approximately 2.5–3%)
- General guidelines for COHb levels:
  - Normal: 0–5 % in non-smokers, 5–10 % in smokers
  - Abnormal: > 10 % in any person
  - Significantly abnormal: > 15 % in any person

(g) On-call HBO_2 physician consultation

Decisions regarding treatment for CO poisoning should be in consultation with the on-call hyperbaric physician. Intermountain has 24/7 HBO_2 chamber availability across all coverage regions. CONSIDER transport issues and cost when recommending HBO_2.

HBO_2 treatment centers and physicians are located at the following facilities:

- LDS: 801-408-3623
- IMC: 801-507-5370
- UVH: 801-357-8156
- DRMC: 435-688-4293
- After-hours answering service for LDS/IMC: 385-297-5060
- After-hours Intermountain Transfer Center: 855-932-3648

(h) Hyperbaric oxygen (HBO_2) therapy

The advantages of HBO_2 therapy for CO poisoning include increased elimination of COHb, restoration of oxidative phosphorylation, and reduced inflammation, brain-cell apoptosis, and lipid peroxidation.

- Avoid delays in HBO_2 treatment. Patient outcomes improve if the time between exposure and treatment is shortened.
- Delayed neuropsychiatric syndrome (DNS) is common after CO poisoning and can be minimized with HBO_2 treatment.
  - Sequelae can appear immediately or be delayed for weeks to months.
  - Sequelae manifest as cognitive deficits, personality changes (including new-onset depression), movement disorders, and focal neurologic deficits. CHA
  - Without hyperbaric oxygen, approximately 50 % of poisoned patients will have cognitive sequelae within 6 weeks after poisoning, and 30 % will have permanent brain injury at 1 year. CHA, HAM2
- Safety concerns and contraindications:
  - The decision to treat should not be solely based on COHb levels, as they rarely correlate with clinical symptoms or outcome. CHAS, HAM2, ROS **In addition, symptoms do not correlate well with poisoning severity.**
  - The risk for side effects related to HBO_2 treatment at experienced centers is extremely low.

HOUSEHOLD PETS

Pets are often involved in household exposures as well, sometimes with devastating consequences. While we cannot treat or make recommendations for treatment, one facility in the Salt Lake region does accept consultation for hyperbaric treatment in animal-specific HBO_2 treatment chambers with 24/7 coverage.

Advanced Veterinary Care
1021 E. 3300 S.
Salt Lake City, UT
801-942-3951

SPECIAL POPULATIONS

Special consideration must be made for treating pregnant patients. Fetal hemoglobin has a greater affinity for CO than hemoglobin in the mother's red blood cells; therefore, the fetus may be at a much higher risk than the mother. It is recommended to treat all pregnant patients with confirmed or suspected CO exposure, regardless of gestation time or presence of symptoms. HBO_2 treatment itself does not present an increased risk to either the mother or fetus.

Pediatric patients can be safely treated with HBO_2. Children with CO poisoning are at risk for brain injury, which sometimes is not fully recognized until many years later. There are no randomized trials of HBO_2 in CO-poisoned children, but based on the pathophysiology of CO poisoning and the trial results from adults, treating CO-poisoned children with HBO_2 is reasonable.

MEASURING CO WITH PULSE OXIMETRY

The pulse oximetry measurement of carbon monoxide (SpCO) uses multiple wavelengths of near-infrared light to measure carboxyhemoglobin and oxyhemoglobin. The currently available product is the Masimo Rad 57 CO oximeter. Some monitors measure methemoglobin and even hemoglobin. An SpCO measurement (finger) can rule in CO poisoning but does not have the sensitivity to rule it out.

- The Rad 57 95% confidence intervals are +/-6 points, with a 2-point bias underestimating the SpCO.[WEA4] For example, if the COHb = 10 %, 95 % of the time SpCO variability will be 2 – 12 %.
- This device has not been approved for use in children.

If clinical suspicion is high and/or the reading is high, then carboxyhemoglobin measurement should be done on a blood sample as soon as possible after the suspected CO exposure, either by venous or arterial venipuncture. There is no reason to do an arterial measurement of COHb unless an arterial blood gas is otherwise indicated. Venous CO-oximetry measurements correlate to arterial measurements.

If the blood draw is delayed significantly following removal from exposure, then SpCO measurements near the time of poisoning may present a more accurate reflection of exposure to CO. Other lab evaluations may include complete blood count (CBC), comprehensive metabolic panel, lactic acid, troponin 1, and blood gas.

Masimo Rad 57 CO oximeter

RESEARCH FINDINGS

Two randomized control trials showed that HBO_2 therapy, when administered within the first 24 hours of CO exposure, reduced the risk of neurologic sequelae by about 40 %. One of these trials met the CONSORT criteria for study quality, and had two-thirds of participants recieve HBO_2 therapy within six hours and a one-year follow-up period.[WEA1,WEA5]

Two other trials showed no benefit of HBO_2 treatment, but did not account for timing between exposure and therapy and had limited follow-up. These methodological flaws limit inferences about the efficacy of HBO_2 therapy for acute CO poisoning.[SCH, RAP]

Cerebellar dysfunction seems to be of particular concern in CO poisoning as a prospective clinical trial showed a substantial risk for six-week cognitive sequelae in patients with cerebellar dysfunction at the time of presentation.[WEA2]

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This CPM presents a model of best care based on the best available scientific evidence at the time of publication. It is not a prescription for every physician or every patient, nor does it replace clinical judgment. All statements, protocols, and recommendations herein are viewed as transitory and iterative. Although physicians are encouraged to follow the CPM to help focus on and measure quality, deviations are a means for discovering improvements in patient care and expanding the knowledge base. Send feedback to Marc Robins, DO, MPH, Senior Medical Director, Intermountain Healthcare marc.robins@imail.org.

RESOURCES

Intermountain patient resources

Access patient education handouts at Intermountainhealthcare.org. You can order patient education handouts using Print It! at Intermountain's Design and Print Center for one-stop access and ordering for Intermountain-approved education, such as fact sheets, booklets, and trackers.


FACT SHEET FOR PATIENTS AND FAMILIES

Hyperbaric Oxygen Therapy:
Carbon monoxide poisoning

What is carbon monoxide poisoning?

What are the signs and symptoms?

How is it treated?

Hyperbaric Oxygen Therapy: Carbon monoxide poisoning

Available in English and Spanish

Provider resources

To find this and other CPMs as well as Best Practices Flash Cards, access: Intermountain Physician/tools and resources/Care Process Models (CPM).

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