Carbon Monoxide Poisoning and Hypothermia: Diagnosis and Management

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Carbon Monoxide Poisoning

Carbon monoxide (CO), an odorless, colorless gas, which can cause sudden illness and death. It can be produced by gas or oil burning furnaces, portable generators, charcoal grills and any time a fossil fuel is burned.

The below information was obtained from references[1-4] and some information is copied directly from the CDC website.

For Patients

- **Do** have your heating system, water heater and any other gas, oil, or coal burning appliances serviced by a qualified technician every year.
- **Do** install a battery-operated or battery back-up CO detector in your home. Check or replace the battery when you change the time on your clocks each spring and fall. If the detector sounds leave your home immediately and call 911.
- **Do** seek prompt medical help if you suspect CO poisoning and are feeling dizzy, light-headed, or nauseated.
- **Don't** use a generator, charcoal grill, camp stove, or other gasoline or charcoal-burning device inside your home, basement, garage, or outside near a window.
- **Don't** run a car or truck inside a garage attached to your house, even if you leave the door open.
- **Don't** burn anything in a stove or fireplace that isn't vented.
- **Don't** heat your house with a gas oven.

- **Don't** use a generator, pressure washer, or any gasoline-powered engine less than 20 feet from any window, door, or vent. Use an extension cord that is **more than 20 feet long** to keep the generator at a safe distance.

For Providers

The signs and symptoms of CO exposure are variable and nonspecific. A tension-type headache is the most common symptom of mild CO poisoning. Other common symptoms of CO poisoning are dizziness, weakness, drowsiness, upset stomach, vomiting, chest pain, and confusion.[3]

Clinical manifestations of severe CO poisoning are a result of impaired oxygen delivery and utilization at a cellular level, especially in the cardiologic and neurologic systems. Common signs include: tachycardia, tachypnea, hypotension, metabolic acidosis, dysrhythmias, myocardial ischemia or infarction, noncardiogenic pulmonary edema, irritability, impaired memory, cognitive and sensory disturbances, ataxia, altered or loss of consciousness, seizures, coma, and death, although any organ system might be involved.

CO poisoning can be fatal to anyone, but particularly high-risk populations include children, pregnant people and the fetus, persons with sickle cell disease, older adults, and persons with chronic illness (e.g., heart or lung disease).

The effects of CO poisoning on the developing fetus depend greatly on the gestational age of exposure and the dose. As a general rule, fetal injury is more likely when acute maternal CO poisoning is associated with more severe symptoms such as loss of consciousness. An anoxic event during the early gestational ages of embryogenesis or shortly after may be associated with anatomical malformations such as limb abnormalities or microcephaly, specifically in fetuses that survive to viability. At later gestational ages, severe exposures can be associated with the fetal neurological sequelae of anoxia, including but not limited to hypoxic ischemic encephalopathy, hypotonia, and cerebral palsy. Mortality rates for fetuses may be as high as 67% in severe intoxications. Generally, mild maternal exposures presenting with only headaches and nausea are more likely to result in favorable fetal outcomes.

Pregnant people poisoned with CO should be hospitalized and fetal monitoring should be provided. Affinity of CO to hemoglobin is stronger in the fetus compared with other age groups. In the event of CO poisoning, fetal COHb level will be higher than that of mother, and clearance is 5 times slower. The Fetal COHb value returns to a normal level 40 hours after the COHb level normalizes in the mother. Fetal involvement may occur even if maternal CO level is non-toxic. Therefore, when compared with other cases of CO poisoning, HBO treatment is initiated at lower maternal CO level in pregnant people, and should be more aggressive and longer lasting in order to protect the fetus. No correlation has been determined between fetal death and maternal COHb level. Despite administration of HBO, in cases of CO poisoning during third trimester, adverse effects on fetal brain have been reported.

Management of Suspected CO Poisoning

1. Assess symptoms and recent patient activities that point to likely CO exposure. Evaluation should also include examination for other conditions, including smoke inhalation, trauma, medical illness, or intoxication. Remove the patient from the source of CO.
2. Administer 100% oxygen until the patient is symptom-free or until a diagnosis of CO poisoning has been ruled out.
3. Perform carboxyhemoglobin (COHgb) testing when CO poisoning is suspected.
    - Venous or arterial blood may be used for testing.
    - A fingertip pulse multiple wavelength spectrophotometer, or pulse CO-oximeter, can be used to measure heart rate, oxygen saturation, and COHgb levels in the field, but any suspicion of CO poisoning should be confirmed with a COHgb level by multiple wavelength spectrophotometer (CO-oximeter).
    - A conventional two-wavelength pulse oximeter is not accurate when COHgb is present.
4. **An elevated COHgb level of 2% or higher for non-smokers and 9% or higher COHgb level for smokers strongly supports a diagnosis of CO poisoning**.

- The COHgb level must be interpreted in light of the patient's exposure history and length of time away from CO exposure, as levels gradually fall once the patient is removed from the exposure.
- Notably, CO can be produced endogenously as a by-product of heme metabolism. Patients with sickle cell disease can have an elevated COHgb level as a result of hemolytic anemia or hemolysis. Additional information about interpretation of COHgb levels can be found within the Clinical Guidance, or call your local Poison Control at (800) 222-1222.

5. Hyperbaric oxygen (HBO) therapy should be considered in consultation with a toxicologist, hyperbaric oxygen facility, or Poison Control Center (800) 222-1222. For additional management considerations, consult a medical toxicologist, Poison Control at (800) 222-1222, or a hyperbaric oxygen facility**. HBO should be considered if there is loss of consciousness, visual impairment, and any clinical findings persisting for more than 3 weeks.**
    - HBO is not advisable for pregnant patients except for CO poisoning. In a case series of 32 pregnant patients, it was observed that HBO treatment under 2.4 ATA pressure for 120 min had no harmful effects on the mother and the fetus. Note that HBO is contraindicated if acute pneumothorax.
6. Be aware that CO exposure may be ongoing for others spending time in or near the same environment as the patient. These individuals should be evaluated and tested as described in this advisory.
7. Healthcare professionals treating people for CO poisoning should notify emergency medical services (EMS), the fire department, or law enforcement to investigate and mitigate the source and advise people when it is safe to return.
8. Advise patients about the CDC's Generator Safety Fact Sheet. There is also risk for CO poisoning with grills, camp stoves, or other gasoline, propane, natural gas, or charcoal-burning devices. Stress that that these devices should never be used inside an enclosed space, home, basement, garage, or camper — or even outside near an open window or window air conditioner.

Hypothermia in Pregnancy[5-8]

What is hypothermia?

- Hypothermia is caused by prolonged exposure to very cold temperatures. When exposed to cold temperatures, your body begins to lose heat faster than it's produced. Lengthy exposures will eventually use up your body's stored energy, which leads to lower body temperature.
- Hypothermia occurs when the core body temperature drops below 95°F (35°C).
- Body temperature that is too low affects the brain, making the victim unable to think clearly or move well. This makes hypothermia especially dangerous, because a person may not know that it's happening and won't be able to do anything about it.
  - While hypothermia is most likely at very cold temperatures, it can occur even at cool temperatures (above 40°F) if a person becomes chilled from rain, sweat, or submersion in cold water.

Swiss Staging System for Hypothermia

Stage	Symptoms	Suspected core temperature
I	Conscious and shivering	89.6 to 95°F (32 to 35°C)
II	Altered mental status, not shivering	82.4 to 89.6°F (28 to 32°C)
III	Unconscious, not shivering, vital signs present	75.2 to 82.4°F (24 to 28°C)
IV	No vital signs	< 75.2°F (< 24°C)

Information from references 13 and 14.

Signs and symptoms of hypothermia

Adults

- Shivering
- Exhaustion or feeling very tired
- Confusion
- Fumbling hands
- Memory loss
- Slurred speech
- Drowsiness
- Very low energy

Babies

- bright red, cold skin
- very low energy

Risks of Hypothermia

Life threatening cardiac arrhythmias or hypotension may result from hypothermia. Patients with cardiac disease, medical complications of pregnancy, or excessive blood loss are at increased risk for complications. Based on post-anesthesia literature in pregnancy, an increase in myocardial work occurs during rewarming.

Blood volume is decreased in hypothermic patients because of intense peripheral vasoconstriction and fluid shifts from intravascular to extravascular spaces. Heart rate and cardiac output subsequently fall. Initial hypertension is followed by hypotension with rewarming, and a greater intravascular volume is demanded.

Cardiac arrest is more likely below 20°C [9]. Enzymatic activity is also severely affected at low temperatures, which is especially relevant for appropriate coagulation in the obstetric patient, placing them at increased risk of platelet dysfunction and disseminated intravascular coagulation.

The association between maternal temperature and fetal heart rate is not completely understood; however, it is known that hyperthermia is associated with fetal tachycardia, and hypothermia correspondingly with fetal bradycardia. A case report of accidental maternal hypothermia demonstrated fetal bradycardia that resolved with maternal re-warming.

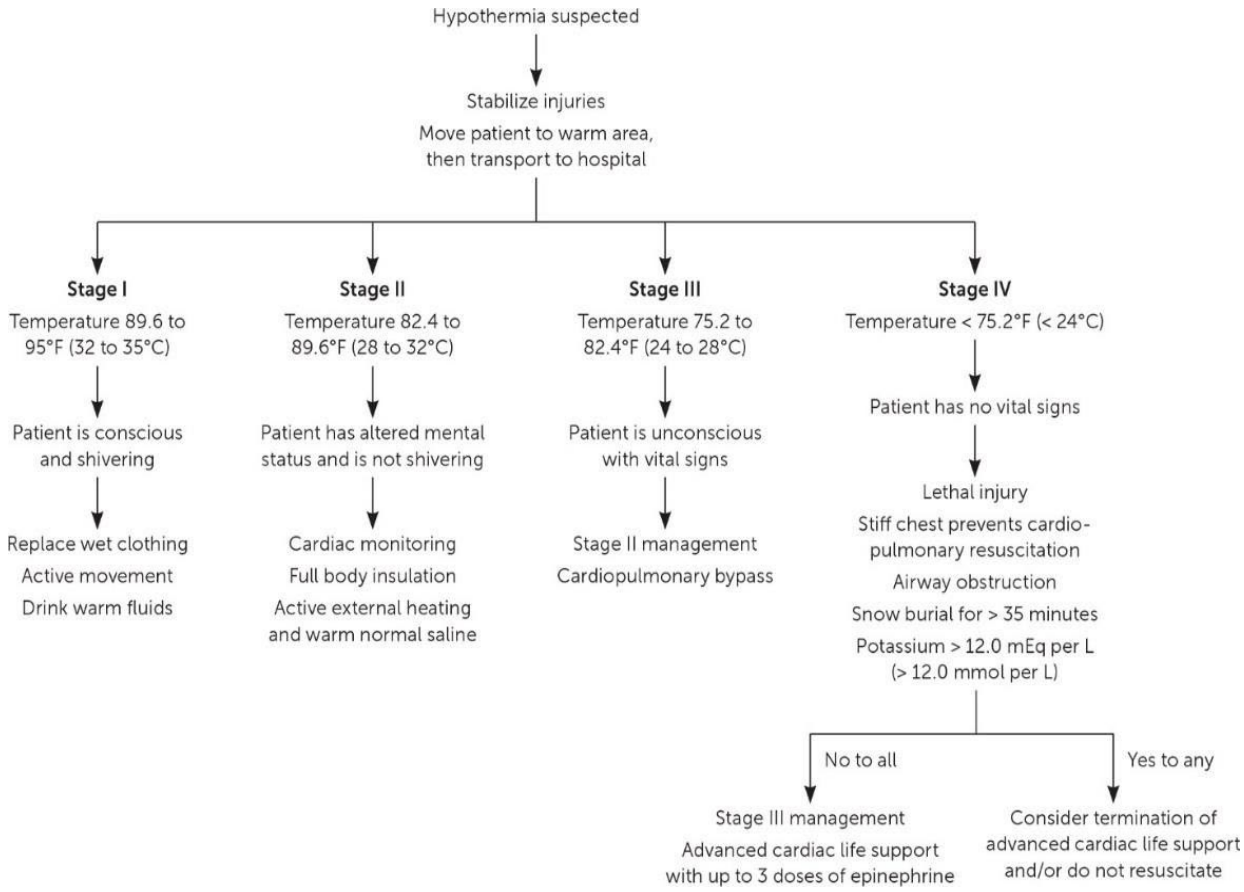
Management of Hypothermia

Initial treatment of hypothermia should be based on symptoms alone, with core temperature used to confirm staging and to aid management decisions. Thermometers capable of reading low temperatures are essential because many standard thermometers do not read below 94°F (34.4°C). The use of rectal thermometers may be inadvisable in the field because exposure can increase heat loss. When accurate measurement of core temperature is not practical, management decisions should be based on the Swiss Staging System.

In anticipation of possible cardiac dysrhythmia, cardiac monitoring should be used for high-risk patients and anti-dysrhythmic agents should be available. In addition, continuous administration of warmed oxygen may be indicated. **Because vasoconstriction also may be associated with hemodynamic instability, blood pressure and heart rate should be monitored every 5-15 minutes until the patient's temperature reaches ~95 degrees F**. **To avoid profound hypotension in patients who are volume depleted, adequate volume replacement is essential in conjunction with rewarming.**

When fluid resuscitation is warranted, normal saline is preferred over lactated Ringer solution because hypothermic patients cannot effectively metabolize lactate. Fluids should be warmed to 100.4 to 107.6°F (38 to 42°C). Passive heat transfer from warmed crystalloids allows for symmetric internal rewarming. Patients who have cardiac instability (e.g., systolic blood pressure less than 90 mm Hg, ventricular arrhythmias, core temperature less than 82.4°F) or who are in cardiac arrest should be transported to a center capable of providing cardiopulmonary bypass services. Survival without significant neurologic impairment may be possible for extended periods of time because of the decrease in total body metabolic demand and a concomitant decrease in cerebral oxygen requirements. In most circumstances, hypothermic patients should be rewarmed—ideally to a core temperature of 98.6°F— before pronouncing death. However, terminating or avoiding advanced cardiac life support without rewarming is advisable for hypothermic patients with lethal injury, a stiff chest, airway obstruction, snow burial for more than 35 minutes, or serum potassium level greater than 12.0 mEq per L (12.0 mmol per L).

Figure 1. *Management of Hypothermia*



Frostnip and Frostbite

Frostnip is a self-limiting process that presents similarly to frostbite, with hyperesthesia, paresthesia, and pallor. However, there is no tissue loss when the area is warmed, and symptoms resolve within 10 minutes. The extremities and face are most commonly affected. The time between frostnip and frostbite varies depending on the severity of environmental exposure, presence or lack of insulating clothing, and use of medications or recreational drugs. Frostnip should be addressed at the onset of symptoms.

Frostbite is a freezing injury in which initial cooling causes vasoconstriction and localized ischemia. Continued exposure leads to ice crystal formation that causes cellular lysis, electrolyte abnormalities, and microvascular occlusion. Rewarming causes an inflammatory response, which increases the risk of thrombosis and reperfusion injuries. This process is worsened if tissue is allowed to refreeze.

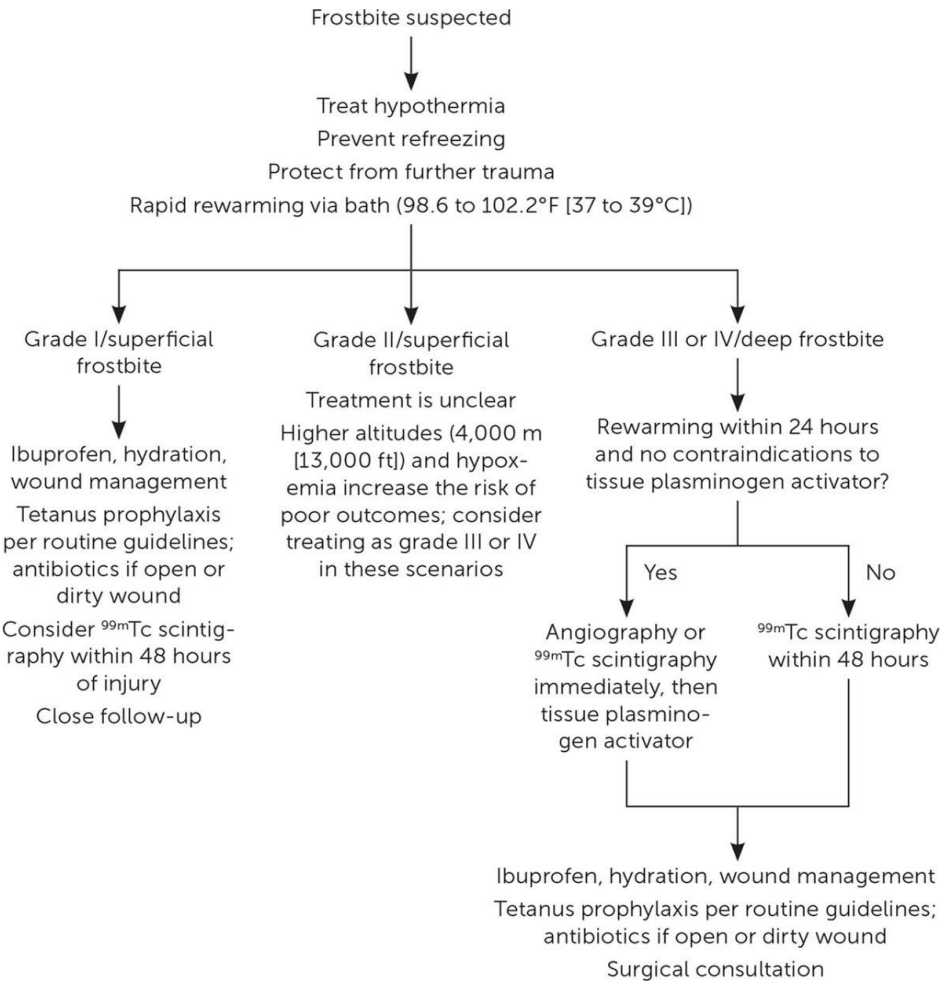
Traditional Frostbite Grading System

Grade	Presentation
First degree (superficial)	Edema, pallor, and erythema; slightly raised plaque; no blisters; absent to minimal tissue loss
Second degree (superficial)	Clear blisters with edema and erythema; absent to minimal tissue loss; blisters develop 6 to 24 hours after rewarming[1]
Third degree (deep)	Hemorrhagic blisters suggest subcutaneous or dermal involvement; black eschar develops over weeks; tissue loss
Fourth degree (deep)	Muscle and/or bone involvement; mummification and gangrene; full-thickness tissue loss; absence of blisters in deep frostbite is a poor prognostic factor[1]

Note: Frostbite severity may take several weeks to completely assess and is difficult to assess before rewarming.

Information from references 1, 16, and 18-20.

Figure 2. Diagnosis and Management of Frostbite



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