ROPER HYPERBARIC MEDICINE
TREATMENT PROTOCOL

INDICATION: ACUTE CARBON MONOXIDE POISONING

ICD-9 CODE: 986

DESCRIPTION: Symptomatic or laboratory-evident exposure to exogenous or endogenous carbon monoxide.


DIAGNOSTIC CONSIDERATIONS: Elevated carboxyhemoglobin levels. History of smoke inhalation, exposure to elevated carbon monoxide, or exposure to methylene chloride. See flowchart below.

MINIMUM CRITERIA: Elevated COHb level, associated with related history of either LOC; pregnancy; neurological or ischemic presentations. Failure to respond to normobaric 100% oxygen within 3-4 hours. Abnormal mental status evaluation.

SUGGESTED WORK-UP (per discretion of the attending hyperbaric physician):

Patient breathing 100% oxygen via non-rebreathing reservoir mask during work up.

A. Comprehensive history, where obtainable, and time/patient's condition allows.
B. Physical examination.
C. Labs: order or review:
   i. ABG's; HbCO
   ii. CBC
   iii. BUN
   iv. Glucose
   v. Cardiac enzymes
   vi. Electrolytes - Lactate
   vii. Drug/alcohol screen
   viii. Pregnancy test on all women of childbearing age
D. Chest x-ray: order or review.
E. ECG: order or review.
F. Baseline psychometric test, if possible/indicated. Detailed mental status exam may be substituted/documentated per MD.
G. Psychiatric evaluation for potential attempt for further self harm in chamber, when suicidality is suspected.
H. Screening for history of seizure disorder or pneumothorax.

*Consider CN levels in smoke inhalation associated with closed space fires involving synthetic materials.
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TREATMENT: After signed informed consent:
* See discussion at end of this document for discussion of “Enhanced Weaver/Nebraska” protocol. Adopted 6/16/10.

A. i. Adult, non-pregnant, patients. No seizure risk.
   Preferred: “Enhanced Weaver Protocol” or “Weaver/Nebraska” protocol.
   For patients with no seizure history/risk. First dive (ASAP after CO exposure):
   HBO for 120 minutes at treatment pressure with 10 minute air breaks at minutes 40 and 85. Second and third dives per normal Weaver protocol (see below). After third dive, HBO physician may prescribe up to 10 dives to treat persistent symptoms, in consultation with neurology and other specialists, as needed. Dives 4-10 would follow same profile of 2.0 ATA for 90 minutes with 5 min air breaks at minutes 40 and 80.
   Alternate: Normal Weaver protocol: For adult, non-pregnant patients with seizure risk. May also be used at any time, per physician discretion:
   Hyperbaric oxygen therapy at 3.0 ATA oxygen for sixty minutes at pressure, with 5 minute air breaks at minutes 25 and 55. Then ascend to 2.0 ATA and remain for 60 minutes with a 5 minute air break after 25 minutes at 2.0 ATA.
   Repeat hyperbaric oxygen therapy at 2.0 ATA oxygen for a total time of 120 minutes (including compression and decompression times), with air breaks at minutes 40 and 80. This repeat protocol is administered twice, following 6 hour intervals.
   ii. Pregnant and pediatric patients
   Hyperbaric oxygen therapy, at 3.0 ATA oxygen for 90 minutes, with 2 10 minute air breaks (same as Enhanced Weaver). Where residual symptoms persist, or the post-treatment neurological exam remains abnormal, provide additional hyperbaric oxygen treatment at 2.0 ATA, following a 6-12 hour interval, depending upon symptom severity.

B. Provide medical supportive care as necessary. Soft restraints for unconscious patients.

C. Monitor ECG

D. Institute/maintain intravenous fluid therapy, as indicated

E. If patient is pregnant and HBO therapy cannot be given, (unsafe, absolute contraindications, refuses treatment, for example) treat with 100% oxygen by mask for a duration of five times that required to reduce maternal carboxyhemoglobin to less than 5%.

F. Repeat neuropsychometric/mental status/neurological screening following each treatment where possible/indicated.

G. It must be noted that the evidence of benefit of hyperbaric oxygen over normobaric 100% oxygen for acute and chronic effects of CO poisoning is modest. Each case must be viewed from a risk-benefit standpoint, to determine if HBO2 is in the patient's overall best interest.

FOLLOW-UP:

A. Consider psychometric/mental status screening. Consider referral for neuropsychiatric testing.

B. 24 hour telephone follow-up, if discharged to home.

C. Assessment of home for carbon monoxide level and source, where appropriate

D. Delayed symptoms may occur 1-21 days later in 3 – 40% of patients. Presentations include aphasia, apraxia, apathy, disorientation, hallucinations, nuchal rigidity, gait disturbances, fecal and urinary incontinence, bradykinesia, cognitive and/or neurologic deficits, personality changes with impulsiveness, violence, verbal aggressiveness and mood changes.

TREATMENT RANGE: 1-10 treatments
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NOTES:  
A. Consider emergent needle myringotomies. However, TM rupture may be acceptable in emergent cases.
B. In diabetic patients, finger stick for blood glucose prior to each treatment if sample not drawn and value available within 60-90 minutes prior to HBO.
C. Intubation should occur if patients clinical situation demands it (unable to support airway). Intubation should not occur to make a patient compliant enough to safely achieve HBOT (combative or suicidal patients).
D. Contraindications to HBOT: History of spontaneous, pneumothorax (absolute), active/suspected suicidality (until clearly and reliably able to contract for safety); history of seizure disorder (strong); history of recent or unhealed pneumothorax, any cause (absolute); any condition which makes a patient unsafe to be in the chamber (absolute); uncontrollable hypoglycemia (example: insulin overdose and pt is too combative for glucose drip). Severe lung disease, especially emphysema, advanced cancer and cavitary lesions, due to the risk of pneumothorax (strong).

SPECIAL CONSIDERATIONS- SUICIDAL PATIENTS (or patients with altered mentation/combateness due to drugs and/or pre-existing neurological dysfuction and/or behavioral disorders):

Suicidal/uncooperative patients pose special risks to themselves and the hyperbaric medicine staff. The hyperbaric chamber is a pressurized oxygen environment with surrounding, exposed electronics. It is in reality a large potential fire/explosion risk. It also has intrinsic risks of harm to the patient (pneumothorax, eardrum rupture, seizure, etc). In order to achieve safe HBOT, patients must be able and willing to follow instructions per the HBO staff. The hyperbaric physician, nurse and/or safety director has the right to decline treatment to any patient who is deemed to be a serious and unresolvable safety risk to themselves or others. All such patients should be viewed in terms of overall benefit vs risk.

It should be realized that HBOT is usually elective and non-lifesaving for patients. Evidence of its absolute benefit remains unclear. 100% normobaric oxygen therapy will invariably normalize CO blood levels over time, and may still offer protection against late stage cognitive sequelae, and is thus a reasonable treatment option for unsafe patients. Suicidal/uncooperative patients may create safety hazards by inappropriate breath holding (pneumothorax risk), refusal to follow staff commands, and may increase fire risk via contraband or tampering with the equipment.

Suicidal patients who are involuntarily committed/admitted may still refuse HBO at any time, with effort by the HBO staff to communicate risks of such refusal. Forcing an unwilling patient into the chamber creates a safety hazard and the benefit of HBO is not compelling enough to force treatment against a patient’s will.

Patients whose mental status changes may be due in part to drugs, toxins, psychiatric illness, neurological disease or injury or other non-CO causes, should be evaluated thoroughly. These conditions may make a patients clinical presentation appear severe enough to warrant HBO for CO poisoning.

SPECIAL CONSIDERATIONS-INTUBATED/CRITICALLY ILL/UNSTABLE PATIENTS:

The benefits of HBOT over normobaric 100% O2 are not compelling enough to justify intubation/sedation simply to make a patient compliant enough to be uncombative in the chamber, in any case. The HBO unit can accommodate ventilated and sedated patients whose clinical status required intubation/sedation for survival. Basic cardiac and blood pressure monitoring are also available for unstable patients (awake or sedated). However the following must be considered prior to initiating HBOT in critically ill/unstable patients.

-Hemodynamic monitoring is rudimentary in the chamber, and safe extrication for patients who acutely decompensate may require up to 20 minutes.
- Ventilatory support coupled with HBO pressure changes may increase risk of pneumothorax. This is especially concerning in patients with a history of lung disease.

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-Patients with end-organ ischemia due to CO poisoning usually recover quickly with 100% normobaric oxygen, which supports the organs and increases the rate of CO off-gassing. Often patients have resolved the signs of end organ ischemia by the time they are transferred from the Emergency department to the HBO unit.

-Critically ill patients in an HBO chamber are physically removed from the care team. Full ACLS resuscitation measures are physically impossible.

SPECIAL CONSIDERATIONS-PATIENTS WHO PRESENT TO NON-ROPER FACILITIES

Carbon monoxide patients are often complex from a medical, psychiatric, social and follow-up standpoint. Acceptance of a patient to the Roper Hyperbaric Medicine unit does not automatically constitute a transfer to Roper Hospital inpatient status, for patients requiring more than simple HBO treatment as an outpatient. The referring, outside facility should assume that a significantly ill or suicidal patient will return to that system for inpatient care after required HBO therapy is delivered at Roper. Such patients should be admitted to the appropriate level of care at the presenting facility, in coordination with the inpatient team and emergency department at the referring facility, and then transfer arranged to Roper HBO. This is assure that a patient continually has an appropriate bed available at all times, and the lines of responsibility are clear.

If extended HBO is required or other clinical reasons emerge as reasons for a complete transfer of care, the attending hyperbaric medicine physician may decide to coordinate with the inpatient team at Roper (floor, ICU, psychiatry, etc). If the inpatient team agrees that the transfer is in the patients best interest, the attending hyperbaric physician will coordinate the transfer and decide where the patient should first arrive at Roper (ED/ICU for further stabilization, psychiatric bed for further evaluation, or directly to HBO unit).

If the case occurs during on-call hours and the referring facility has its own non-emergent HBO capability, that will be operational for routine schedule within a period of time that will not significantly effect the patients outcome, and the patient has recovered to a point that the referring facility's HBO facility can render appropriate treatment, then transfer should not occur.

Example: A patient attempts suicide via carbon monoxide and is found unconscious in his car at 5am. He is transported to the ED of a hospital with a level 2 (non-emergent) HBO facility with normal working hours listed as 7:30 am to 4 pm. He regains consciousness and normal mentation on 100% oxygen by facemask, but is not willing to contract for safety in the HBO chamber, and is kept on 100% normbaric oxygen. He is seen by the attending psychiatrist on call that day. After discussion, the patient expresses sincere desire for treatment for both HBO treatment and for underlying depression. The psychiatrist notes that he is convinced that the patient does not pose a threat to himself or the HBO staff. It is now 8:05 am. The patient should be then treated in the outpatient HBO facility of the hospital to which he presented. There is no reason to justify transfer to the Roper facility.

DISCUSSION OF ENHANCED WEAVER/NEBRASKA PROTOCOL

Weaver protocol is UHMS standard. 3.0 ATA x 60 min to 2.0 ATA x 60 min. Then 2 follow up dives within 24 hrs at 2.0 ATA. Many patients do not show up for their second and third dives if asymptomatic.

Nebraska protocol has some advantages. 3.0 ATA x 2 full hrs supports Thom’s idea that deeper/longer is required to address long term brain injury. It also calls for continued dives if symptoms persist.

Combining the two protocols confers advantages of intense first treatment for max benefit, while still offering second and third dives routinely, and then subsequent dives for persistent symptoms.
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Acute Carbon Monoxide Poisoning – Treatment algorithm

**Diagnosis:** CO Poisoning
~elevated COHb levels*

**With safety in mind, consider hyperbaric medicine consultation/treatment for:**

i. All patients with a reliable history of:
~confirmed loss of consciousness
~syncope (with or without exertion)
~seizures
~altered mental status, other than simple headache (examples include: disorientation; confusion; dizziness; ataxia; aphasia; visual disturbances)

ii. All patients who present with:
~coma
~altered mental status, other than simple headache (examples above).
~persistent ischemic chest pain, dyspnea, or ischemic ECG changes despite normobaric O2.
~persistent metabolic acidosis despite normobaric O2.
~a COHb level above 25% at any time, regardless of symptom presentation

iii. All pregnant patients with COHb levels above 10%

*Treat with 100% normobaric oxygen:
~patients who complain of symptoms less severe than those to the left.
~Any patient who generates an unresolved safety, until such time as it can be resolved and the patient still meets criteria to consider HBO treatment.

Consider hyperbaric oxygen therapy in those patients who complain of persistent symptoms, after 3-4 hours of 100% oxygen breathing, and who do not pose an unresolved safety threat.

* Age >36 or confirmed CO exposure > 24 hours may increase the risk of neurologic sequelae, and may positively influence the decision to treat in marginal cases.

* Suicidal patients present special risks to themselves and the staff in the Hyperbaric Oxygen unit. Consideration is given to these patients in the HBO CO protocol. The hyperbaric medicine staff has the right to decline treatment to any suicidal patient who poses a safety risk.

* Endogenous CO poisoning as a by-product of methylene chloride ingestion requires prolonged observation and serial COHb levels, because CO levels may rebound after normobaric or hyperbaric O2

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*Elevated blood carbon monoxide levels provide a *diagnosis* of carbon monoxide exposure. They do not, however, provide useful information regarding the severity of poisoning. This is best determined by presentation and clinical evaluation.

*It is important to emphasize that severely CO poisoned patients who have apparently recovered following conservative (normobaric oxygen) therapy may develop a late neurologic deterioration, with manifestations not unlike Parkinson's Disease.
REFERENCES:

Carbon Monoxide Poisoning and Smoke Inhalation. Hyperbaric Oxygen Therapy: A Committee Report, 2003;11-17


