

Carbon Monoxide Toxicity: Hyperbaric Oxygen or Not?

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Treat Carbon Monoxide Poisoning With Hyperbaric Oxygen or Normal Oxygen?

YES!

Carbon Monoxide Epidemiology

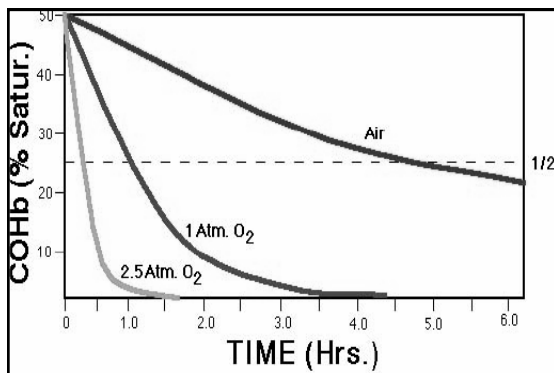
- #1 cause of poisoning death in US every year (400-500)
- Occurs in both cold weather/winter and warm weather/summer
- Accidental exposure and suicidal exposures both result in deaths

Carbon Monoxide Pathophysiology

- CO binds to hemoglobin ~ 250 times greater than oxygen
- Heart and brain are main tissues injured
- Binding is not linear
 - ◆ 1% atmospheric CO = 14% COHb
 - ◆ 5% atmospheric CO = 44% COHb
 - ◆ 10% atmospheric CO=66% COHb
- Slight exertion increases uptake 3-5 times
 - ◆ Firefighter in 10% CO can develop 50-75% COHb in 30-60 seconds

Carbon Monoxide Pathophysiology

- Binding Hb prevents oxygen delivery
- Other toxicity
 - ◆ Left shift in oxygen-hemoglobin dissociation
 - ◆ Binds myoglobin
 - ◆ Binds cytochrome oxidase (block mitochondrial respiration)
 - ◆ 20% of extravascular CO binds to myoglobin and cytochrome oxidase
- Tissue and cellular hypoxia result
 - ◆ Cardiac injury
 - ◆ Brain injury



Carbon Monoxide Toxicity- Acute

- | Cardiac | Brain |
|---------------|------------------|
| ■ Palpitation | ■ Confusion |
| ■ Tachycardia | ■ Disorientation |
| ■ Chest pain | ■ Syncope |
| ■ Ischemia | ■ Lethargy |
| ■ Infarction | ■ Coma |
| ■ Dysrhythmia | ■ Seizure |
| ■ Hypotension | |
| ■ Syncope | |

Carbon Monoxide Toxicity- Delayed Neurologic

- | | |
|------------------------|---------------------|
| ■ Neuro-Psychiatric | ■ Parkinson-like |
| ◆ Personality changes | ◆ Muscle rigidity |
| ◆ Cognitive impairment | ◆ Cogwheel rigidity |
| ◆ Disorientation | ◆ Bradykinesia |
| ◆ Aphasia | ◆ Shuffling gait |
| ◆ Hallucinations | |

Delayed Neurologic Sequelae

- Incidence up to 5-40%
- Typical history
 - ◆ CO exposure with syncope/loss of consciousness
 - ◆ Recovery with room air or normobaric O₂
 - ◆ Onset of symptoms 0.5-3 weeks later
 - ◆ Rapid deterioration in neurologic function, onset of Parkinson-like symptoms
- NO CORRELATION WITH COHb LEVEL!

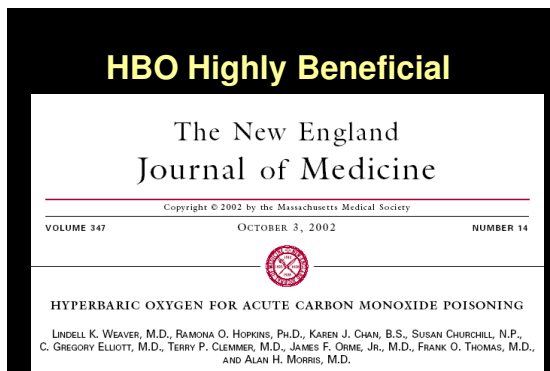
Indications for HBO

- Coma, loss of consciousness, altered mental status
- Any COHb>25% with symptoms or 40% without
- Pregnancy
 - ◆ Fetal Hb binds CO more than Hb
 - ◆ HBO may injure fetus or threaten pregnancy
 - ◆ Risk-benefit ratio favors HBO
 - ◆ Symptoms and COHb>15 or any COHb>25

HBO Not Beneficial

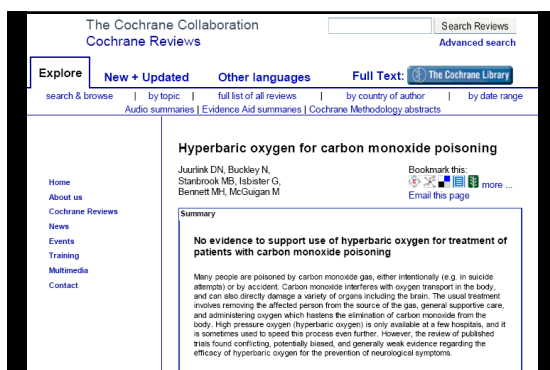
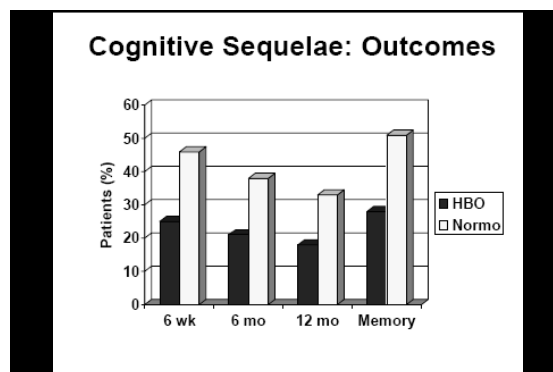
Scheinkestel CD, Bailey M, Myles PS, et al. Hyperbaric or normobaric oxygen for acute carbon monoxide poisoning: a randomized controlled clinical trial. Med J Aust 1999;170(5):203-10

- 191 patients randomized to HBO or normal O₂
- Worse neurologic outcome at 1 month in HBO group
- Problems
 - ◆ Treatment given > 6 hours (7.3 hours average) post exposure
 - ◆ Half lost to follow up
 - ◆ Half of patients were suicidal, may have had neuropsychiatric problems before exposure



Methods We randomly assigned patients with symptomatic acute carbon monoxide poisoning in equal proportions to three chamber sessions within a 24-hour period, consisting of either three hyperbaric-oxygen treatments or one normobaric-oxygen treatment plus two sessions of exposure to normobaric room air. Oxygen treatments were administered from a high-flow reservoir through a face mask that prevented rebreathing or by endotracheal tube. Neuropsychological tests were administered immediately after chamber sessions 1 and 3, and 2 weeks, 6 weeks, 6 months, and 12 months after enrollment. The primary outcome was cognitive sequelae six weeks after carbon monoxide poisoning.

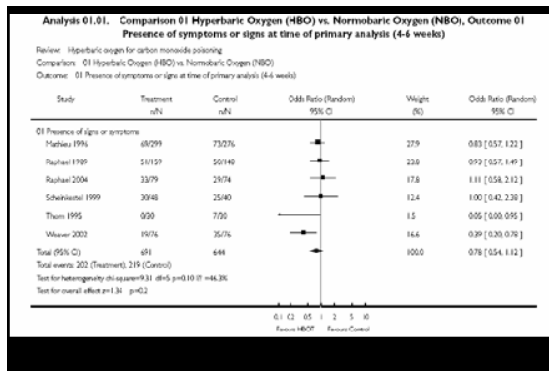
Results The trial was stopped after the third of four scheduled interim analyses, at which point there were 76 patients in each group. Cognitive sequelae at six weeks were less frequent in the hyperbaric-oxygen group (19 of 76 [25.0 percent]) than in the normobaric-oxygen group (35 of 76 [46.1 percent], $P=0.007$), even after adjustment for cerebellar dysfunction and for stratification variables (adjusted odds ratio, 0.45 [95 percent confidence interval, 0.22 to 0.92]; $P=0.03$). The presence of cerebellar dysfunction before treatment was associated with the occurrence of cognitive sequelae (odds ratio, 5.71 [95 percent confidence interval, 1.69 to 19.31]; $P=0.005$) and was more frequent in the normobaric-oxygen group (15 percent vs. 4 percent, $P=0.03$). Cognitive sequelae were less frequent in the hyperbaric-oxygen group at 12 months, according to the intention-to-treat analysis ($P=0.04$).



Cochrane Review

"No evidence to support use of hyperbaric oxygen for treatment of patients with carbon monoxide poisoning"

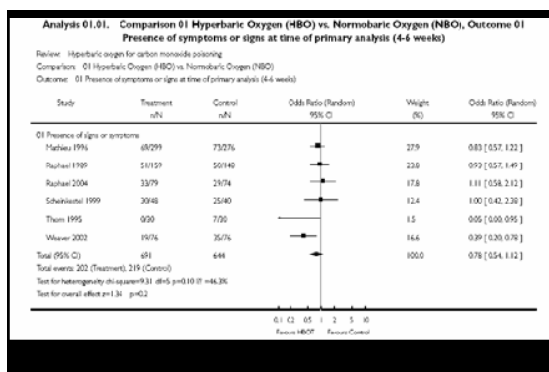
Juurlink DN, Buckley N, Stanbrook MB, Isbister G, Bennett MH, McGuigan M. Hyperbaric oxygen for carbon monoxide poisoning. Cochrane Database of Systematic Reviews 2005, Issue 1. Updated April 15, 2010.



Evidence Based Medicine

"Select evidence that supports your clinical practice and ignore the rest..."

Anonymous Emergency Medicine faculty



Evidence Based Medicine

"The article by Weaver et al. provides a reliable foundation on which to base decisions regarding management."

*Stephen R. Thom, MD, PhD
 University of Pennsylvania, Philadelphia
 New England Journal of Medicine, 2002*

Evidence Based Medicine- The Circumcision Analogy

- Medical evidence supporting circumcision is conflicting.

What is the single greatest predictor of whether an American boy is circumcised?

- Fathers circumcision status!

Pediatric Carbon Monoxide Poisoning

Carbon Monoxide Poisoning in Children Cho CH, Chiu NC, Ho CS, Peng CC. Pediatrics and Neonatology 2008;49:121-125

- 10 year retrospective study, 30 cases
- Epidemiology
 - Gas water heater (53%)
 - House fire (27%)
 - Intentional poisoning by parents (20%)
- Clinical
 - Depressed consciousness (87%)
 - Delayed neurologic sequelae in 5 children (17%)
 - ALL FULLY RECOVERED!

Severe Carbon Monoxide Poisoning in Children

Epidemiology of Severe Carbon Monoxide Poisoning in Children Mendoza JA, Hampton NB Undersea & Hyperbaric Medicine 2006 33(6):439-446

■ 250 cases of poisoning with hyperbaric treatment

■ Epidemiology

- ◆ Most poisonings in Winter
- ◆ Children > 2 years poisoned by automobile
- ◆ Males more often poisoned by automobile
- ◆ All intentional cases > 17 years

■ Clinical

- ◆ Loss of consciousness in 50%
- ◆ Neurologic outcome better than adult cases

Pediatric Carbon Monoxide Poisoning Outcomes

- Children appear to have syncope or loss of consciousness more often than adults
- Children have neurologic sequelae
- Full recovery or better recovery than with adults is typical
- Unclear if HBO is less critical in children, but this is possible.

HBO or Mechanical Ventilation for CO Poisoning

Hawkins M, Harrison J, Charters P. Severe carbon monoxide poisoning: outcome after treatment with hyperbaric oxygen. British Journal of Anaesthesia 2000;84:584-6.

- Retrospective review of 31 cases of CO toxicity treated with HBO and compared to 79 cases without HBO
- All cases required mechanical ventilation
- HBO Group: 5/31 (16%) mortality, 1/31 (3%) had neurologic sequelae in hospital
- O₂ Group: 20% mortality, 20% neurologic sequelae
- 10 patients follow up, 4 had neurologic sequelae (40%)

HBO or Mechanical Ventilation for CO Poisoning

- Patients who require mechanical ventilation after CO poisoning are extremely sick and likely to have poor outcome
- Study groups are not comparable
 - ◆ Critical care therapy in 1987 is not same as in 1999
 - ◆ Therapy in a center that provides HBO is likely to be higher than in centers without HBO
- Conclusions:
 - ◆ Limited - retrospective metaanalysis of 2 studies 12 years apart
 - ◆ Rely on better designed prospective studies to make decisions

Conflicting Evidence

- Currently, Weaver *et al* remains strongest HBO study in publication
- Unless other evidence disproves Weaver *et al* continue to provide HBO when indicated
- Can the Weaver study be duplicated or improved?
 - ◆ Yes, but difficult
 - ◆ Not in the USA

Optimal HBO Study

- Healthy adults with certain ability to closely follow up
- Pre/post-exposure neurocognitive testing
- Likely exposure to CO
- Ability to assess for CO as well as cyanide
- Ability to provide HBO
- Ability to randomize to normal O₂
- Firefighters!

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