

SHORT REPORT

Carbon monoxide poisoning and treatment with hyperbaric oxygen in the subacute phase

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Abstract

The use of normobaric versus hyperbaric (>2 atm) oxygen in the treatment of carbon monoxide intoxication continues to be a matter of debate despite reports of increased efficacy with hyperbaric oxygen. When hyperbaric oxygen is used, immediate treatment is preferred for best results. The therapeutic window of time, however, is unknown. A patient presented with acute confusion and partial retrograde and total anterograde memory loss due to carbon monoxide poisoning. He was initially treated with normobaric oxygen and failed to show appreciable improvement. One month after carbon monoxide exposure the patient underwent treatment with hyperbaric oxygen and showed appreciable symptom relief confirmed by clinical findings and neuropsychological testing. This case shows that hyperbaric oxygen may be efficacious in the recovery of neuropsychiatric function up to 1 month after carbon monoxide induced brain injury.

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Carbon monoxide exposure is a leading cause of morbidity and mortality secondary to poisoning.¹ The symptoms of carbon monoxide poisoning are non-specific. Presenting complaints may consist only of nausea, vomiting, fatigue, headache, or confusion. Ongoing neuronal damage may result in more serious complications such as neuropsychiatric symptoms, coma, or death. As there is a high incidence of neurological sequelae reported after carbon monoxide poisoning,^{2,3} even apparently benign presentations warrant a thorough evaluation and close follow up. The efficacy of hyperbaric versus normobaric oxygen in the treatment of acute and delayed symptoms remains controversial. At centres with a hyperbaric chamber or easy access to one, treatment with hyperbaric oxygen is preferred to provide acute symptom relief and decrease the incidence of delayed neuropsychiatric sequelae.³⁻⁶ Indications for treatment with hyperbaric oxygen include a carboxyhaemo-

globin concentration greater than 25% or any carboxyhaemoglobin concentration associated with loss of consciousness, neuropsychiatric deficits, pregnancy, cardiac dysfunction, or EEG changes.^{6,7}

The therapeutic window of time for the efficacy of hyperbaric oxygen treatment is unknown. There have been a few reported cases in which hyperbaric oxygen therapy was beneficial when given hours to days after exposure.⁸⁻¹⁰ We report a case of significant therapeutic benefit from hyperbaric oxygen therapy instituted 1 month after exposure to carbon monoxide.

Case report

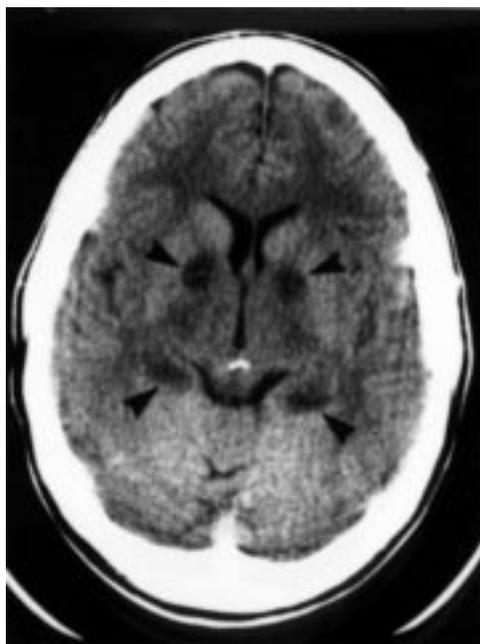
A 40 year old white man presented with acute confusion and partial retrograde and total anterograde memory loss. Psychiatric history was relevant for major depressive disorder and prior suicide attempt by carbon monoxide poisoning 9 months earlier without neuropsychiatric sequelae. His physical state on presentation to the hospital and immediate history provided by the family was consistent with carbon monoxide poisoning from intentional inhalation of automobile exhaust within the two days before admission. The duration of carbon monoxide exposure and occurrence of any loss of consciousness was unknown due to the extent of the patient's memory impairment.

At the time of admission to hospital the patient appeared dishevelled and in no acute distress. Throughout the examination, his behaviour was notable for intermittently staring at an envelope in his shirt pocket and then removing the envelope to examine its contents. Each time he did so, he appeared perplexed by the envelope's presence and would familiarise himself with its contents as if he had never seen them before. He was alert and oriented only to person. Mood was "confused" and affect flat. Speech was spontaneous with normal rate and tone. Thought processes were goal directed (as far as the patient could participate). He denied any perceptual disturbances. There were no suicidal ideations. The patient displayed no immediate recall memory. His mini mental state examination score was 18. Registration, calculation, language, and construction were intact, whereas there was severe impairment in orientation, attention, and anterograde and retrograde memory. The patient was unaware

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Bilateral hypodensity in the globus pallidus and hippocampal regions on admission CT.

of his lack of memory. Physical examination was unremarkable. Cranial CT on admission disclosed areas of hypodensity in the bilateral globus pallidus and hippocampal areas consistent with carbon monoxide poisoning (figure). The patient was placed on 100% ambient pressure oxygen which was continued for three hours until the results of his admission laboratory data were available. Carboxyhaemoglobin concentration in this three pack a day smoker was then 2% (normal range <2% in non-smokers and between 5% and 10% in smokers).¹¹ Admission laboratory tests were otherwise within normal limits.

HOSPITAL COURSE

The patient's initial course was characterised by a flat affect, partial retrograde memory loss dating back about 2 years, and severe impairment in declarative memory. He required constant reorientation by staff to place, time, reason for admission, and name of his clinician. Neuropsychological evaluation was performed at 4, 7, and 9 days after admission and confirmed the patient's profound defect in memory, mental control, and sustained attention. Formal testing of memory could not be obtained due to the density of the patient's impairment in working memory. Also notable was his tendency to forget tasks while he was doing them even when they involved an ongoing physical activity which would be expected to keep him oriented. One example was the patient's inability to perform the basic activities of daily living unless he was constantly reminded of what he was doing and how to do it.

Throughout the patient's initial stay in hospital his ability to recall distant events and form some new memories demonstrated minimal improvement. For instance, after the first two weeks the patient was intermittently able to

identify his doctor from a group of people. Even after three weeks, however, the patient would ask his physician, "Where do I know you from?" The patient showed no ability to recall events spontaneously that had occurred the day before. A diary was provided to aid his recollection of recent events, but he was unable to use it effectively secondary to forgetting its location and purpose. Anecdotally, the patient himself best described the degree of his memory loss when he left his physician's office and stated, "When you close your door...everything behind it disappears...I have no idea what's in there".

One month after initial insult with carbon monoxide and only minimal signs of improvement, informed consent for hyperbaric therapy was obtained from the patient and his family. The patient underwent four, 90 minute treatments with hyperbaric oxygen at 2.4 atm over two days. On completion, his mini mental state examination score was 25. The patient was alert and oriented to person, place, month, and year. He was able to recall one of three objects at 3 minutes and three of three with prompting. There was also an increased ability to recall recent events. The patient showed improved insight into his condition; he was aware of his memory problem and that he had undergone treatment. There was also a remarkable improvement in his ability to care for himself. He was able to perform activities of daily living without assistance. The patient showed an improved ability to sustain a conversation without forgetting what he was talking about. He also had an increased range of affect and would become tearful at times.

Formal neuropsychological testing obtained one week after hyperbaric oxygen treatment disclosed a marked improvement from his initial testing. The patient had improved declarative memory for events of the past year. Overall, his performance on tests sensitive to concentration and attention was low to average. Despite his performance likely representing a decline from premorbid function, it was a substantial improvement when compared with his untestable state at admission. Immediate memory for simple designs was average to high, but the patient was unable to reproduce the designs after a delay. Narrative memory remained very impaired, but the patient was able to identify story elements correctly at well above chance levels.

An additional set of four hyperbaric treatments yielded no further significant signs of improvement.

Discussion

This case is an example of hyperbaric oxygen providing symptom relief from carbon monoxide induced brain injury as late as one month after carbon monoxide insult. Substantial improvement in memory, concentration, attention, and activities of daily living were seen in this patient when treated with hyperbaric oxygen. Although hypoxia often leads to death in cases of severe carbon monoxide poisoning, it does not entirely account for the presence of symptoms in patients with carboxyhaemoglobin concentrations below the lethal range or

in those who develop late neuropsychiatric sequelae. In addition to decreasing the amount of haemoglobin available for oxygen transport and shifting the oxyhaemoglobin curve to the left, carbon monoxide may also effect other intracellular processes important to cellular function and metabolism.¹²⁻¹⁴ Several animal studies show that treatment with hyperbaric oxygen is more effective than normobaric oxygen in reducing carbon monoxide associated brain injury and suggests that hyperbaric oxygen acts in part by inhibiting cellular processes such as oxidative injury and brain lipid peroxidation.^{15 16} The ability of hyperbaric oxygen to exert a therapeutic effect in the subacute period suggests that its mechanism of action is not exclusively dependent on displacing carbon monoxide from haemoglobin and that it may involve the inhibition of cellular pathways responsible for neuronal injury and death. Further research is needed to examine the mechanism by which hyperbaric oxygen acts and define its role in the treatment of carbon monoxide related symptoms.

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