

Title: *Hyperbaric oxygenation prevented brain injury induced by hypoxia-ischemia in a neonatal rat model.*

Author(s): [Calvert JW](#); [Yin W](#); [Patel M](#); [Badr A](#); [Mychaskiw G](#); [Parent AD](#); [Zhang JH](#)

Source: [Brain research](#) [Brain Res] 2002 Sep 27; 951 (1), pp. 1-8.

Abstract: The occurrence of hypoxia-ischemia (HI) during early fetal or neonatal stages of an individual leads to the damaging of immature neurons resulting in behavioral and psychological dysfunctions, such as motor or learning disabilities, **cerebral palsy**, epilepsy or even death. No effective treatment is currently available and this study is the first to use **hyperbaric oxygen** (HBO) as a treatment for neonatal HI. Herein, we sought out to determine if HBO is able to offer neuroprotectivity against an HI insult. Seven-day-old rat pups were subjected to unilateral carotid artery ligation followed by 2.5 h of hypoxia (8% O₂) at 37 degrees C). HBO treatment was administered by placing pups in a chamber (3 ATA for 1 h) 1 h after hypoxia exposure. Brain injury was assessed based on ipsilateral hemispheric weight divided by contralateral hemispheric weight, light microscopy, and EM. Sensorimotor functional tests were administered at 5 weeks after hypoxia exposure. After HI, the ipsilateral hemisphere was 52.65 and 57.64% (P<0.001) of the contralateral hemisphere at 2 and 6 weeks, respectively. In HBO treated groups, the ipsilateral hemisphere was 77.77 and 84.19% (P<0.001) at 2 and 6 weeks. There was much less atrophy and apoptosis in HBO treated animals under light or electron microscopy. Sensorimotor function was also improved by HBO at 5 weeks after hypoxia exposure (Chi-square, P<0.050). The results suggest that HBO is able to attenuate the effects of HI on the neonatal brain by reducing the progression of neuronal injury and increasing sensorimotor function.

Title: *Hyperbaric oxygen for children with cerebral palsy: a randomised multicentre trial.* HBO-CP Research Group.

Author(s): [Collet JP](#); [Vanasse M](#); [Marois P](#); [Amar M](#); [Goldberg J](#); [Lambert J](#); [Lassonde M](#); [Hardy P](#); [Fortin J](#); [Tremblay SD](#); [Montgomery D](#); [Lacroix J](#); [Robinson A](#); [Majnemer A](#)

Source: [Lancet](#) [Lancet] 2001 Feb 24; 357 (9256), pp. 582-6.

Abstract: BACKGROUND: The use of **hyperbaric oxygen** for children with **cerebral palsy** has spread worldwide, despite little scientific evidence of efficacy. We did a randomised trial to assess the efficacy and side-effects of this form of therapy in children with **cerebral palsy**. METHODS: 111 children with **cerebral palsy** aged 3-12 years were randomly assigned **hyperbaric oxygen** (n=57) or slightly pressurised room air (n=54). All children received 40 treatments over 2 months. **Hyperbaric oxygen** treatment was 1 h in 100% **oxygen** at 1.75 atmospheres absolute (ATA); children on slightly pressurised air received air at 1.3 ATA (the lowest pressure at which pressure can be felt, thereby ensuring the maintenance of masking). The main outcome measure was gross motor function. Secondary outcomes included performance in activities of daily living, attention, working memory, and speech. FINDINGS: For all outcomes, both groups improved over the course of the study, but without any difference between the two treatments. The score on the global gross motor function measure increased by 3.0% in the children on slightly pressurised air and 2.9% in those on **hyperbaric oxygen**. The mean difference between treatments was -0.40 (95% CI -1.69 to 0.90, p=0.544). Other changes were seen in speech, attention, memory, and functional skills. Ear problems occurred in 27 children treated by **hyperbaric oxygen** and in 15 treated with **hyperbaric** air (p=0.004). INTERPRETATION: In this study, **hyperbaric oxygen** did not improve the condition of children with **cerebral palsy** compared with slightly pressurised air. The improvement seen in both groups for all dimensions tested deserves further consideration.

Title: *Hyperbaric oxygen therapy for cerebral palsy: two complications of treatment.*

Author(s): [Nuthall G](#); [Seear M](#); [Lepawsky M](#); [Wensley D](#); [Skippen P](#); [Hukin J](#)

Source: [Pediatrics](#) [Pediatrics] 2000 Dec; 106 (6), pp. E80.

Abstract: There is growing interest in the use of **hyperbaric oxygen** therapy (HBO(2)) for children with **cerebral palsy**. Although there is no rigorous evidence to support this management, private **hyperbaric** centers have been established throughout the United States and Canada. There is likely to be increasing pressure on pediatricians and other health professionals to prescribe HBO(2). We describe 2 children with **cerebral palsy** who suffered significant morbidity immediately after treatment with **hyperbaric oxygen**. Both the temporal association and pathologic findings suggest that the **hyperbaric** treatment is likely to have been responsible for the resulting complications. As with any new therapy, we suggest waiting for the results of a randomized, controlled trial before recommending this treatment.

Title: *Effects of hyperbaric oxygen therapy on children with spastic diplegic cerebral palsy: a pilot project.*

Author(s): [Montgomery D](#); [Goldberg J](#); [Amar M](#); [Lacroix V](#); [Lecomte J](#); [Lambert J](#); [Vanasse M](#); [Marois P](#)

Source: [Undersea & hyperbaric medicine : journal of the Undersea and Hyperbaric Medical Society, Inc](#) [Undersea Hyperb Med] 1999 Winter; 26 (4), pp. 235-42.

Abstract: **Hyperbaric oxygen** (HBO2) therapy for children with **cerebral palsy** (CP) is not new. Research documenting the effects in this population has been anecdotal. We evaluated the effects of HBO2 therapy for 25 children ($X = 5.6 \pm 1.6$ yr) with a functional diagnosis of spastic diplegic CP. Pre- and post-HBO2 evaluations consisted of the following measures: gross motor function measure (GMFM), fine motor function (Jebsen test for hand function), spasticity (modified Ashworth scale), video analysis, and parental questionnaire. The protocol for HBO2 therapy was 20 treatments of 95% **oxygen** at 1.75 atm abs for 60 min. The Wilcoxon matched-pairs signed-rank test for non-parametric measures was used to compare pre- and post-treatment data. Results showed improved gross motor function in three of the five items in the GMFM test, improved fine motor function in three of the six hand tests, reduced spasticity in three of four muscle groups when assessed by a physician specializing in CP, and improvements for four of nine questions posed to parents.

Title: *[Effects of hyperbaric oxygen therapy on ischemic brain injury in dogs]*

Author(s): [Yatsuzuka H](#)

Source: [Masui. The Japanese journal of anesthesiology](#) [Masui] 1991 Feb; 40 (2), pp. 208-23.

Abstract: The effects of **hyperbaric oxygen** therapy (OHP) on **brain** circulation and oxidative stress were studied in dogs following 18 min of complete cerebral ischemia. The intracranial pressure (ICP), cerebral blood flow (CBF), thiobarbituric acid reacting substances (TBARS), non-esterified fatty acids (NEFA) and EEG were measured during and after OHP of 2 atmosphere absolute (ATA) and total duration of 170 min. A significant reduction of ICP was observed 120 min after OHP. CBF showed no significant change. NEFA decreased significantly 150 min after OHP. TBARS showed significant reduction 30, 90, 150 min after OHP. On EEG no spike waves were observed and fast waves (spindle-form) of EEG and the amplitude of slow waves seemed to increase during and after OHP. These results showed that OHP after complete cerebral ischemia was effective in reducing **brain** damage without increasing oxidative stress.

Title: Improvement in cerebral metabolism in chronic *brain injury* after *hyperbaric oxygen* therapy.

Author(s): [Golden ZL](#); [Neubauer R](#); [Golden CJ](#); [Greene L](#); [Marsh J](#); [Mleko A](#)

Source: [International journal of neuroscience](#) [Int J Neurosci] 2002 Feb; 112 (2), pp. 119-31.

Abstract: While no research study has yet demonstrated convincing evidence for the efficacy of **Hyperbaric Oxygen** Therapy (HBOT) in patients with chronic neurological disorders (CND), anecdotal studies have been supportive of its use in improving healing of the damaged **brain**. The current study hypothesized that (1) individuals with CND show increases in cerebral blood flow and metabolism as measured by Single Positron Emission Computed Tomography (SPECT) in the cerebral hemispheres, but not on measures of cerebellar and pons blood flow; and (2) younger patients show more improvement than older patients. The study used archival data to compare 25 older and 25 younger subjects who were given SPECT scans pretherapy, midtherapy, and posttherapy. ANOVAs using the SPECT scans as a within subjects variable and age as a between subjects variable confirmed the hypothesis that the cerebral measures all changed but that the cerebellar and pons measures did not. Post-hoc t-tests confirmed that there was improvement in blood flow from the beginning to the end of the study. An age effect was found on only two of the five measures; however, there were no interactions. Analysis by post-hoc t-tests showed that the younger group had higher blood flows, but not more improvement than the older group. The results provided the first statistical research data to show the effectiveness of HBOT in improving blood flow in CND. These results indicate that HBOT can be an effective part of the treatment for such clients. The implications of these findings and future research directions were discussed.

Title: Glasgow Coma Scale, *brain* electric activity mapping and Glasgow Outcome Scale after *hyperbaric oxygen* treatment of severe *brain injury*.

Author(s): [Ren H](#); [Wang W](#); [Ge Z](#)

Source: [Chinese journal of traumatology = Chung-hua ch'uang shang tsa chih](#) [Chin J Traumatol] 2001 Nov; 4 (4), pp. 239-41.

Abstract: OBJECTIVE: To study the effect of **hyperbaric** oxygen (HBO) treatment of severe **brain injury**. METHODS: Fifty-five patients were divided into a treatment group (n=35 receiving HBO therapy) and a control group (n=20 receiving dehydrating, cortical steroid and antibiotic therapy) to observe the alteration of clinic GCS (Glasgow Coma Scale), **brain** electric activity mapping (BEAM), prognosis and GOS (Glasgow Outcome Scale) before and after **hyperbaric oxygen** treatment. RESULTS: In the treatment group GCS, BEAM and GOS were improved obviously after 3 courses of treatment, GCS increased from 5.1 to 14.6 (P<0.01-0.001), the BEAM abnormal rate reduced from 94.3% to 38% (P<0.01-0.001), the GOS good-mild disability rate was 83.7%, and the middle-severe disability rate was 26.3% compared with the control group. There was a statistic significant difference between the two groups (P<0.01-0.001). CONCLUSIONS: **Hyperbaric oxygen** treatment could improve obviously GCS, BEAM and GOS of severe **brain injury** patients, and effectively reduce the mortality and morbidity. It is an effective method to treat severe **brain injury**.

Title: *Hyperbaric oxygen* for *brain injury*.

Author(s): [Neubauer RA](#); [Gottlieb SF](#)

Source: [Journal of neurosurgery](#) [J Neurosurg] 1993 Apr; 78 (4), pp. 687-8.

Title: Clinical, *brain* electric earth map, endothelin and transcranial ultrasonic Doppler findings after *hyperbaric oxygen* treatment for severe *brain injury*.

Author(s): [Ren H](#); [Wang W](#); [Ge Z](#); [Zhang J](#)

Source: [Chinese medical journal \(Engl\)](#) [Chin Med J (Engl)] 2001 Apr; 114 (4), pp. 387-90.

Abstract: OBJECTIVE: To analyze the effect and mechanism of *hyperbaric oxygen* (HBO) treatment for severe *brain injury* (SBI). METHODS: Fifty-five patients were divided into a treatment group of 35 patients and a control group of 20 patients. We observed the alterations of clinical, *brain* electric earth map (BEAM), endothelin (ET) and transcranial ultrasonic Doppler (TCD) findings before and after HBO treatment as well as outcome. RESULTS: In the treatment group, Glasgow coma scale, BEAM and outcome improved after HBO treatment; compared with that of the control group, it showed a significant difference. After one course of treatment, treatment group ET was reduced from 91.24 +/- 12.18 ng/L to 68.88 +/- 14.37 ng/L (P < 0.01); in control group, ET was reduced from 90.78 +/- 15.71 ng/L to 83.12 +/- 12.22 ng/L, with a statistically significant difference (P < 0.05). TCD records of MCA mean velocity (Vm) was reduced from 64.2 +/- 4.8 cm/s to 51.6 +/- 4.2 cm/s (P < 0.01), and a decrease in MCA systolic velocity (Vs) and pulse index (PI) values was statistically significant (P < 0.01). CONCLUSION: HBO treatment can improve the clinical, BEAM and outcome of severely *brain* injured patients, by decreasing acute stage ET and improving the blood velocity of MCA and decreasing cerebral vascular resistance. HBO treatment can reduce cerebral vascular spasms, cerebral ischemia and hypoxia. One of the important mechanisms of HBO treatment for severe *brain injury* is the lowering of intracranial pressure.

Title: The effect of *hyperbaric oxygen* treatment on postural stability and gait of a *brain* injured patient: single case study.

Author(s): [Woolley SM](#); [Lawrence JA](#); [Hornyak J](#)

Source: [Pediatric rehabilitation](#) [Pediatr Rehabil] 1999 Jul-Sep; 3 (3), pp. 81-90.

Abstract: *Hyperbaric oxygen* (HBO) therapy has been found to reduce intracranial and cerebrospinal fluid pressures, and increase grey matter metabolic activity in patients with *brain* injuries. To date, few studies have quantitatively assessed the changes in the patient's functional outcomes following this expensive therapeutic intervention. The purpose of this case study was to examine the immediate and longer term changes in postural stability and gait in a 17 year old patient who sustained a traumatic *brain injury*, following administration of *hyperbaric oxygen* (HBO) therapy combined with physical and occupational therapy. The patient underwent assessments of postural stability and gait 1 week prior to HBO therapy, immediately following, and 6 weeks after completion of HBO therapy. Some improvements in postural stability were observed immediately following HBO, although these improvements were not evident 6 weeks later. Only slight improvements were noted in his walking abilities immediately following the intervention, with essentially little change evident 6 weeks later. The results of this do not support anecdotal evidence that there were substantial improvements in the subject's postural stability and gait following HBO therapy.

Title: [*Hyperbaric oxygen* inhibits neutrophil infiltration and reduces postischemic *brain injury* in rats]

Author(s): [Atochin DN](#); [Fisher D](#); [Thom SR](#); [Demchenko IT](#)

Source: [Rossiiskii fiziologicheskii zhurnal imeni I.M. Sechenova](#) [Ross Fiziol Zh Im I M Sechenova] 2001 Aug; 87 (8), pp. 1118-25.

Abstract: Reversible occlusion of the middle cerebral artery (MCA) was used to test hypothesis that *hyperbaric oxygen* inhibits the neutrophile infiltration into the ischemic *brain* thus reducing the *brain injury*. Treatment with *hyperbaric oxygen* prior to ischemia or during MCA occlusion significantly reduced neutrophile infiltration, motor disorders, and cerebral infarction volume.

Title: *Hyperbaric oxygen therapy for radiation-induced brain injury in children.*

Author(s): [Chuba PJ](#); [Aronin P](#); [Bhambhani K](#); [Eichenhorn M](#); [Zamarano L](#); [Cianci P](#); [Muhlbauer M](#); [Porter AT](#); [Fontanesi J](#)

Source: [Cancer](#) [Cancer] 1997 Nov 15; 80 (10), pp. 2005-12.

Abstract: BACKGROUND: Radiation-induced necrosis (RIN) of the *brain* is a complication associated with the use of aggressive focal treatments such as radioactive implants and stereotactic radiosurgery. In an attempt to treat patients with central nervous system (CNS) RIN, ten patients received *hyperbaric oxygen* treatment (HBOT). METHODS: Patients presented with new or increasing neurologic deficits associated with imaging changes after radiotherapy. Necrosis was proven by biopsy in eight cases. HBOT was comprised of 20-30 sessions at 2.0 to 2.4 atmospheres, for 90 minutes-2 hours. Sites of RIN included the *brain* stem (n = 2), posterior fossa (n = 1), and supratentorial fossa (n = 7). Histologic types included *brain* stem glioma (n = 2), ependymoma (n = 2), germinoma (n = 2), low grade astrocytoma (n = 1), oligodendroglioma (n = 1), glioblastoma multiforme (n = 1), and arteriovenous malformation (n = 1). RESULTS: Initial improvement or stabilization of symptoms and/or imaging findings were documented in all ten patients studied and no severe HBOT toxicity was observed. Four patients died, with the cause of death attributed to tumor progression. Five of six surviving patients were improved by clinical and imaging criteria; one patient was alive with tumor present at last follow-up. CONCLUSIONS: HBOT may prove to be an important adjunct to surgery and steroid therapy for CNS RIN.

Title: *Hyperbaric oxygen after global cerebral ischemia in rabbits reduces brain vascular permeability and blood flow.*

Author(s): [Mink RB](#); [Dutka AJ](#)

Source: [Stroke; a journal of cerebral circulation](#) [Stroke] 1995 Dec; 26 (12), pp. 2307-12.

Abstract: BACKGROUND AND PURPOSE: *Hyperbaric oxygen* (HBO) has been advocated as a therapy to improve neurological recovery after ischemia, since HBO may improve tissue *oxygen* delivery. We examined the effect of HBO treatment after global cerebral ischemia on early *brain injury*. METHODS: Rabbits were subjected to 10 minutes of global cerebral ischemia by cerebrospinal fluid compression. After 30 minutes of reperfusion, rabbits either were subjected to HBO for 125 minutes and then breathed 100% O₂ at ambient pressure for 90 minutes or breathed 100% O₂ for 215 minutes. At the end of reperfusion and 90 minutes after exposure, *brain* vascular permeability and cerebral blood flow were measured. Somatosensory evoked potentials were monitored throughout the experiment. RESULTS: HBO treatment reduced (P < .05) *brain* vascular permeability by 16% in gray matter and by 20% in white matter. Cerebral blood flow was lower (P < .05) in the HBO group (40.9 +/- 1.9 mL/min per 100 g, mean +/- SEM) compared with controls (50.8 +/- 2.0 mL/min per 100 g). Somatosensory evoked potential recovery was similar in the two groups (P > .05). CONCLUSIONS: HBO administered after global cerebral ischemia promoted blood-*brain* barrier integrity. HBO treatment also reduced cerebral blood flow; this effect was not associated with a reduction in evoked potential recovery. Since neurological outcome after global cerebral ischemia is generally poor and treatment options are limited, HBO should be further investigated as a potential therapy.