

# Hyperbaric Oxygen Therapy for Cerebral Palsy: Two Complications of Treatment

Gabrielle Nuthall, MBChB, FRACP\*; Michael Seear, MD, FRCPC\*; Michael Lepawsky, MD, FCFP‡; David Wensley, MBBS, FRCPC\*; Peter Skippen, MBBS, FRCPC\*; and Juliette Hukin, MBBS, FRCPC§

**ABSTRACT.** There is growing interest in the use of hyperbaric oxygen therapy (HBO<sub>2</sub>) 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<sub>2</sub>. 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. *Pediatrics* 2000;106(6). URL: <http://www.pediatrics.org/cgi/content/full/106/6/e80>; *hyperbaric oxygen, cerebral palsy*.

**ABBREVIATIONS.** CP, cerebral palsy; HBO<sub>2</sub>, hyperbaric oxygen therapy; Po<sub>2</sub>, pressure of oxygen; ICU, intensive care unit; ITP, idiopathic thrombocytopenia purpura; CT, computed tomography.

Cerebral palsy (CP) is a nonprogressive disorder of the developing brain affecting the motor system, with a broad clinical spectrum. It can be associated with epilepsy and abnormalities of speech, vision, and intellect. It affects ~2 to 3 per 1000 school-aged children.<sup>1</sup> It was previously believed that CP was the result of medical complications occurring around the time of delivery. However, there is growing evidence that the majority of cases are caused by intrauterine insults or structural abnormalities of the central nervous system.<sup>1,2</sup>

There is currently no known medical treatment for CP other than supportive care, usually provided by a multidisciplinary team in most pediatric centers. Understandably, some parents look for treatments outside conventional mainstream medicine. There is growing interest in the use of hyperbaric oxygen therapy (HBO<sub>2</sub>) for children with CP.<sup>3-7</sup> Although there is no scientific data to support the use of this therapy, private hyperbaric centers have been estab-

lished in Europe and North America principally for the treatment of CP.

Montgomery et al<sup>7</sup> recently published the results of a pilot study on the treatment of 25 children with spastic diplegic CP with HBO<sub>2</sub>. Results showed improved gross motor function and fine motor control, reduced spasticity, and improvements noted by the parents. However, this study has a number of limitations, many of which are acknowledged by the authors. It involved a small number of children, there was no control group, and there was no blinding of the therapists performing the assessments. The treatments were conducted at 2 different hyperbaric centers with different treatment protocols and some of the assessments were of a subjective nature.

During HBO<sub>2</sub>, the partial pressure of oxygen (Po<sub>2</sub>) in the blood is greatly increased by exposing the child to elevated ambient pressures while breathing 100% oxygen. Treatment regimens differ but generally treatments involve pressurization to 1.5 to 2 atmospheres for 60 to 90 minutes. Clients must breath 100% oxygen. In a multiplace chamber (hyperbaric chamber in which several patients can be treated simultaneously), this is administered through an enclosed vinyl diving hood with neck seals. Justifications for HBO<sub>2</sub> in CP vary but generally rely on a claim that high tissue oxygen levels can improve the function of damaged cells within the central nervous system.<sup>4,8,9</sup> There are no controlled trials to support these claims. At least 2 private centers have informative web sites explaining their rationale for treatment.<sup>8,9</sup>

When used for conventional indications, HBO<sub>2</sub> is generally safe. For treatments <120 minutes and pressures below 3 atmospheres, central nervous system complications occur in 1% to 2% of patients and reversible barotrauma in 15% to 20%.<sup>3</sup> We report 2 children with CP who required admission to our pediatric intensive care unit (ICU), each within a few hours of a hyperbaric oxygen treatment. The clinical presentation and close temporal association with HBO<sub>2</sub> suggest that this therapy is likely to have contributed to the complications.

## CASE REPORTS

### Case 1

A 4-year-old boy with CP was admitted to our pediatric ICU with severe respiratory distress, 2 hours after completing a hyperbaric oxygen treatment. He was the product of a breech presentation and required extensive resuscitation at birth. By 4 years of age, he could stand with support but had no speech and poor

From the \*Intensive Care Unit, Children's and Women's Hospital; ‡Hyperbaric Unit, Vancouver General Hospital; and the §Division of Neurology, Children's and Woman's Hospital, Vancouver, Canada.

Received for publication Apr 28, 2000; accepted Jul 14, 2000.

Reprint requests to (M.S.) Children's and Women's Hospital, Room 1C42, 4480 Oak St, Vancouver, BC V6H 3V4, Canada. E-mail: mseear@cw.bc.ca  
PEDIATRICS (ISSN 0031 4005). Copyright © 2000 by the American Academy of Pediatrics.

comprehension. He required anticonvulsant therapy for a symptomatic seizure disorder. During the day of admission, he received 2 courses of HBO<sub>2</sub>; each treatment lasted 90 minutes with 15 minutes for descent and 15 minutes for ascent. The child was dived to 1.75 atmospheres on each occasion. During treatment his head was completely enclosed by a vinyl hood with latex seals around his neck for delivery of oxygen. Between the 2 treatments he was fed orally. He regurgitated his feed during the second treatment. He subsequently developed increasing respiratory distress that prompted his intensive care admission. He had been well on the morning of the treatments and had no past history of aspiration or choking episodes. His chest radiograph revealed dense opacification of the left lung field compatible with an acute aspiration. He was treated with intravenous antibiotics, intensive chest physiotherapy, and bi-level positive pressure mask ventilation. He was discharged to the ward after 3 days in the ICU. A feeding study subsequently revealed free reflux and tracheal aspiration of feeds.

## Case 2

A 10-month-old boy with CP was admitted to our ICU with acute respiratory failure that required immediate intubation and ventilatory support. He also required intravenous anticonvulsants for control of what was observed to be a brief generalized tonic clonic seizure that occurred after positive pressure ventilation was instituted. His medical history was significant for severe perinatal asphyxia after uterine rupture during delivery. This resulted in spastic CP with microcephaly and developmental delay, cortical visual impairment, bulbar dysfunction, and recurrent pneumonia. The child had been receiving twice-daily hyperbaric oxygen treatments for the 2 days before admission. Each treatment involved pressurization to 1.5 atmospheres for 1 hour with 15 minutes to dive and 15 minutes to ascend. HBO<sub>2</sub> treatment was administered in a monoplace chamber, with a parent present, and with ambient oxygen of 100%. There were no obvious complications during treatment. Routine hematology on admission to the ICU revealed a platelet count of  $16 \times 10^9/L$  (normal range:  $180-140 \times 10^9/L$ ). A diagnosis of idiopathic thrombocytopenic purpura (ITP) was made, which was believed to be related to the parainfluenza type 3 found on tracheal aspirate. He subsequently had 2 further generalized tonic clonic seizures during the first day of admission. In view of the low platelet count and the ongoing seizure activity, a computed tomography (CT) scan of his head was organized to exclude an acute intracerebral hemorrhage. A CT scan of his head showed an acute nonhemorrhagic infarction of the left hemisphere thought to be attributable to a thrombus or embolus to the middle cerebral artery. An echocardiogram demonstrated a patent foramen ovale with bidirectional flow. No other embolic events were identified and coagulation studies were normal, no other investigations for a hypercoagulable state were performed. His thrombocytopenia responded rapidly to treatment with intravenous  $\gamma$ -globulin. In view of this rapid response and the recent association of a number of other children developing ITP in association with parainfluenza type 3, it was believed that a bone marrow aspirate to confirm the diagnosis of ITP was not necessary. He was extubated successfully soon after transfer back to his home state. The only clinical manifestation of the left hemispheric infarction was the onset of seizure activity. There was otherwise no change in his neurological examination.

## DISCUSSION

These 2 children with CP suffered significant medical problems shortly after hyperbaric oxygen therapy. We believe that the close temporal relationship between these 2 events, combined with the clinical features of the cases, support the suggestion that HBO<sub>2</sub> is likely to have been responsible for these complications.

In the first case, the child was well on the morning of his admission, did not have a fever, and was subsequently shown to have free gastroesophageal reflux with aspiration. It is likely that he suffered a serious aspiration event during the 90 minutes that his head was completely enclosed within a tight-

fitting vinyl hood. Gas buildup in the stomach during pressurization, either from a recent feed or from air swallowing, will conform to Boyle's law. During ascent from the treatment depth, there will be gas expansion with potential for reflux, aspiration, and vomiting.<sup>10</sup> This may have contributed to this child's aspiration event. Swallowing disorders and reflux are common among children with CP.<sup>11</sup> When planning a treatment regimen for this group of children, consideration of oral feeding, access to the airway, provision of trained personnel, and suction equipment would be a sensible minimum requirement.

Although the second case had a very low platelet count, the CT scan revealed an embolic or thrombotic, rather than a hemorrhagic, stroke. We propose that the most likely mechanism for the middle cerebral artery occlusion was a gas embolism. It was unlikely to have been an air embolism, but theoretically possible to have been an oxygen embolism. When breathing 100% oxygen at 2 atmospheres, the Po<sub>2</sub> in the arterial blood is  $>1000$  mm Hg. During the 15-minute ascent, this begins to fall, dropping to 100 mm Hg when breathing atmospheric pressure air. Oxygen is not highly soluble in plasma, so it is theoretically possible for bubbles of oxygen to form in the arterial blood during this equilibration period leading to occlusion of the middle cerebral artery.

Two other pathophysiological factors may be considered in accounting for the proposed clinical presentation of a cerebral oxygen embolism. During the decompression phase of treatment, oxygen bubbles might form in the lower pressure venous system and be ejected into the left atrium through the patent foramen ovale. They would then travel through the left atrium into the systemic circulation and might lodge in the left middle cerebral artery. Alternatively bubbles might sequester in the pulmonary arterial bed, ultimately pass through to the pulmonary venous bed, travel to the left atrium and left ventricle, and be ejected to lodge in the left middle cerebral artery. Both these mechanisms have been described in the literature.<sup>12,13</sup>

The Undersea and Hyperbaric Medical Society provides a list of conditions for which HBO<sub>2</sub> is an acceptable treatment. CP is not one of these indications. Their recommendation is that HBO<sub>2</sub> should not be used for any other indication except in the context of controlled clinical trials. Although HBO<sub>2</sub> is a relatively safe treatment, it does have documented risks.<sup>3</sup> Until the results of a randomized, controlled trial are available, we would suggest that HBO<sub>2</sub> not be recommended as a treatment for CP in children.

## REFERENCES

1. Perlman JM. Intrapartum hypoxic-ischemic cerebral injury and subsequent cerebral palsy: medicolegal issues. *Pediatrics*. 1997;99:851-859. Review article
2. MacLennan A. For the International Cerebral Palsy Task Force. A template for defining a causal relation between acute intrapartum events and cerebral palsy: International Consensus Statement. *Br Med J*. 1999; 319:1054-1059
3. Leach P, Rees P, Wilmhurst P. Hyperbaric oxygen therapy. *Br Med J*. 1998;317:1140-1143
4. Venter A, Leary M, Schoeman J, et al. Hyperbaric oxygen treatment for

- children with cerebral palsy. *S Afr Med J*. 1998;88:1362–1363
5. Cronje F. Hyperbaric oxygen therapy for children with cerebral palsy. *S Afr Med J*. 1999;89:359–361
  6. Kent H. Customers lining up for high-cost hyperbaric therapy. *Can Med Assoc J*. 1999;160:1043
  7. Montgomery D, Goldberg J, Amar M, et al. Effects of hyperbaric oxygen therapy on children with spastic diplegic cerebral palsy: a pilot project. *Undersea Hyperb Med*. 1999;26:235–242
  8. Available at: <http://www.hbotoday.com>
  9. Available at: <http://www.richmond-hyperbaric.com>
  10. Guyton A, Hall J. *Textbook of Medical Physiology*. 9th ed. Philadelphia, PA: WB Saunders Co; 1996:557
  11. Del Giudice E, Staino A, Capano G, et al. Gastrointestinal manifestations in children with cerebral palsy. *Brain Dev*. 1999;21:307–311
  12. Murphy B, Hartford F, Cramer F. Cerebral air embolism resulting from invasive medical procedures: treatment with hyperbaric oxygen. *Ann Surg*. 1985;201:242–245
  13. Muth C, Shank E. Gas embolism. *N Engl J Med*. 2000;342:476–482

## Hyperbaric Oxygen Therapy for Cerebral Palsy: Two Complications of Treatment

Gabrielle Nuthall, Michael Seear, Michael Lepawsky, David Wensley, Peter Skippen and Juliette Hukin

*Pediatrics* 2000;106:e80

DOI: 10.1542/peds.106.6.e80

|   |   |
|---|---|
| <b>Updated Information &amp; Services</b> | including high resolution figures, can be found at:<br><a href="http://pediatrics.aappublications.org/content/106/6/e80.full.html">http://pediatrics.aappublications.org/content/106/6/e80.full.html</a>  |
| <b>References</b>                         | This article cites 9 articles, 3 of which can be accessed free at:<br><a href="http://pediatrics.aappublications.org/content/106/6/e80.full.html#ref-list-1">http://pediatrics.aappublications.org/content/106/6/e80.full.html#ref-list-1</a>                         |
| <b>Subspecialty Collections</b>           | This article, along with others on similar topics, appears in the following collection(s):<br><b>Neurology</b><br><a href="http://pediatrics.aappublications.org/cgi/collection/neurology_sub">http://pediatrics.aappublications.org/cgi/collection/neurology_sub</a> |
| <b>Permissions &amp; Licensing</b>        | Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:<br><a href="http://pediatrics.aappublications.org/site/misc/Permissions.xhtml">http://pediatrics.aappublications.org/site/misc/Permissions.xhtml</a> |
| <b>Reprints</b>                           | Information about ordering reprints can be found online:<br><a href="http://pediatrics.aappublications.org/site/misc/reprints.xhtml">http://pediatrics.aappublications.org/site/misc/reprints.xhtml</a>   |

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2000 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



# PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

## **Hyperbaric Oxygen Therapy for Cerebral Palsy: Two Complications of Treatment**

Gabrielle Nuthall, Michael Seear, Michael Lepawsky, David Wensley, Peter Skippen and Juliette Hukin

*Pediatrics* 2000;106:e80

DOI: 10.1542/peds.106.6.e80

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/106/6/e80.full.html>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2000 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

