NEW DEVELOPMENTS IN CHILD NEUROLOGY

Editor

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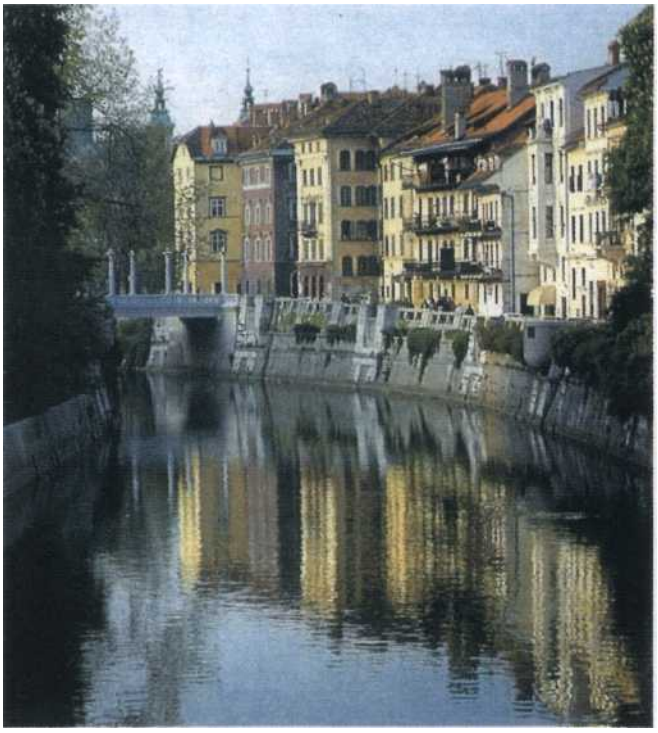

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Hyperbaric oxygenation: the recoverable brain in certain pediatric patients

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SUMMARY

Anoxic-ischemic encephalopathy and traumatic brain injury in children are examples of devastating conditions which can be responsible for decades of disability. A regimen of single photon emission computerized tomography (SPECT) scanning and hyperbaric oxygen (HBO) treatment is now available to identify recoverable (stunned or dormant) brain tissue and potentially improve function in such patients. A baseline scan is performed. A challenge with hyperbaric oxygen (1.5 ATA, 1 Hr, 1-20 txs) is given and the scan is repeated. Observation of increased flow is indicative of increased metabolism since the tracer crosses the blood brain barrier. Such positive changes seen in the SPECT are frequently paralleled with clinical improvement. PT, **OT, speech, biofeedback, occasional herbal medications are used as part of a multi-disciplinary brain repair approach. Three such cases will be presented, two cerebral palsy (M ages 3 and 4) and a F age 8, with closed head injury.**

MATERIALS AND METHODS

The protocol is one that had been previously published (1). It involves sequential SPECT (brain) functional imaging with an HBO challenge of (1 hr x 1.5 ATA) 1-2 times a day in a monoplace hyperbaric chamber (Vickers Ltd, Hampshire, UK). 10-20 exposures to HBO were performed to ascertain the possibility of recoverable brain tissue. The second scan was done within two hours following the HBO exposure prior to the second scan. **The radioactive tracer used was Tc 99m dl-**

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hexamethylpropyleneamine oxime (exametazime, dl HM-PAO, Ceretec). Scanning was done with a single head gamma camera technology (El Scint Model #SP 6). Certain patients required up to 200 exposures for maximum benefit.

CASE REPORTS

DW (Figs lA & 1B): 3 year old white male suffered perinatal hypoxic ischemic encephalopathy with renal failure consisting of acute tubular necrosis, thrombocytopenia, sepsis, respiratory insufficiency, hypovolemia and apnea related to seizure disorder. The CT scan showed progressive cortical atrophy. It is remarkable that this patient survived with the multiple illnesses. The patient received 21 treatments of HBO and is now able to sit up, hold a cup for the first time in his life

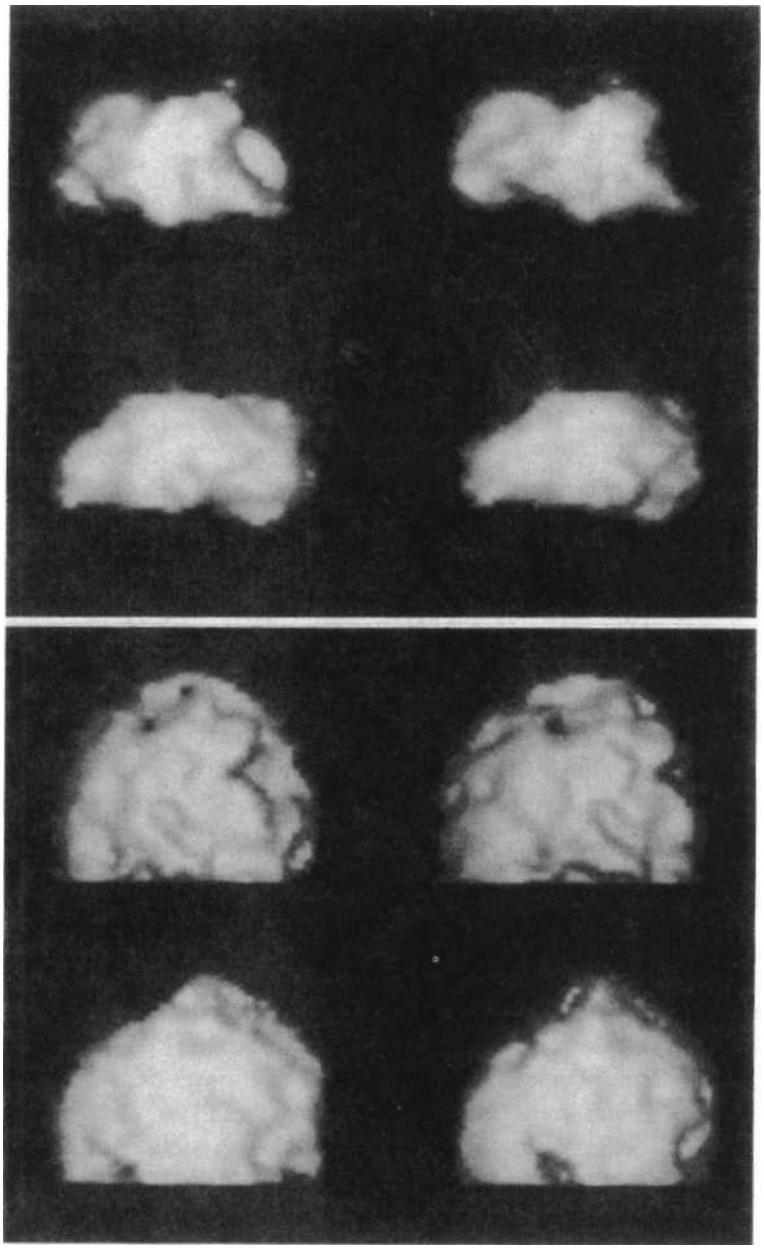

Figure 1 A: Case DW 3-D reconstruction pre-HBO treatment
Figure 1B: Case DW post 21 HBO treatments

and is more attentive. He is much more alert, makes new vocal sounds, is more aware of his surroundings and is beginning to grab at everything. These changes parallel SPECT scan imprint. It is hoped that future HBO treatments will be available with all types of supportive therapy.

DS (Figs 2A & 2B): 4 year old white male was seen with a severe traumatic birth, which caused a left mid cerebral rupture and then further developed Lennox-Gastaut syndrome (severe seizure disorder). He was seen four years later and had been continuously receiving PT, OT, and SP three days per week. He had done well on a ketogenic diet and developed the ability to chew. On the daily scale of infant development, mental status, he was less than 50 (normal = 90-110) basically with about an eight month level. He was seen with a spastic paraplegia, barely able to ambulate with assistance. The patient received 92 HBO treatments and improved

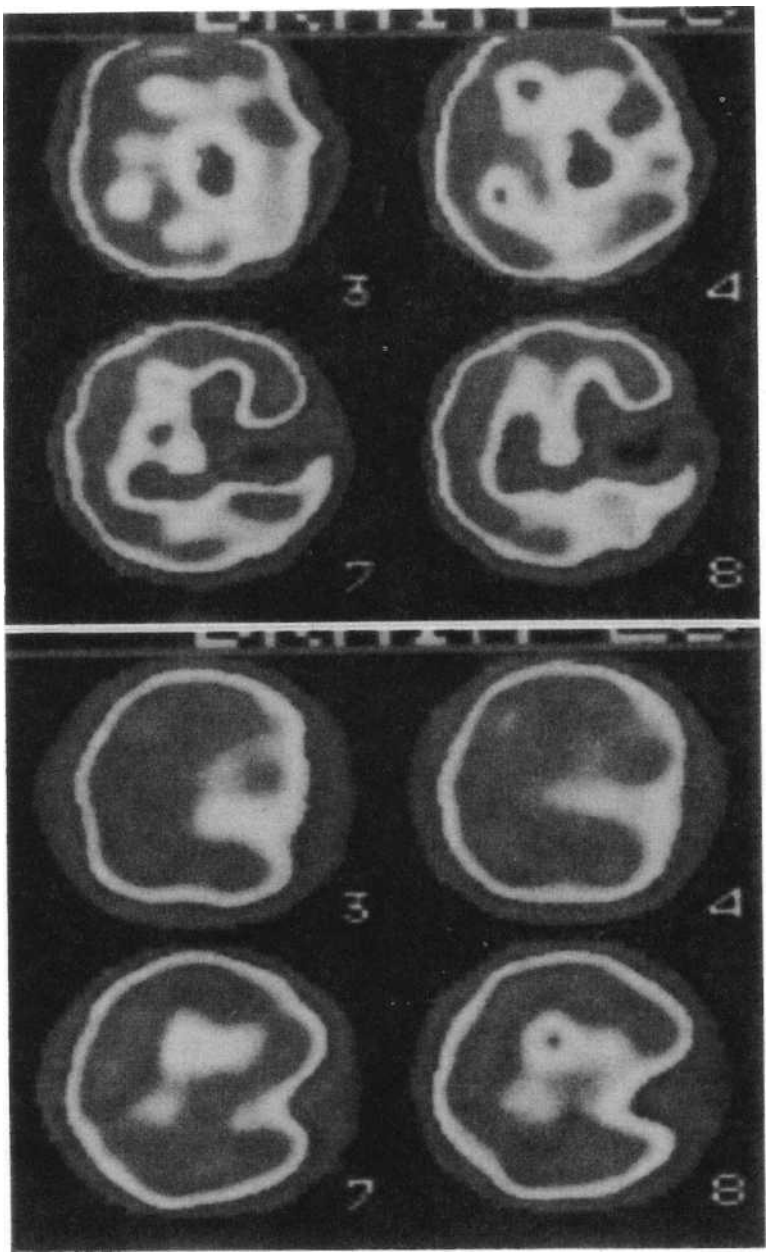

Figure 2A: Case DS axial view pre-HBO treatment
Figure 2B: Case DS post 76 HBO treatments

dramatically. The patient has become very much more active, following more commands, beginning to use his right hand to hold things, responds to his name and now able to run, but still with a slight limp.

TB (Figs 3A & 3B): 8 year old girl in motor vehicle accident, closed head trauma and 3 mo coma, total occlusion of the R mid-cerebral artery and spastic hemiparesis on the left. She wore a brace, had severe limp, speech deficits and was slow mentally, although attempting to go to school. SPECT scan showed an extensive deficit or complete infarct with the R middle cerebral **artery distribution.** She was seen 1 1 months post incident. SPECT scan before and after HBO showed substantial improvement. She was only able to stay for 24 treatments, but with HBO along with therapy, she was able to remove the brace. She became sharp mentally and was able to almost enter into full activities with other children. She was most pleased to become more socially accepted by her peers.

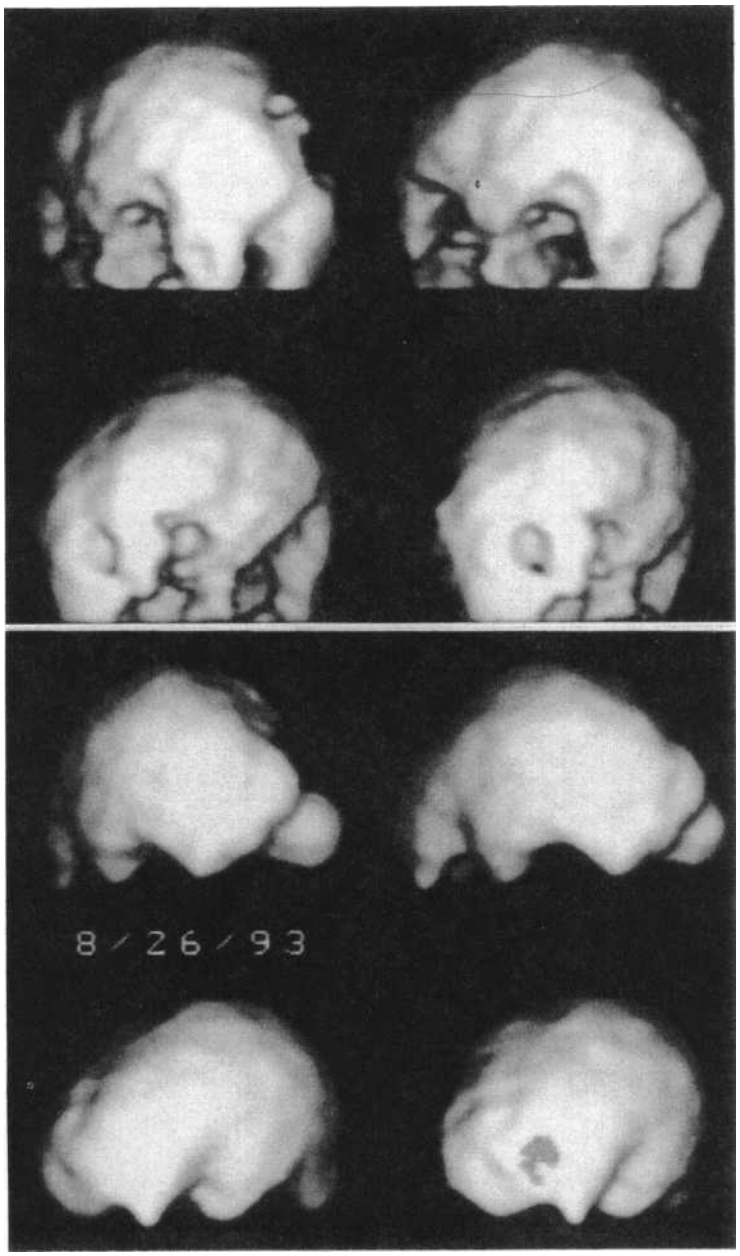

Figure 3A: Case TB 3-D reconstruction pre-HBO treatment
Figure 3B: Case TB post 3 HBO treatments

DISCUSSION

Cerebral palsy basically is an all inclusive term. In each instance, there is an ischemic or traumatic event that develops in utero, at birth or post delivery. A study has shown that the reduction of oxygen levels in the newborn has increased the incidence of brain injury or cerebral palsy (2). The use of 100% surface oxygen in infants has been abandoned because of the perceived risk of retrolental fibroplasia, which is only associated with prematurity. The use of intermittent high dosage oxygen under hyperbaric conditions is not associated with such a risk. In other areas of the world HBO has been used to treat in utero small fetuses and neo-nates without complications (3). Traumatic brain injury also produces varying degrees of incapacitation.

It is unfortunate that such children are sometimes not evaluated for hyperbaric oxygen for years after the insult and continue to sustain massive neurologic deficits. Recently, a charity in the United Kingdom "The Hyperbaric Oxygen Trust" was formed which is dedicated to the use of HBO therapy for cerebral palsy and the brain injured child. In this presentation we document specific evidence showing the positive effects of hyperbaric oxygen in three exemplary cases. These SPECT images show the marked increase in brain blood flow and metabolism following exposure to hyperbaric oxygen, paralleling clinical improvement, irrespective of the length of time from the original insult. We feel that the addition of hyperbaric oxygen will "jump start" the brain, particularly in the newborns and younger individuals who will be growing brain tissue in a more appropriate internal milleau.

HBO is the use of oxygen at greater than atmospheric pressure. It is the only method to achieve a significant increase in the concentration of oxygen in all body fluids: plasma, lymph, bone, urine and most importantly, the cerebrospinal fluid. According to Henry's Law there is a direct relationship between the pressure and the dissolution of oxygen. The ultimate mechanism of HBO is to furnish free molecular oxygen to hypoxic tissues. With this delivery it is immediately available for metabolic use without energy exchange. A significant experiment was done in 1959 showing that pigs could survive totally without blood in a hyperbaric environment (4). The delivery of oxygen under pressurized means is sufficient to sustain life.

Around the world, HBO is relegated primarily to wound care, air embolism, radiation damage, bone infections, decompression illness and carbon monoxide poisoning. More recently, there is a trend to further investigate the use of hyperbaric oxygen in the both acute and long term neurologic deficits. In both acute and chronic brain injury, where there is no matrix, pressurized oxygen has beneficial effects in that it: 1) reduces cerebral edema, 2) reduces intracranial pressure, 3) restores the integrity of the blood-brain barrier and cell membranes, 4) neutralizes toxic amines, 5) increases neovascularization, 6) acts as a scavenger of free radicals, 7) efficiently elevates diffusional driving force oxygen thereby, increasing tissue oxygen availability, 8) promotes phagocytosis, (thereby internal debridement), 9) stimulates angiogenesis and, 10) reactivates idling neurons. 11) Anti-platelet effects are also known along with a reduction of global and local ischemia. 12) Lactate peaks are promptly reduced. 13) Protection of the blood brain barrier and the integrity of the cell wall along with 14) oxygenation of the mitochondria are also achieved (5).

The side effects from the appropriate dose (dose = depth (ATA) of pressure + length of exposure + frequency + total number of treatments) of HBO are virtually non-existent (over 1.2 million treatments have been given in the United Kingdom). Perhaps this documentation will stimulate further interest in the use of hyperbaric

oxygen therapy in the early and late manifestations of cerebral palsy, anoxia and traumatic brain injury.

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