Effectiveness and Permanent Effect of Hyperbaric Oxygen Therapy for Cerebral Palsy with Single Photon Emission Computed Tomography imaging : a case report

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Conception of the article, literature research , data acquisition, article preparation and editing.

Abstract

A newborn boy was diagnosed with Cerebral Palsy (CP) after premature birth. Soon he needed intubation and transfer to neonatal care. At the age of 5 years and 6 months a SPECT scan with a tracer 99mTc-HMPAO demonstrated a prominent hypo perfusion at the right orbital gyrus, a minor hypo perfusion in the right precentral gyrus and the left post central gyrus and a deficit in activity in the right thalamus. After 5 months of hyperbaric oxygen treatment (2 months treatment, 1 month rest and then again 2 months treatment) there were obvious imaging and clinical improvements : a repeat SPECT scan demonstrated a complete normalized perfusion. This case study showed a normalization of the cerebral perfusion which was still visible 1 year after hyperbaric treatment and suggests an effect on a possible concomitant treatment of CP.

Keywords : Cerebral Palsy, Hyperbaric Oxygen Therapy, Single Photon Emission Computed Tomography, imaging pharmacokinetics, pressure pharmacodynamics.

Background

Cerebral Palsy is characterized by a neonatal oxygen deprivation. Treatments are focused on pharmacotherapy and physiotherapy and no current therapy has shown a clear benefit on reversing the patients disability.(17-21) The first notice of treating CP patients with HBOT was done in 1994 by Dr. Paul Harch, who is a Clinical Professor of Medicine, Section of Emergency Medicine at LSU School of Medicine, New Orleans.(12) Since then many other researchers have shown benefits with HBOT for CP children. (14-16) Although most studies are case reports, little Randomized Controlled Trials have been published. Mostly the results which where not in favor were made with a control/ placebo group at 1.3 ATA.(22) In this case report we gave a treatment with 1.3 ATA and analyzed the effects of HBOT by SPECT scan.

Case History

The patiënt is a 5 year old boy who was diagnosed with Cerebral Palsy after birth at 30 weeks 3/7. He was born with a cesarian sectio and needed intubation directly after birth, with a transfer to Neonatal intensive care. Apgar score : 6 after 1 minute, 6 after 5 minutes and 7 after 10 minutes. He showed a hypotonie with a low respiratory drive. He was extubated at day 1 and got nCPAP till day 7. His MRSA screening was positive, a MRSA decontamination was executed. Controls stayed positive so a 2nd and even 3rd decontamination was needed. The cerebral ultrasound at day 14 showed a intraventricular hemorrhage degree 3 on the left side. A repeat ultrasound at day 17 showed some dilatation of both ventricles.
In an attempt to restore the developmental abnormalities, several concomitant therapies have been tried : Bobath, TrainM, spalking, speech therapy and physiotherapy. Continuing therapies from before and during HBOT treatment are : ABM, ABR and MNRI.

Management and Outcome

At the age of 5,5 years he started Hyperbaric Oxygen Therapy (HBOT). The patiënt received 2 x 40 sessions : 1.30 ATA/60 min total treatment time (building up pressure is 5 min, 55 min of 1.30 ATA) , once per day, 5 days per week. After 40 treatments there was a pauze of 1 month. Then the same protocol was used for the last 40 treatments.

Before HBOT a SPECT scan with a tracer 99mTc-HMPAO demonstrated a prominent hypo perfusion at the right orbital gyri, a minor hypo perfusion in the right precentral gyrus and the left post central gyrus and a deficit in activity in the right thalamus. He then received 2 x 40 sessions of HBOT and a control SPECT was made that showed a normalization of the perfusion over the whole brain. (Fig. 1)

A third SPECT was made 1 year after the second to evaluate if this therapy has made permanent changes to the brain circulation. In this third scan we saw that there was no decrease of perfusion if compared to the second scan. Which indicates that HBOT has had a permanent effect and that there was not only a temporary increase of the circulation due to the administration of oxygen.

Clinically there were also remarkable changes since the start of the HBOT. At session 7 he started to eat more, which has always been a problem before. At session 9 the physiotherapist noticed less spasms and better movement. At session 16 he walked with more stability and he could keep his balance when pushed in standing position. During session 25 he was able to keep his legs parallel to each other while lying down. A clinical control showed a better walking stability with a strait back. During the rest of the sessions there were slighter improvements. A clinical evaluation after session 40 showed a great increase of stability and mobility, which were even more visible after session 80.

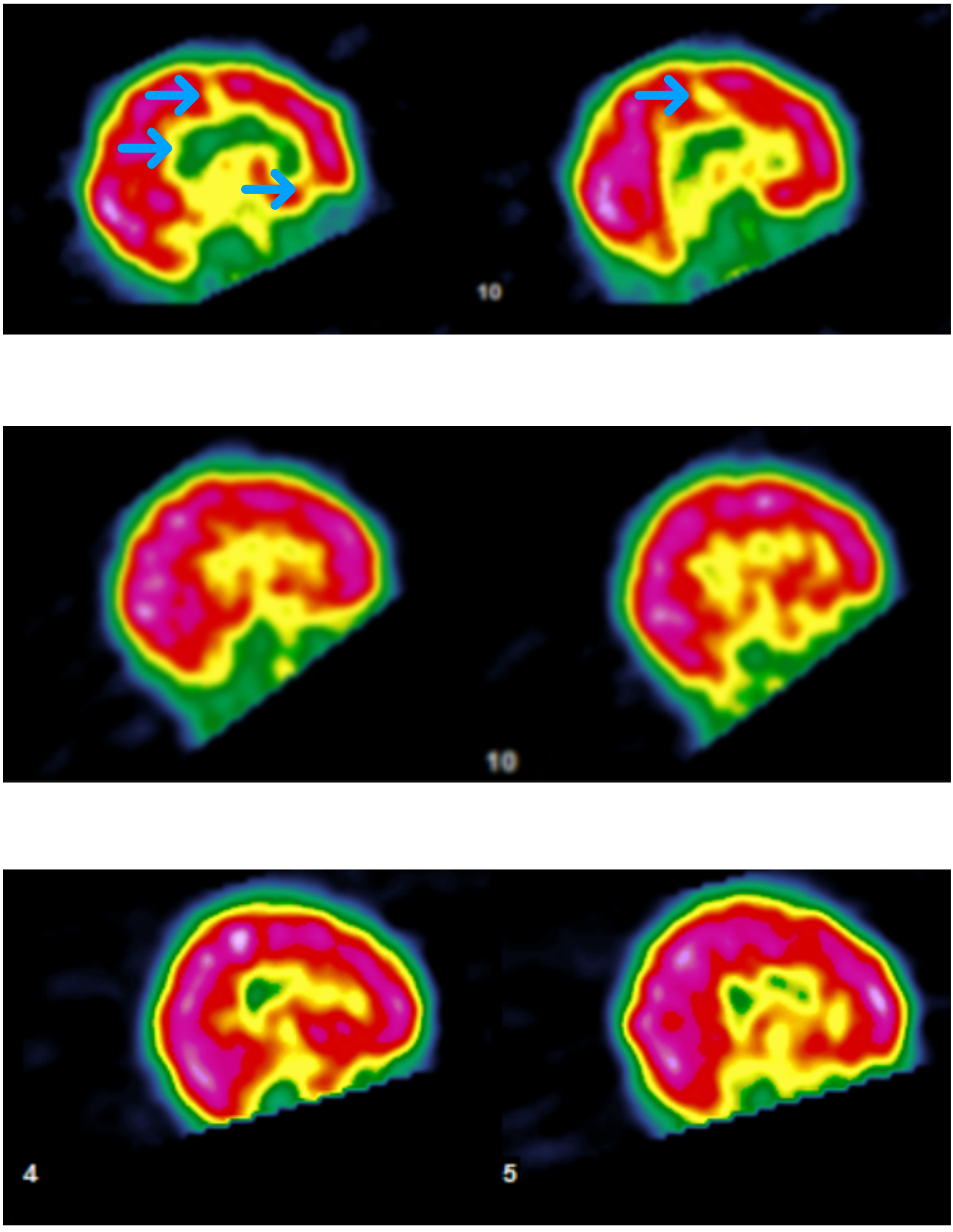

Fig. 1 : Single Photon Emission Computed Tomography brain flow imaging 3 days before (first picture), 3 days after 80 sessions of HBOT (middle picture) and 1 year after hyperbaric treatment (last picture). Note the local (arrows) and global increase of perfusion

Discussion

Cerebral Palsy (CP) is a group of movement disorders that appear mostly within the first two years of life and affects a child's ability to move and maintain balance and posture.(1) (4) CP is caused by abnormal brain development or damage to the developing brain and is the most common motor disability in childhood. (5) It occurs in about 2.1 per 1,000 live births. (2)
Symptoms include poor coordination, stiff or weak muscles and tremors (1) and they may vary among people and over time. (1)(3). The patients may have seizures, intellectual problems, or problems with sensation, vision, hearing, swallowing or speaking. (1)
There are four types of CP : Spastic CP (80%), Dyskinetic CP, Ataxic CP and Mixed CP.
Treatment exists mainly of supportive treatment : physiotherapy, occupational therapy and speech therapy. Medications could be diazepam, baclofen and botulinum toxin. Surgery may include lengthening of muscles and cutting overly active nerves (1). Also braces and robotic aide are used to overcome the symptoms. But, until now, no treatment has scientifically proven to be beneficial in the treatment of CP.

The UHMS defines hyperbaric oxygen (HBO2) as : "An intervention in which an individual breathes near 100% oxygen intermittently while inside a hyperbaric chamber that is pressurized to greater than sea level pressure (1 atmosphere absolute, or ATA)". (6)
According to the 3 gas laws (fig. 2) (especially Henry's Law) the higher pressure dissolves the oxygen in the plasma, allowing it to reach regions that are difficult to reach by the red blood cells (7). So more oxygen can be delivered to the cells and enhance the mitochondrial activity (8) of the penumbra (9). This penumbra is the region around the infarcted area that gets just enough oxygen to stay alive, but that can't perform any other function.

- Dalton's Law : In a gas mixture, each gas exerts its pressure according to its proportion of the total volume.
- Henry's Law : The concentration of a gas in a fluid is determined not only by the pressure but also by the "solubility coefficient" of the gas.
- Boyle's Law : The absolute pressure and volume of a given mass of confined gas are inversely proportional, provided the temperature remains unchanged within a closed system.

Fig. 2 : The 3 gas laws

Low-pressure HBOT is also known to grow new vascularization in lesions, restoring the function of the penumbra. (13)

These findings were also confirmed in this case study of a 5 year old boy with CP. Before the beginning of the HBOT treatment, a 99mTc-HMPAO SPECT imaging showed clear perfusion lesions in the brain. Due to the extra amount of oxygen delivered by HBOT we saw an increase of the perfusion on a control SPECT after 80 sessions of HBOT. No angiography was performed, but the increase of perfusion could be explained by the creation of new vascularization in the affected areas. The 99mTc-HMPAO SPECT imaging showed clearly the full restoration of the perfusion after the 80 sessions of HBOT. In the third SPECT we saw that the increase of circulation was still present 1 year after treatment. This suggests that the effect seen in the second SPECT was not only created by the high intake of oxygen, but was due to anatomical changes in the brain, probably the growth of new vascularization. Accordingly the functional tests also showed an increase of gross motor function (which are still visible after 1 year), suggesting an increase and possibly a restoration of cerebral cell function.

A limitation of this study was the single patient setting and the lack of angiography.

While HBOT has long been described as a possible treatment of CP (10), no large randomized studies has yet been conducted and further research is needed.(10)(11)

Conclusion

In this case study of a 5 year old boy with CP, a 2 times 8 week treatment of low-pressure HBOT (80 sessions) at 1.3 ATA caused a significant increase in cerebral perfusion on 99mTc-HMPAO SPECT imaging with concomitant symptomatic improvement. This effect was still visible on imaging 1 year after the hyperbaric treatment. So treatment with hyperbaric oxygen therapy could be considered to treat CP children who do not respond well to classic treatments.

Footnotes

Conflicts of interest

Kris De Pauw is medical director of a hyperbaric facility that does treatment and consulting on hyperbaric medicine.

Declaration of patient consent

The autor certifies that he obtained a patient consent form. The parents of the patient have given their consent for the images and other clinical information to be reported in the journal. They understand that his name and initials will not be published and due efforts will be made to conceal his identity, but total anonymity cannot be guaranteed.

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