Hyperbaric Oxygen for Treatment of Stroke & Traumatic Brain Injuries

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Oxygen is Mother Nature's most natural drug, most important nutrient and the element most essential to life. Hyperbaric oxygen therapy is a unique and important treatment which uses oxygen under pressure for the correction and healing of stroke and traumatically brain injured (TBI) individuals. The first clinical use of hyperbaric oxygen for the treatment of stroke patients was reported in 1965 and many studies have been done since then proving its safety and effectiveness.1,2

Most people believe that a stroke is due to the death of brain cells. Brain cells are thought to die as a direct result of the interruption of blood flow and the resulting lack of oxygen to a part of the brain. This concept of what a stroke is has been dogma for at least the last 100 years. This traditional concept of infarction, that the brain tissue dies from a blood and oxygen shortage lasting more than a few minutes, is no longer valid.1 A different concept has been slowly evolving over the past 25 years that the death of brain cells occurs only when the flow of blood falls below a certain level (approximately 8-10 ml/100 gr./min.) while at slightly higher levels the tissue remains alive but not able to function. Thus in the acute stroke the affected central core brain tissue may die while the more peripheral tissues remain alive for many years after the initial insult, depending on the amount of blood the brain tissue receives.

Those brain areas that are injured and are not receiving enough blood flow as a result of the stroke or trauma are now referred to as the "ischemic penumbra." This is the area that surrounds the central core of infarcted (dead) tissue. These "rim" tissues do not receive enough oxygen to function but do receive enough to stay alive. These brain cells have been described as "sleeping beauties," "sleeping neurons," or "dormant" or "idling neurons." These neurons are nonfunctional but anatomically intact and can be revived. When I describe this phenomena to my patients, I explain that some of the brain cells are sick and just like we do when we are sick, we want to lie down and not do anything. You also tend to be more grumpy, tired and irritable than otherwise. These sick brain cells often are responsible for the stroke or TBI patient being grumpy, irritable, fatigued, depressed, etc. because cells in the emotional and cognitive areas of the brain are not functioning effectively.

In the acute case as much as 85% of the brain injury involves those tissues that surround the central core of dead brain tissue. It is this ischemic penumbral tissue that the newly approved "clot busting" drugs (tPA-tissue plasminogen activator) help to save if they are given within the first three hours of the onset of a blood clot type of stroke. Hyperbaric oxygen is being considered as a treatment in conjunction with tPA in the acute stroke setting since it will extend the period of time during which the tPA can be given.

A fundamental aspect of the pathology of chronic stroke and TBI patients is that damaged blood vessels are the cause of the ischemic penumbra. Unfortunately the brain has only limited healing properties and these seem to run their course during the first year after the traumatic brain injury. During this first year a number of healing processes are occurring. A major damaging process that occurs in the acute stroke or TBI is edema (swelling of the tissues as a result of the damage). This swelling may take up to 9 to 12 months to resolve and during this time the swelling will be compressing brain blood vessels Ð limiting the flow of blood to the damaged tissues. As the swelling goes away, some of the blood vessels will regain their original diameters and normal blood flow will resume.

Another process that occurs during this first year is "neovascularization," also known as "angiogenesis." This is the process of forming new capillaries which extend from the surrounding healthy brain tissue into the areas of the ischemic penumbra. The outermost portions of the ischemic penumbra (those portions closest to normal brain tissue) are able to metabolize slightly since they are receiving more blood than the more centrally located ischemic tissues. This metabolism releases a breakdown product of ATP called adenosine. Adenosine is released from ischemic tissues when ATP is being utilized by the cell for repair processes. Adenosine is a vasodilator and also stimulates new capillaries to grow into the ischemic penumbra (neovascularization). Thus during the first year after a stroke or TBI, new blood vessels are stimulated to move into the ischemic penumbra to re-supply it with a new blood supply.

Unfortunately, the ischemic penumbral tissues closer to the infarct area usually are not receiving enough oxygen or nutrients to generate ATP Ð either from aerobic or anaerobic metabolism. Due to the lack of ATP formation, adenosine

is not produced and the formation of new capillaries does not occur. Thus the ischemic penumbra remains ischemic because the process of neovascularization is not able to be completed. This often results in a substantial amount of brain tissue that remains ischemic and non-functioning in the chronic stroke and TBI patient's brain. This failure of natural healing processes is due ultimately to damaged blood vessels and their inability to provide oxygen and nutrients to those portions of the brain that are damaged.

Hyperbaric oxygen works to improve stroke and TBI patients by repairing and generating new blood vessels to the injured parts of the brain. Once the ischemic tissues no longer suffer from a lack of oxygen, they are able to begin to repair the injured neurons, glial cells and extracellular matrix. The generation of new blood vessels occurs as a direct result of daily hyperbaric oxygen treatments. This does not occur with pure oxygen at normal atmospheric pressures. The number of treatments required varies for each individual but in my experience the best results occur when at least 60 daily treatments are done. If only 20 to 30 treatments are done, the patient will often experience "backsliding" and may lose some of the improvement they gained from the hyperbaric oxygen treatments. In addition, some patients will not even begin to improve until they have had more than 30 or 40 treatments.

Hyperbaric oxygen therapy feels much like going for a ride in a modern day jet Đ the chamber even looks like the cockpit of a jet fighter plane! As you start your treatment you are sitting upright at a comfortable angle inside of this cockpit-like chamber. You have an oxygen mask over your mouth and nose, the door is shut and you feel a slight movement of air as the chamber begins to be filled with more air. As the air enters the chamber you may notice a slight discomfort in one or both ears just like you have experienced while flying in the large commercial jets. You may choose to swallow, chew gum or hold your nose and blow outward to help equalize the pressure in your ears. We have seen three patients out of more than 500 who have had enough pain and discomfort in clearing their ears that we have had to send them to the ear specialist for a simple insertion of a small tube through the ear drum. In these cases, this cured the problem so the person was able to continue with the program without further pain and with no problems with their hearing.

Severe, advanced emphysema may be a contraindication if the person has large lung bullae (large air filled sacks within the lung). The bullae may trap the oxygen and rupture while the person is decompressing. The presence of large bullae can be checked by ordering a CT exam of the chest.

Patients who have had a seizure worry about having another episode while in the chamber. K.K. Jain1 the MD neurosurgeon who wrote the Textbook of Hyperbaric Medicine states, "Seizures are extremely rare and no more than a chance occurrence during HBO sessions at pressures between 1.5 and 2 ATA even in patients with a history of epilepsy." Our experience is similar.

Claustrophobia is an often voiced fear but once the person begins to work with our technicians, he or she is generally able to overcome their fears without a problem.

Muscle, bone and peripheral nerve dysfunction and atrophy are also major factors that are present in many patients. This is due to inactivity, loss of weight bearing, hormonal deficiencies, mineral deficiencies and a variety of different disease states. These dysfunctions and atrophy require aggressive, daily rehabilitative efforts for a minimum of two months to produce significant, long term beneficial results.

From a practical point of view, the patient who is being considered for hyperbaric oxygen therapy can be tested to determine if he/she is a candidate. A 3-D SPECT scan (single photon computerized tomogram) for determining cerebral blood flow is available at most larger hospitals in the USA. If this test is done and shows diminished brain blood flow, the patient has a good chance for significant improvement with a course of hyperbaric oxygen treatments.

The treatments are usually 90 minutes each day for 60 days. In my experience, this protocol produces the best overall results when the therapy is given in combination with other treatments such as physical, occupational and biofeedback therapy. Our average patient comes to us 2-1/2 years after their stroke or TBI. They usually have gone through all of the standard therapies and have not improved over the past year despite continuing physical therapy and an active exercise program. They or their family members recognize their lack of improvement and come to us as "the last hope." Due to the severity of their disabilities and their failure to improve with conventional therapies, most patients hope that the use

of hyperbaric oxygen will produce gratifying results. However, even with 60 days of hyperbaric oxygen treatments, the results may not reach their expectations, especially if only hyperbaric oxygen is used. Most every patient we see would like to maximize their chances of improving while they are attending our clinic. In view of their desires and the fact that the combination of hyperbaric oxygen and other therapies produces improved overall results, we offer daily physical, occupational, speech, vision, biofeedback, nutritional, vitamin, hormonal and growth factor therapies to help our patients reach their maximum recovery potential.

In addition to the use of the above mentioned therapies I have also found that many patients have other disease processes which must be treated to maximize their recovery. Many patients when entering our program suffer from chronic urinary tract or other infections, have autoimmune disorders such as vasculitis, suffer from diabetes and diabetic neuropathy, have osteoporosis of the paralyzed limb(s), have serious atherosclerosis or have hormonal deficiencies. All of these conditions and problems must be addressed to help maximize the patient's healing.

Results of Fifty Cases:

Fifty stable and no longer improving stroke patients (average age 62 years) with an average time of 28 months since their stroke received hyperbaric oxygen therapy for 90 minutes each day, 6 days a week for 60 treatments, as well as physical therapy for 2 hours and EEG Biofeedback for 30 minutes each day, 5 days a week. Physical therapist's evaluations and patient's questionnaires were collected prior to and after the program.

Results from patients' questionnaires showed that 95.83% of the patients or their family members believed that the patient experienced one or more improvements in their motor ability, sensitivity to touch and temperature, bladder and bowel control, cognition, memory, speech, sight and hearing. At the conclusion of the program, 29% of the patients ranked the program as good, 42% of the patients ranked it as excellent, and 25% reported that this program was stupendous.

The physical therapist's evaluation included range of motion, extremity's strength, bed mobility, bed to chair transfers and body's balance level. By the therapist's evaluations, 100% of the patients showed improvements in one or more functions. Of those, 18% had a mild gain, 48% received a good gain, and 34% an excellent gain.

No side effects or problems were encountered with the combination of therapies for treating chronic stroke patients.

Hyperbaric Oxygen Therapy Can Repair Brain Damage

A new way of treating brain damage might help people who sustained brain injury following stroke or other trauma, even years after the fact.

Researchers at Tel Aviv University in Israel used hyperbaric oxygen therapy (HBOT) — a well-known method of treating decompression sickness, or "the bends," in scuba divers — in 74 post-stroke patients whose conditions were no longer improving six months to three years following the stroke.

Hyperbaric oxygen therapy takes place in a high-pressure oxygen chamber and raises the body's oxygen level tenfold. Led by Tel Aviv University's Shai Efrati, MD, the researchers hypothesized that such amped-up oxygen levels could revive inactive neurons in the brains of the post-stroke patients.

It seemed to work. After two months of hyperbaric oxygen therapy, brain images showed increased activity in the treatment group compared to a non-treatment control group. The patients showed visible improvements, too, such as paralysis reversal, increased sensation, and renewed language use.

The findings, published in the journal PLOS ONE, suggest that hyperbaric oxygen therapy is a viable treatment for post-stoke patients — even patients for whom it may seem too late for additional treatment. The study didn't include any

participants more than three years post-stroke, but the researchers believe they would see similar results in patients whose stroke had occurred far earlier.

"The findings challenge the leading paradigm since they demonstrate beyond any doubt that neuroplasticity can still be activated for months and years after acute brain injury, thus revealing that many aspects of the brain remain plastic into adulthood," said Eshel Ben-Jacob, a Tel Aviv University professor who also worked on the study, in a release from the university. ("Neuroplasticity" refers to the brain's ability to make new neurons and build new nerve pathways.)

Hyperbaric oxygen therapy appears to help restore brain activity by providing brain cells with a major energy boost. Of course, the brain gets oxygen from normal breathing — but apparently not enough to repair brain damage. Ten times the amount of normal oxygen, via hyperbaric oxygen therapy, kicks brain cells into high-gear, according to Dr. Efrati, rebuilding brain connections and stimulating inactive neurons.

Efrati and colleagues are currently testing hyperbaric treatment on people with traumatic brain injury. The therapy may also have a place in treating early-stage Alzheimer's disease and dementia.

Additionally, a 2012 study found hyperbaric oxygen therapy useful in slowing the progression of type 1 diabetes in mice.

"It is now understood that many brain disorders are related to inefficient energy supply to the brain," Efrati said in the Tel Aviv University release. "[Hyperbaric oxygen therapy] could right such metabolic abnormalities before the onset of full dementia, where there is still potential for recovery."