**HYPERBARIC OXYGEN THERAPY:**

**A Game changer in the practice of veterinary medicine**

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**Introduction**

**Of all the relatively new technology that I have been using as a practicing veterinarian over the last 25 years, it is without a doubt, that hyperbaric oxygen therapy (HBOT), or *therapy done by placing a patient in a sealed chamber and adding air or oxygen or a combination to it so that the pressure being applied to the patient is greater than the surrounding atmospheric pressure*, is one of the most effective in the care of *almost all diseases and injuries as an adjunct* to that care, and in some cases, like carbon monoxide and acetaminophen poisoning, as *a primary therapy*. (1) It is estimated that I have been involved as a consultant, or as the primary health care provider in HBOT more than 13,000 times.** With this experience I have literally seen results what would be called a miracle in the lives of countless numbers of patients. I also have other colleagues that have first-hand knowledge or witnessed many improvements in the patients following HBOT. These colleagues include Cheryl Braswell, DVM, DACVECC, CHT-V, CCPM; Salley Gregg, DVM; Dan Hume, DVM, DACVECC; Pierre Bichsel, DVM, DECVN, DACVIM (Neurology); DACVIM; Ron Lyman, DVM, DACVIM, DACVIM (Neurology); Diane Levitan, DVM, DACVIM; Jerry Jensen, RVT; Kelly Kesling RVT; Hilty Burr, DVM; Joey Gross, DVM and Tiffiny Husan, RVT. Others, as well, have experienced and have documented improvements in patients following HBOT and their names could also have been included as clinicians with experience in this presentation and I apologize for not including them. The patients (or friends or relatives) I have treated have included dogs, cats, humans, rabbit, duck, goose, chicken, mouse, rat, turtle, lamb, deer and hamster. Because of documented improvements in their lives from the use of HBOT I am providing this white paper prior to submission for publication and give permission to FETCH 360 to make it available to all.

I am a board-certified surgeon (since 1985) and a board-certified emergency and critical care specialist (since 1989) with both in academic and private practice experience as well as being honored to have been chosen by the Veterinary Emergency and Critical Care Society as the 2004 Dr. Ira M. Zaslow Award winner “in recognition of excellence in teaching, and innovation in critical patient care.” It is from innovation that I began using HBOT in clinical practice and I genuinely believe every veterinary practice and their patients (foremost in the minds of each practicing veterinarian) would benefit from getting a chamber (either a mild or standard pressure hyperbaric chamber) and using it as a standard part of the care that they commonly provide.

I was introduced to HBOT in 1993 when I was doing a trauma surgery rotation at the RA Cowley Shock Trauma Center in Baltimore, Maryland. It is a seven-story hospital devoted to the care of the trauma patients from the four state region around Baltimore.

In the basement level of the center (which is a seven-story level-I trauma center, devoted almost exclusively to the care of human trauma patients), was a multi-place HBOT chamber and this chamber and its crew was directed by Roy A M Myers, MD, FACS, a trauma and general surgeon with a specialty in hyperbaric medicine. He was the Director of the Hyperbaric Medicine Program, Maryland Institute for Emergency Medical Services Systems, and a member of the Undersea and Hyperbaric Medical Society (UHMS) Hyperbaric Oxygen Committee. I remember only meeting him briefly, but while there at Shock Trauma I had an opportunity to observe patients with various types of injuries being treated in the multi-place HBOT chamber. I was impressed of what I could see visibly and heard from patients and trauma physicians and surgeons caring for these people. The dissipation of wound edema and improvement in the color of the tissues was striking when comparing those treated with HBOT and those not treated. *After seeing such a positive outcome with those that were treated with HBOT compared to those not treated I wondered why ALL patients were not treated with HBOT.* The answer to that involves too many aspects of health care in general to go into much detail, but suffice it to say, I believe the answer has to do with the lack of education and training that doctors receive regarding HBOT in most all the US medical schools and residencies (2), that HBOT has specific indications but going outside these is “subject to question” by the FDA and the NIH as there are not research dollars in HBOT as there is in pharmaceuticals. (2) In many other countries there are over 60 conditions approved by the medical authorities. (3,4) In the US only 14 are approved. (3,4,5,6, 7) I will cover more of this later after I provide information as to many changes that HBOT does to various types of cells and tissues that provide extremely positive environment for healing and that includes *all wounds*, both acute and chronic, and *both those externally that one can see as well as those that are internal and affect all body systems* (such as a “wound” involving the heart caused by a myocardial infarction or a “wound” involving inflammation of the lungs caused by SARSCoV2 COVID-19 viral infection). (4,5,6,7) Back to the introduction history as to my start with HBOT.

I came back from that rotation with the thought that I should be looking into this for our own 24-hour emergency-critical care and specialty center in Milwaukee, WI. Then, as it was planned by God, *and now I am sure that it was,* two things happened to me:

1. I was able to attend some lectures on hyperbaric medicine that Dr. Eric Kindwall was giving at the Medical College of Wisconsin in Milwaukee, only a few miles away from AEC. He then invited me to spend time with him at his practice at Saint Luke’s Medical Center where he was the Director of the Hyperbaric Center there. He was also on the UHMS Hyperbaric Oxygen Committee at the time. I was fascinated by the breadth of the knowledge regarding HBOT that he had. He encouraged me to get the chamber, get the training I would need to operate it safely and effectively, and then get started. He gave me a copy of the latest book he had edited, Hyperbaric Medicine Practice. (7)

2. I was introduced to a man who had developed HBOT chambers for small animals. His name was Robert Groenevelt, who he later told me he was related to a cardiovascular surgeon in Holland that had performed many operations repairing heart defects in children in a large hyperbaric operating room in Holland in the 1950’s and 60’s. (5) I remember that Robert said maybe someday we could design a hyperbaric operating room for small animal veterinary surgery as well, and he smiled at me. He said this as I saw, for the first time, his chamber. It was at a Wisconsin VMA Meeting. It was made primarily of very thick stainless steel and was approximately 4’ long and 3 ½’ in diameter. I found out his hyperbaric company, Oxy-Tec, Inc, was based in Waukesha, WI, not far from the Animal Emergency Center [AEC] in Milwaukee where I was practicing. It was the Animal Emergency Center that we had converted into a 24-hour emergency and specialty practice in July,1991.

I signed a Revenue Sharing Agreement with Mr. Groenevelt in March 1997, and he brought the chamber over to the practice and installed the oxygen supply and ventilation system we all were given training sessions on safety and how to perform HBOT on pets. Soon our practice was treating dogs and cats with the chamber. We were the only veterinary HBOT facility in all of Wisconsin. After the course of several weeks the practice had treated over 40 animals. The diseases and injuries I centered on were the same ones I had seen being treated at Shock Trauma. Many were wounds and as we were the only 24-hour emergency and specialty practice in the area we did not have a shortage of these. What impressed me initially wad the observations that were made with severe dog bites with much crushed and infected tissue. The experience I had briefly observed at Shock Trauma was mimicked, with rather dramatic decreases in swelling and improved healing rates and with less infection and healing complications noted as compared to before (when we did not have the ability to treat them with HBOT.

As a veterinary surgeon, I was particularly sold. My practice partner, Dr. Rebecca Kirby, also saw the difference in similar cases (when comparing those that were treated with HBOT and those where not treated with HBOT. Our interns and residents also saw positive results with HBOT, and owners were also incredibly pleased. With these results that we had seen, the purchase of the animal chamber was made. Mr. Robert Groenevelt, and his team that built the chamber continued to provide further training and helped with announcements to many veterinarians in the area that we had a chamber available for their patients and we would provide the HBOT service on either an outpatient or inpatient bases, with those requiring inpatient care being generally those more critical, such as those with neurological injuries, severe wounds, severe infections, or those with diseases involving severe inflammations.

OxyVet chambers were also sold to other practices and training was provided to veterinarians in several other states. One of those practices was in Carson City, Nevada. Little did I know it at the time I had begun using the chamber in Milwaukee, that I would be asked to join that practice a little bit of time later. Again, it was God, I believe, that had guided the owner of that practice to purchase a chamber, but until I began working at that practice in July 1997, the chamber had not been used much at all. It was truly a blessing that I was asked to become a surgeon and emergency and critical care specialist for that practice. As soon as I was there, I encouraged the owner and other veterinarians in that practice to begin providing HBOT in so many of the cases seen, as again, this practice was a 24-7 emergency and specialty practice.

In those early years of HBOT experience in veterinary medicine practices had a chamber and many were not used to their full potential. But as time marched on, I as well as others, became very convinced that the *HBOT could benefit so many small animal patients*. And so, I started this road that has taken me to various hyperbaric centers and visits with learned men and women that has made much of their career in the development and use of HBOT in clinical practice, and in research.

Another one of these giants in hyperbaric medicine, like Dr. Kindwall, was Dr. Richard Neubauer, MD, FACHM, who demonstrated and proved the positive effects of HBOT with clinical follow-up and SPECT (single positron emission computer tomography) imaging in human patients that had sustained some type of brain injury, including trauma, stroke, Parkinson’s, Multiple Sclerosis, Dementia, Alzheimer’s disease, cerebral palsy, and following drowning or other hypoxia inducted brain dysfunction entities. (1) Unfortunately, even though he proved the positive effectiveness with clinical follow-up exams and SEPCT imaging that showed remarkable improvements in neurologic function, his work was largely ignored by the medical profession, and especially the specialty of neurology and neurosurgery. Today, this is still the case.

I visited Dr. Neubauer for a few days at his hyperbaric center in Fort Lauderdale by the Sea in 1997 and learned a great deal. He was nice enough to provide me with some training and it helped me when I returned to Wisconsin to continue my work with our HBOT chamber that we had recently installed. I was impressed by the results he was documenting. While with him, a Russian physician (Dr. Natalja Kazantseva, as I recall her name) that was doing HBOT in Russia for those with neurologic injuries and diseases, went to dinner with Dr. Neubauer and myself. I was so fortunate to have this opportunity.

At dinner, while relaxing after a busy day, and after the Russian doctor had also been observing how he was treating his patients with HBOT, I will always remember what she said, “**Dr. Neubauer you are using too much pressure for your neurologically injured patients, too much pressure.**” Then she went on the explain that her and her group of medical professionals had found improvement in their neuro-trauma and stroke patients that were much better than Dr. Neubauer was reporting, and that with *only using about half the pressure in the chamber* than Dr. Neubauer was using. She went on to explained that the *ideal pressure* was somewhere between 1.1 and 1.5 ATA. ATA stands for **at**omospheric pressure **a**bsolute. This is the total pressure placed on a patient when in the hyperbaric chamber and , following the addition of the gas being used to bring the *chamber gauge pressure* reading to the desired reading. This gauge pressure (psig) is then added to the atmospheric pressure or that pressure created by our atmosphere which is commonly approximately 14.7 psi. She said they have been using a gauge pressure reading of 1.47 to 5.87 psig, but most often is 2.95 psig. This is compared to the psig of what Dr Neubauer was using routinely of 7.35 to 14.7 psig. *Yes, truly much less pressure.*

Then she also said they were not using 100% oxygen to provide the pressure within the chamber as Dr. Neubauer was. They were using either air or an oxygen and air mixture to provide that pressure in the sealed chamber. To bring home this point she said emphatically, “*You are then also using too much per cent oxygen*”. She was using 30 % and Dr. Neubauer was using 100%. She went on to try and explain why but it was difficult for me, at least to understand. He was sitting right next to her while I was on the other side of the table and could not hear her explanations well.

Dr. Neubauer seemed to take note of this Russian physician’s comments, and later Dr. Neubauer began looking at what the best pressure would be for traumatic and hypoxic induced brain trauma. He went on to published many of the cases he treated and the effects of elevated atmospheric pressures on areas of the injured brain and described what has now been accepted to be called the “penumbra.” (1,8) It is that part of the brain that had become dysfunctional but able to respond in a positive way and be brought back to function with the use of HBOT. As we said good night at the conclusion of the meal, I remember Dr Neubauer saying, “I believe I will be looking into what she has said”. Years later I came across an article written by Dr. Kazantseva. It was a publication in a 2002 Proceedings on Hyperbaric Oxygenation for Cerebral Palsy and the Brain Injured Child; a meeting that had been organized by Dr. Neubauer. (9) Maybe this was that reason that she had come to the US, for the meeting: an invitation by Dr Neubauer to further explain the reasons why *lower pressures and lower oxygen concentrations were being so effective in neuro-injury*. She stated that cerebral ischemia, coming from such conditions as acute stroke, traumatic brain injury, etc., and leading to dementia, Parkinson’s disease, or vascular epilepsy, and all these conditions have in common a disparity between cerebral blood flow (CBF) and the cortex’s metabolic requirement. There is an impairment in CBF autoregulation and the reason for this impairment is due to a deficit in ATP formation. She then went on to state that in some cases standard HBOT may lead to untoward clinical results. Her group in Russia, she said, have been carrying out studies experimentally and clinically the efficacy and mechanisms of action of different regimens of HBOT in cerebral edema for the last 20 years, and they had found that normalization of tissue respiration and pronounced positive clinical effects in cerebral ischemia in a narrow range of surplus pressure values in a chamber. They called their approach “minimized hyperbaric treatment” or MHT. She said it restores tissue respiration and regulation of oxygen transport, which is always impaired in cerebral ischemia. They propose that MHT is the “minimum effective dose of oxygen under pressure that leads to normalization of external and tissue respiration and lipid peroxidation, recovery of CO2 reserve, renewal of normal microcirculation and autoregulation of CBF. They have determined this to be <1.1 ATA for 15-30 minutes at 30% oxygen, with 4-10 or more sessions and providing 30-60 mg CoQ 10 and 50 mg picnogenol once a day. They found that HBOT using 1.2 ATA for 20 minutes and a maximum of 3-4 sessions with 40 % oxygen was the *maximum dose that did not lead to”revoke phenomenon” in stroke* patients and the attendant negative dynamics of laboratory data. If they used 1.5 ATA and 100 % oxygen and a 60 minute at pressure treatment, this was the *very maximum they would ever use.* Going higher in any values past she said was noted to be associated with an evoked phenomenon in stroke and negative dynamics of laboratory data including the activation of lipopolysaccharide.

**Definitions and Initial Thoughts**

Hyperbaric oxygen therapy (HBOT) = Therapeutic use of increased pressure around the entire body (also increases O2 pressure [p]). Any p >1 ata) atmosphere absolute is “hyperbaric” (1.1 psi to 14.7 psi added to normal atmospheric pressure (14.7 psi or 760 mmHg) commonly used in both veterinary and human medicine. *Gauge pressure* is the pressure added inside the sealed hyperbaric chamber. Although some do not include pressures added to the chamber as “hyperbaric” until that gauge pressure reaches a minimum of 5.879 psi (i.e.1.4 ata), more and more those in the hyperbaric field are agreeing that *ANY* pressure above standard atmospheric pressure is also “hyperbaric” in the true sense of the word and research is proving many of the effects and benefits of the use of much lower pressures and oxygen concentration treatments and what has been termed now as “mild hyperbaric oxygen therapy”. (2, 9-18)

Monoplace chambers – those chambers designed for use with one patient being inside the chamber for a treatment. (19) This is based on the size of an average to large adult human. Human monoplace chambers are classified as standard B class or mild hyperbaric chambers based on the amount of gauge pressure that can be reached safely. (1-5,18) These are several companies that make monoplace chambers that I have first-hand knowledge with. There also those These include Sechrist human & veterinary chambers; OxyHealth, Inc; Newtowne Hyperbarics, Inc; Summit to Sea, LLC; ANDI International, Hyperbaric Veterinary Medicine; and OxyHealth. Others I am not as familiar with include Hyperbaric SAC; HEAR MEC; OxyHelp Industries. There is no doubt many others that have been developed and are becoming more available. Just visit the internet. When I did just recently, I noted that several veterinary hyperbaric suppliers have listed over 70 chambers now in veterinary hospitals throughout the US and over 15 are noted in other countries. Brazil alone had 5 working chambers. Most of these listed are standard monoplace hyperbaric chambers, so we really have no idea how many veterinary facilities offer HBOT.

NOTE: Even though the “monoplace” chamber name is based on the fact that they are meant for the treatment of ONE patient this is an adult human patient and so very often we can place more than one animal patient in the chamber. I have treated as many as 5 patients at the same time so long as each is in a separate container within the chamber (one that is not capable of generating an electrostatic spark such as those made of a dense plastic, plastic coated wire or steel and even cardboard boxes).

Standard HBOT – 1.5 to 2 ATA = 7.3 to 14.7 psi gauge pressure. Most chambers use oxygen as the pressurizing gas and are made of a solid construction (steel or acrylic) but a few are made of a dense polyvinyl like material. Others use *air only as the pressurizing gas*, and then oxygen is supplied into the chamber and directed to supplement the patient via a breathing apparatus that the patient wears (www.andihq.com).(19) These are Demand Mask systems, head hood system, free-flow mask systems (standard non-rebreather mask, non-rebreather mask with a Tru-fit anesthesia mask face seal, high-volume non-rebreather mask with a Tru-fit anesthesia mask), all of which require sedation and innovative retrofitting for use in dogs and cats and other species; or the supplemental oxygen is simply supplied into the chamber as an “uncontained gas” within the chamber and its concentration % then is not able to be tailored as it is with the use of the BIBS (built-in-breathing systems), and hence the chamber oxygen concentration then only commonly reaching from a 22 to 28%. (Ed Betts, Mark Betts, DVM - Personal Communication, 2021)

Mild HBOT – 1.1 to1.35 ATA = 4.4 to 5.0 psi gauge pressure. Uses air as the pressurizing gas, provided by1-2 air compressors that continue to supply fresh air into a flexible chamber to maintain the 4.4 – 5 psi pressure and the atmosphere inside the chamber is supplemented with oxygen either directly supplied into the chamber, again to provide an oxygen concentration ranging from 22 to 24% or is provided directly to the patient as a non-rebreathing mask or other BIBS (Built-In-Breathing System) that the patient wears as discussed before. Most of the time the supplemental oxygen is simply delivered with the same ports as the air that is used to compress the chamber. (20) Because of the difficulties with using BIBS with animals and children, these are not commonly used and the risk of the animal possibly injuring the hull of the mild HBO chambers sedation is almost always used. If higher concentrations of oxygen supplied to the patient are deemed necessary (rare in my opinion) some ingenuity and sedation would be required to provide a system that will work with the dog, cat, and other animal species. People simply place a non-rebreather mask on electively in most cases.

Minimized Hyperbaric Treatment (MHOT) – That pressure, according to Russian investigators, that is the maximum of pressure that can be used before negative effects of HBOT are noted that leads to a stable clinical effect and normalization of tissue respiration and lipid peroxidation, recovery of CO2 reserve, renewal of balanced microcirculation and autoregulation in all tissue beds but especially that of cerebral blood flow. (9)

Multiplace Chambers – Those chambers designed for use for than one human patient being inside the chamber for a treatment. These are often only available at large hyperbaric centers that are made for humans only. Animal chambers can also be made to be multiplace as well and was initially what was used during the 1918 Spanish Flu when Dr. Orval Cunningham MD, Anesthesiologist at Univ of Kansas in Kansas City, MO used to treat successfully human patients that had severe respiratory illness from the virus and they were the only patients with that degree of severity that were documented to have recovered (following the application of approximately 10 psi of pressure 1 hour and using air as the principle gas and only supplemented with oxygen. (21)

Comparing mild verses standard hyperbaric oxygen therapy - Suffice it to say there are many more completed and published studies that have been accomplished using standard HBOT and in fact some references refuse to recognize mild pressure HBOT as even hyperbaric oxygen therapy and state that they are not really a medical device at all. (22) While other sources point to mild pressure HBOT as effective and in some cases preferred to over standard HBOT particularly when neurologic diseases and injuries are treated (9-15,17,18) Mild HBOT has also been recommended by very prominent and educated physicians that have had significant experience with them. These have included Drs. Maxfield, Neubauer, and Harsh. (1,2,4) They also encourage many of their patients and those of other physicians to obtain a mild hyperbaric oxygen chamber for home use and then followed their progress.

Human patients have seen very positive results with improvement include those with the following diseases when using mild HBOT: mitochondrial dysfunction, autoimmune diseases of various types including lupus, Crohn’s disease, Lyme disease, fibromyalgia, rheumatoid arthritis, head and spinal cord injuries, PTSD, stroke, migraine headaches, cerebral palsy, concussions, Alzheimer’s, depression, autism, chronic obstructive pulmonary disorder, emphysema, dementia, Muscular dystrophy, asthma, cortical blindness, vertigo, seizures, multiple sclerosis, and age related loss of cognitive function (9,18, 21).Recent studies have even shown that HBOT given to normal individuals can improve cognitive and memory junction. This was an excessively big surprise and is causing a stir in the scientific community associated with learning. (1,2,4,23, 24,)

# Any area where there is a “wound” we can treat it with HBOT and have seen positive responses. This includes wounds that are not just that are external but includes all that are within the body as well. This includes “wounds” have been sustained by trauma (mechanical, thermal, chemical, or radiation) forces causing injury, either acutely or chronically, or are internal and caused by inflammations, degeneration, occlusive diseases, and cancer.

# I recommend you seek information on the internet for further information on indications that HBOT will help with. Here are a few suggested sights:

# 1.YouTube for presentations by Dr Shai Efrati, who is the Director of the Sagol Center for Hyperbaric Medicine and Research at**Shamir** Medical Center, and is an Associate Professor at the Sackler School of Medicine and the Sagol School of Neuroscience at Tel Aviv University. One of his presentations is on brain injury and stroke at the 2019 Exponential Medicine Conference and the other is on improving cognition and reversing aging by inducing the body for self-rejuvenation at the DxWhiteCity 2017 (23, 24)

# 2.International Board of Undersea Medicine. They have a great video that outlines the effects of HBOT as it applies to HBOT use in COVID-19 patients. I recommend you view this video as it also explains many of the positive effects HBOT has on all wounds (external and internal).

# 3. Any scientific articles written by Dr. Paul Harch, Dr. Richard Neubauer, Dr. Morton Walker, Dr. William Maxfield. Dr. George ‘Babe’ Hart, and others over the last 30 years. I am grateful for having had an opportunity to personally have met and learn from Drs. Harch, and Neubauer, and Hart, as well as Dr. Strauss, and Kindwall.

# 4.In the coming months there will be more publications by many that are just now finding out just how important HBOT is in the treatment of disease. Taken as a quote from a group of scientists that are editing a special issue in the journal Biomolecules (25): “Moreover, the intermittent increase of oxygen concentration activates many of the mediators and cellular pathways that are usually induced by hypoxia but not hazardous hypoxia—termed the hyperoxic–hypoxic paradox. Among others, the intermittent hyperoxic exposure during HBOT can affect the levels of hypoxia-inducible factor 1-alpha (HIF-1a), vascular endothelial growth factor (VEGF), and matrix metalloproteinases (MMP) activity, induce stem cell proliferation, augment circulating levels of endothelial progenitor cells (EPCs) and angiogenesis factors, as well as induce angiogenesis and improve blood flow. In addition to the stimulation of EPCs, HBOT can decrease the inflammatory response in endothelial cells mediated by TNF-alpha, and thus promote vascular recovery. Recently, HBOT also been shown to improve acute neurological conditions like stroke and traumatic brain injury and alleviates chronic conditions such as vascular dementia. In addition, both animal and human studies have demonstrated the beneficial effects of HBOT on mitochondrial function” (23-27).

# Rx needed for HBOT Involves: Species, Age, Temperature, Breathing, Pathology being treated, History, Oxygen, Pressure, Time, Previous treatments that may affect HBOT.

# As I look over many books and articles on HBOT and I try to make sense of all the data I come to the conclusion that much of the results of what has been observed both clinically and experimentally can be summarized by what I will term “*the 10 variables of hyperbaric oxygen therapy dose*”. These must all be taken into consideration when determining the best therapy for the patient and must be recorded in the patient’s medical record. These are: 1. Patient’s species; 2. age; 3. body temperature; 4. Work of breathing (all will affect metabolic rate); 5. Primary Indication. Patient’s illness or injury, organ(s) involved, severity of the pathology; 6. Length of the illness or injury; 7. Percent of oxygen that will be breathed; 8 Pressure of the treatment; 9. Length of the treatment; 10. Previous non-hyperbaric treatments that may affect such important variables as: a. expected neuro and vascular reactivity as determined by the estimated amount of blood flow and oxygen being delivered to the affected (abnormal) tissues involved with the disease process; b. medications, as some sensitize the cells to increased oxygen levels in tissues such as some chemo therapy agents such as bleomycin, doxorubicin, and cisplatin, (27) the type of water the patient is drinking as research, as will be discussed next has shown that ionized electrolyzed reduced water (ERW) that contains 4-6 ppm of hydrogen, hence is also called strong hydrogen water is a very significant oxygen radical scavenger and it is recommended that ALL patients receiving HBOT also drink ERW. (28).

# Ionized Electrolyzed Water as An Enhancer the HBOT Positive Effects

# This water which has 4-6 ppb of strong hydrogen acts as a scavenger of superoxide radicles that are manufactured by standard HBOT. For example, electrolyzed reduced water (ERW) ingested, (verses non-electrolyzed water); acts as a hydrogen *electron* doner and thus is a supporter of antioxidation and is a protector of cellular oxidation while regular water is a oxidant with neutral or acidic pH. Portable ionizers with its generation of ERW (pH 8 to10) is popular as a health-beneficial water in Japan. Japan is number 1 in health and the US is number 57 according to the World Health Organization. Over ¼ of the entire human population in Japan drink ERW as its main source of water. ERW is also termed alkaline electrolyzed water, alkali-ionic water, alkaline cathodic water, and alkaline ionized water, based on its physicochemical and physiological aspects. ERW exhibits an alkaline pH, is hydrogen molecule-rich, and has an oxidation reduction potential (ORP) of a *negative* 750 mv, verses regular drinking water that has an ORP of a *positive* 300-500 mv, indicating that regular water is a strong cellular oxidizer while ERW is a strong antioxidant and scavenges cellular reactive oxygen species (ROS) (28,29). The use of ERW in other research studies strongly suggests to me that it *should be part of the prescription of treatment every time HBOT is used in both humans and animals.*(30-39) I have been recommending this approach in practice since 2007, when I had been using the combination of HBOT and the ingestion ERW in all my patients since I received the instruction of the importance of this water by a health care professional and scientist Dr. Ray Stewart. (personal communication 2007)

# I purchased a high medical grade water ionizer from Japan in 2007 (SD 501, Enagic. enagic.com) and I use it in conjunction with HBOT and for all patients, regardless of whether HBOT is received or not. (39) Studies on the functions of ERW were initiated in Japan in 1931and unfortunately many of the qualities of ERW for health have been largely gone unnoticed by the medical health professions (human and animal). In my opinion, this information has not been widely taught in health care education or associations, even though the scientific studies, without question, have provided ample evidence of the health benefits of the consuming ERW for all domestic animals and humans (28-39) and animal and human health care practitioners that have experience with the use of it in their patients have published papers citing the positive effects that they have seen in their patients. (38, 39)

# All these variables, as indicated above, are important when determining the plan for treatment and even with the best of care their may be only basic guidelines that may be followed, and the outcome will simply have to be followed to determine the results of a certain HBOT treatment protocol followed.

# HBOT Pressure and Oxygen and Time Dosing

# Dr. Paul Harch has provided a many insight as to just how difficult it is to determine the best HBOT protocol to use. (2,16) He uses “total dose of oxygen” = depth x time x number of HBOT sessions (all of his using 100% oxygen) to provide a number he calls “atmosphere hours”. (26) (In reading his later report I find that he also changes the protocol, *as needed*, to avoid repeating undesirable effects in many human patients with chronic brain injury. I am suggesting that due to oxygen induced seizures in dogs especially (as these were frequent when I first began treating dogs and cats, up to 10%), I often *begin with lower oxygen concentrations* (below 100 % if that is possible) or if this is not possible (because the chamber uses only oxygen to pressurize) then *shorter treatment times* (less than 1 hour) and *less pressure* to be used.

# The smaller the animal the less oxygen dose that is needed in my opinion. More work needs to be done to find out the desired oxygen dose for each size patient, species, and condition being treated. Until that time references that I have provided at the conclusion of this article should be consulted, or if one has a question on the protocol to use, I also encourage everyone to contact someone that has already had a significant amount of experience treating patients with HBOT. Please feel free to also contact me if you have a question regarding a possible, calling my cell number 706-296-7020 is preferred over leaving an email.

# Recommended Treatment Times and Pressures with Standard HBOT

# Commonly I provide 45 min to 1 hour of treatment time “at depth” and use a total of NO MORE than 2 ata (gauge pressure of 14.7), and the maximum to be given in a 24-hour period is 3-4 HBOT per day. This is due to dogs being more sensitive to humans in having oxygen inducted seizures if more than 2 ATA and more than 1 hour of treatment “at depth” pressure is used and the fact that generally takes 4 to 6 hours to clear the oxygen indued free radicals from the brain based on research and clinical studies. The only exceptions to this are the following: Carbon Monoxide Poisoning; Cyanide Poisoning; Acetaminophen Toxicity; Severe Shock (any cause); acute crush injury; acute burns; acute compartment syndrome; acute frostbite; and flaps and graphs that appear compromised. There may be other indications for three per day, but I suggest referring to texts that cover protocols in more detail. (2, 3,7, 19) But do keep in mind that most of these protocols are based on that of an adult human at 70 Kg body weight and with a metabolic rate that is slower than dogs and cats and other small animal species of animals that most veterinary practitioners will care for. (1-7)

# If one is to use a more aggressive protocol than 2 treatments per day (with 6-hour intervals between treatments) with chambers that use 100 % oxygen as the principal compression gas then it is advised to definitely have someone watching the patient for signs of oxygen toxicity. These include nausea, twitches, muscle spasms, unusual behavior such as chewing movements, and seizures. (3, 19) If these are seen it is recommended to decrease the dose of oxygen that is being provided by decreasing the pressure within the chamber. Often the clinical signs observed resolve within a few minutes of beginning to lower the pressure. Most patients can continue with the treatment but just at a lower pressure (below the CNS toxicity threshold). (3,19) Generally, gauge pressure is dropped to approximately 50% of the pressure being used when the signs of toxicity are observed. Continued observation is of course warranted to ensure no further signs are observed. Following the dissipation of the observed clinical signs the pressure may tried to be gradually increased. Often at least 75% of the planned pressure may be reached provided the increase in pressure occurs gradually in my experience.

# Before Placing Patient into Standard Chamber - Safety Concerns Need to be Followed

# Because most of these chambers made for veterinary use (Class C – NFPA classification) (40) only oxygen to pressurize the chamber ALL animals, prior to going into the chamber must have no metal on them that might cause a spark as this would cause ignition of the carbon material in the chamber and an extremely hot and aggressive fire inside the chamber would occur. This includes metal on collars, ECG electrodes, and surgical staples. If these are present, they must be completely covered with tape to prevent a possible spark. If an external fixator is being used it must be completely covered with a cotton-based bandage so that no chance is possible for the metal to come in contact with the metal of the chamber and possibly cause a spark, again leading to an aggressive internal fire. No electrical devices can be in the chamber, nor can petroleum-based products be on be on the animal’s fur anywhere, as these can “off gas” when in the chamber and provide a rich gas source for possible ignition as well. In one incidence in Florida, a horse was placed into a hyperbaric chamber and its shoes had not been taken off. The horse kicked a rubber protective lid guarding the rear wall of the chamber and then with continued kicking the unguarded metal shoe caused a spark from it hitting the metal of inside chamber wall. This caused an intense and rapid fire and lead to rupture of the chamber from the expansion of the hot gases of combustion, causing the death of the horse, and one of the nursing attendants that was near the chamber. Another attendant, standing somewhat farther away from the chamber, was also severely injured. (41)

# If the patient also has a very dry hair coat and clothing material is placed within the chamber that may elicit a spark, then this could also cause an explosion as well*. Only cotton materials are allowed within the chamber* as polyester materials are known to cause electrostatic sparks. I provide you these important guidelines as a part of your early training to the use of *standard* hyperbaric chambers IF they use only oxygen to pressurize them it is critically important to follow all precautionary guidelines to prevent fires with possible devastating results. Research was shown that most all catastrophic oxygen associated fires in chambers have been due to lack of adherence to strict safety protocol. (42,43)

# As will be discussed later, these precautions to prevent spark and fire generation within the chamber generally do not apply to HBOT chambers that are mild pressure only.

# Mild hyperbaric chambers do not have near the compression risk as they use compressed with air and not oxygen. The air, due to its nitrogen content acting as an “insulator” provides a strong measure of safety against electrostatic sparks being able to cause a fire within the chamber in mild HBO chambers. However, in my opinion, using the same guidelines is a good recommendation to follow for patient safety.

# There are also, as mentioned earlier, standard pressure chambers that use air for pressurization up to 2 -3 ATA (ANDI Hyperbaric Chambers) but then the patient wears an oxygen mask or hood of some sort to get an increased FiO2 level. Then, with the use of these standard HBOT chambers the patient generally needs to be sedated so that they will continue to tolerate the mask or hood that is attached to or over their head.

# Other precautions with patients considered for HBOT:

# 1. Patients that have a fever of > 104, those that are extremely nervous should NOT be placed into the chamber until the fever is below this level or sedation is provided to quiet the patient. This decreases their metabolic rate and provides protection from oxygen induced seizures. If large dogs become anxious or super excited with in the chamber as they are placed into the chamber, sedation is also recommended before the treatment as these dogs also tend to get further hyperthermia and more anxious and have a higher incidence of seizing;

# 2. Those that have IV catheters should have these well secured and protected to prevent accidental dislodgement.

# 3. Those that have wound drains also need to have the drains covered. If the drains are active drains or a’ wound vac’ is being used to help heal a wound, the vacuum system should be disconnected, and the drain or wound port simply covered until after the HBOT is completed.

# 4. Those patients that have a pneumothorax should have chest tube placed and a Heimlich Valve attached to protect against a sudden build-up of air within the pleural space as the patient ascends following the treatment.

# 5. All patients with tubes or medicine patches such as fentanyl patches should have an Elizabethan Collar applied to guard against disruption or accidental or intentional removal by the patient.

# 6. Patients with unstable blood glucoses (diabetic on insulin, sepsis patient) also should receive a blood glucose test immediately before they receive an HBOT session. Blood glucose (BG) must be not below 100 mg/dl, and best be above 120 if they are a diabetic on insulin) this is because HBOT causes, in many cases, a slight decrease in resting BG. HBOT potentiates the insulin given by injection and it also can decrease cortisol levels as pain deceases from the use of the pressure within the chamber.

# 7. Patients with indwelling feeding tubes should have the exposed external orifice closed to prevent air from entering the stomach and esophagus. A Heimlich valve can also be used on the tip of the indwelling feeding tube to allow air within the stomach or esophagus to become evacuated as the pressure in the chamber increases.

# 8. Any tubes leading to the urinary bladder or any other hollow viscus should have either a Heimlich valve attached to it or the tube should be simply caped to prevent air from going into it via the uncovered tube.

# 9. All patients at risk of stopping breathing should have an attendant always observing them as pressure is applied, during the session and upon a rise to normal pressure.

# Taking these precautions, I have not had any major complications in greater than an estimated 13,000 episodes of HBOT I have overseen. I trust you also would have a perfect safety record as well but again it is so vitally important to follow with all the precautions I have listed.

# The Standard Pressure HBO Treatment Protocol:

# Patient has temperature. And a brief physical exam. Those with a fever 104 or greater or have a significant airway compromise are not candidates for HBOT.

# Those with a possibility of having a pneumothorax (for example a recent history of trauma) should have thoracic radiographs before HBOT to rule this out. If a pneumothorax is observed a chest tube must be placed and a Heimlich Valved used with it to allow any free air within the pleural space to be able to escape as the HBOT session is completed.

# If the patient is very anxious or panting a lot a sedative should be given, or acupressure, acupuncture, or stimulation of the active acupuncture points with a 660 nm red light (photonic light therapy developed by Dr Brian McLaren from Australia) should be done prior to the patient entering the chamber. (44) Pericardium 6 is targeted with the red light and this provides activation of this acupuncture point and has been shown to decrease vomiting and nausea is scientific studies.

# If there is a history of recent vomiting an injection of Cerinia should be provided to help prevent aspiration prior the placing the patient in the HBOT chamber.

# Place the patient within the HBOT chamber and close the chamber door. If a hood or head fitted nonrebreathing mask is needed to provide the increase oxygen content, then attach this device and observe for a few minutes. If toleration is observed, then continue. If the patient needs sedation to help him or her tolerate the mask or hood, then provide the sedation and then place the patient into the HBOT chamber.

# 

# Tighten the door to prevent air/oxygen gas from escaping and then *slowly* increase pressure as you watch the patient for signs of distress. This is exceedingly rare in my experience, but if you notice anxiousness, head shaking, pawing at the ears, or other signs that may be due to problems associated with a pressure equilibrium in the ears, stop or slow the inflow of gas into the chamber and continue to watch the patient. Stay at that pressure until you see the signs resolve. Then continue a gradual increase in pressure as you increase the gas flow going into the chamber.

# When the ideal pressure is reached (this generally takes approximately 10-15 minutes from the start of pressurization) begin to time the treatment time as you have now reached the needed “at pressure”. This ranges from 6 to 14.7 psi on the gauge (psig.) at sea level.

# Occasionally observe the patient during the “at pressure” time. Most protocols I have used for most all indications is 45 to 60 minutes.

# After the time at pressure is completed then slowly decrease the pressure over the next 15 minutes. Observe for the same signs as done before when the pressure in the chamber was increasing. If signs of problems with pressure equilibrium are seen, then stop the gas flowing out and let the patient adjust to the lower pressure. This problem is rarely observed in my experience. When signs are no longer observed, gradually bring the pressure in the chamber lower and lower until the pressure gauge reads 0 psi.

# Open the chamber and retrieve the patient. This concludes the HBO treatment.

# Take vital signs (TPR) and record these and any pertinent clinical changes noted post treatment. Fill out the logbook to record the treatment and any issues that might have been seen. Also record visible improvements noted post treatment.

# Mild HBOT Treatment Protocol

# With low or mild hyperbaric treatments, I commonly use 3.5 to 5 psi (ave. 4.4 PSI) and approx. 22-30%\* oxygen and time at this pressure is between 60-120 minutes (ave. 90 min.) and these are given as 1-2 treatments per day. Those patients with low blood glucoses or having some difficulty in breathing or a history of seizures the gauge pressure is maintained no higher than 2.55 -3.5 psi and treatment at pressure times are generally 20-30 minutes and no longer than 45 minutes. This is just an estimate of that provided at a 10L/min O2 flow rate given into the chamber as the air compressor (1-2) are running (which is continuously through the session).

# Here is the step-by-step protocol:

# 1.Examine the patient pre-treatment. Again, there are very few contraindications but

# these are the ones I have observed over the last 25 years: Pneumothorax, a partially obstructed airway that places the patient at risk for complete airway compromise. If these are seen, then only a short treatment time may be use initially to see how everything goes.

# 2.Place the patient in the chamber after assured that he or she will be quiet during the HBOT. If there is ANY DOUBT, then provide sedate first before placing into the HBO chamber. This is generally done with the mild chamber treatments because the chamber could be damaged by the patient should they begin chewing at the inside of the wall of the chamber. This has happened in the past in my experience so most all patients that are not in a secondary enclosure within the soft chamber are now sedated (as of 2019).

# Common medications used include butorphanol, diazepam, midazolam, dexmedetomidine. In surgical patients that are experiencing significant pain postoperatively I have used fantail on board by way of a transdermal patch secured to the rear legs just above the foot on the dorsum of the metatarsal region. It is commonly secured with vet rap and when in the chamber it is covered a second time with a gauze and Elasticon or other tape dressing. (This is also used safely, in my experience, and those of others, in patients going into a standard pressure chamber). NOTE: There is some concern, by some, that the effects of sedatives and analgesics, as mentioned, will be potentiated by HBOT and should not be in the patient’s system when a HBOT is given (personal communication with Dr Dennis Geiser, UT). This has not been experienced in well over 1,000 patients, given these medications during their HBOT in my experience but caution should always be used to ensure the patient is ventilating well before they are placed into a hyperbaric chamber or any kind.

# 3. Zip up the two sets of zippers and turn on the air compressor(s) that are plugged into the wall of the chamber. Observe the patient, as done with the standard chamber treatment. In some cases, and with some older chambers, this may be somewhat difficult, due to the position of the patient

# within the chamber and the location of the port hole, as the visibility through the port hole may be compromised. However, again in my experience, this has not been an issue with well over 300 patients having been treated at one hospital with an older chamber. It is my belief that the reason for this is because of the low pressures that are reached with mild HBOT.

# 4.If oxygen is being used to enrich the atmospheric gas within the chamber a 10 LPM flow is provided continuously as the treatment is given beginning at the beginning of inflow of the air into the chamber. The oxygen line can be attached to the chamber by a separate port that is commonly included on most mild HBOT chambers. If there is not one, the line can be spliced into the air compressor supply line going into the chamber. The valve that allows the flow of the chamber gases to escape (Air escape valve) is closed and pressure thus begins to increase within the chamber.

# 5.Treatment time begins with the chamber gauge pressure reaches the target pressure. At that time, the built-in pressure control valves in the wall of the chamber begin venting, so the chamber pressure gauge remains at 4.4 to 5 psi. Most protocols range from 60 to 90 minutes of treatment time.

# 6. At the conclusion of the treatment time, the decompression is begun by turning the air escape valve open. The air is allowed to flow out through this orifice that has been made so that decompression does not go faster than necessary, to prevent any difficulties with pressure equilibrium.

# 7. After gauge pressure reaches 0 psi then the chamber is opened, and the patient removed from the chamber. NOTE: I have used the same treatment time to treat as many as 5 small animal patients in the chamber at the same time (all in separate containers). Also. I have had attendants accompany the patient in the chamber to provide comfort, continue to give support ventilations, or even do CPR or provide continued intravenous volume support in patients in shock. In those special cases the oxygen line is connected directly to the oxygen port in the wall of the chamber and an oxygen line is then continued from the same port on the inside of the chamber. This line is then connected to what is needed, such as an AMBU resuscitation respirator (to provide support ventilations by a mask or endotracheal tube); to a non-rebreathing mask made from a commercial cone mask attached to the fittings of an AMBU bag; to the opening of a cone mask that is just placed over the patients mouth and nose, providing supplemental oxygen; to the exposed end of nasopharyngeal oxygen catheter; or to a nasal cannula.

# Post Chamber Use Cleaning and Maintenance

# Following each patient use of the chamber and containers which held patients within the chamber (such as plastic cages, wire cages totally coated with plastic or rubber) a thorough cleaning and disinfection should occur. It takes as little as 3 -5 minutes to thoroughly clean the chamber. The inside of the chamber should be disinfected with an approved material that is compatible with the type of chamber you have: For metal and acrylic chambers Asepti-HB, Mediclean, and Enviroguard 64 is an effective disinfectant for bacteria and viruses including respiratory viruses, parvo virus, and others. It is also effective with molds and yeasts. There should be a 10 to15 minute wait time following the disinfection to allow the airdry process to complete. A prominent hyperbaric company also suggests the use of another product called Blue Gold Clenser as an oxygen compatible cleaning agent for oxygen equipment and all types of chambers including all hard and soft chambers (acrylic, steel, PVC, and urethane fabric units. (19) Blue Gold Cleanser is very economical (1:50 ratio with clean water) and is non-toxic and highly effective. (19)

Should a proper cleaning degreasing agent be temporarily unavailable wash the chamber with a mild dishwashing soap (1:100 water solution). Cleaning is most effective when the detergent is in a solution of *very warm water* but not exceeding 50 C or 120 F Wash with clean-soft lint free cloth that has been moistened in the detergent solution then rinse with a soft lint free cloth moistened with the clean water. Do not allow the detergent or water or disinfectant liquid to accumulate inside the chamber. Never use a dry cloth or abrasive cleaning agent on any acrylic window or any other of the materials used for hyperbaric chambers. Take care that the cleaning cloth has not picked up hard grit or particles during the cleaning process, as abrasion or scratching can occur and this they can contribute to less life of the chamber. I provide a protocol that will help keep chambers in a good, sanitized state:

**The Chamber Disinfection Protocol**

1.Wear appropriate PPE (personal protection equipment) of gloves; N95 mask (if available) otherwise a surgical mask if the organisms involved are not contagious to humans; and protective eyewear.

2. Place a fan near the open door or open port of the chamber to allow good ventilation while the disinfection process is carried out.

3. Use cotton towels to do the cleaning of the inside surfaces using the detergent and water in a ratio per instructions based on the type of detergent. (Another alternative is to use an atomizer sprayer to spray a mist of the detergent/disinfectant onto all surfaces inside the chamber).

4. Wipe down with a clean dry cotton towel and allow to airdry using the fan at the door of the chamber.

5. When no more liquid and no odor of the detergent/disinfectant is detected place the chamber back into service.

6. While the inside of the chamber is airing out clean the exterior surfaces as was done on the inside. This can be done also with the sprayer or soft towel containing the detergent/disinfectant and then dry with a soft towel.

Warning: Do not use cleaners or disinfectants containing high concentrations of ethyl alcohol, isopropyl alcohol, or benzyl alcohol as well as hospital cleaners that contain alcohols as these cause injuries to acrylic and soft chamber materials. (19)

**Safety and Training Recommendations**

It is recommended that all that operate the chamber receive basic training that includes safety, patient loading and unloading, compression, maintenance, and decompression, troubleshooting correct protocols, and cleaning and maintenance of the chamber. There are several courses that can be taken from various agencies and companies and even the Veterinary Hyperbaric Medical Society and the Veterinary Hyperbaric Association. Courses are certificate courses designed to provide pertinent information for veterinarians and veterinary technicians along with other professionals on the safe and efficacious application of hyperbaric oxygen therapy in veterinary and human medicine but centers on the veterinary applications. These are comprehensive courses that cover physics, physiology, indications, side effects, equipment, and safety. Successful completion generally fulfills the first credential for achieving Certified Veterinary Hyperbaric Technician (CHT-V) status which is recommended for all those especially that will be operating a standard pressure chamber. Costs generally run approximately 4-500.00 and take 2 ½ days to complete. Faculty are those professionals that have had significant experience and knowledge/training in HBOT. There are also courses and education available through the Undersea and Hyperbaric Medical Society and a website entitled “Hyperbaric Research & Studies: An archive of Hyperbaric Oxygen Therapy Research, Studies and Testimonials” at ttps://hyperbaricstudies.com. These are very well done and can be used to help educate potential clients as the benefits and precautions regarding the use of HBOT.

Because oxygen is a very reactive gas compared to air, which for practical purposes is well insulated with inert gases (Nitrogen, N2 78 %, Argon 0.93 %, primarily) and trace amounts of neon, helium, methane, krypton, and hydrogen, even though it is not flammable it is a very reactive element, and it is necessary for all animal life. Because of the limitations of this presentation, it will be simply stated that HBOT chambers that use 100% oxygen to pressurize the chamber carry important requirements for safety that must be followed to prevent flash fires. All veterinarians and their staff that will be operating HBOT chambers, especially those in which the gas used to produce the hyperbaric environment is oxygen, need to have a thorough training and knowledge regarding protocols that MUST be followed to ensure that utmost safety measures are ALWAYS followed which will prevent fires, or worse, a rapid flash fire that can lead to an explosion caused by the expansion of the gases within a sealed chamber. When these have occurred there has always been a lapse in the following of safety protocols. (42) Therefore, it is highly recommended that all chamber operators attend a standard training course BEFORE they operate a chamber or attend to caring for patients receiving HBOT. If only mild hyperbaric chambers are going to be used the risks of fire and explosion are considerably less and to date none have been reported when the per cent of oxygen within the chamber has not been concentrated to above 28%. (43) However, the percentage of oxygen in the chamber environment, not the O2 partial pressure, is the principal concern, as concentrations above 23.5 % O2 increase the rate of flame spread. Thirty percent O2 in nitrogen at 1 ATA (228 mm Hg pO2) increases burning rate. For further information, the reader is referred to Chapter 14 of the National Fire Protection Association (NFPA) document 99-2015 (40) and other references cited earlier. (3,7,19, 43)

# Summary of Some of HBOT’s Main Effects

# Increases oxygen delivery to all tissues and this improves cellular metabolism, mitochondrial function, angiogenesis, macrophage, and fibroblast function. (1-4)

# Increase in pressure that decreases edema (and pain). (1-4)

# Increases in oxygen to cells with rapid metabolism such as the brain allow these cells and their interconnections to improve in function. This has led researchers to conclude that providing HBOT improves memory and many other neurological functions. (16)

# Increase in pressure changes gene expression (last count ~ 850 genes) begins at 1.1 psi from causes cytokine production to move from proinflammatory to anti-inflammatory. (15)

# Initially there is a decrease in blood flow due to the higher levels of oxygen being delivered to tissues but after the therapy is concluded there is an increase in blood flow from a post treatment vasodilation, especially in areas that had marginal blood flow. (16)

# Even mild increases in atmospheric pressure (1.3 ATA) and 30-40% supplemental oxygen cause a decrease in inflammation and assist in the wellbeing of the GI microbiome. (17)

1. Pressure from atmospheric gases especially oxygen determines gene effects [new research shows this begins at 1-2 psi above sea level] as oxidative stress increase occurs. Mild hyperbaric oxygen improved a decreased mRNA levels of Pgc-1α and oxidative capacity in the skeletal muscle of animal models with metabolic syndrome. (17)
2. Increase in pressure changes water structure (to a hydrogel water that enhances cell signaling and electron transmissions). Dr. Gerald Pollock, the discoverer of EZ water or 4th phase hydrogen water maintains that is change in water structure that is seen with HBOT is one of the main reasons HBOT is effective in virtually every disease. (18-20)
3. Increases in reactive oxygen species (ROS) that is virucidal, bactericidal, fungicide (enhances macrophage and PMN effectiveness, activates SOD, glutathione peroxidase, catalase). ROS also acts in conjunction with several redox systems involving glutathione, thioredoxin and pyridine nucleotides, and plays a central role in coordinating cell signaling. (21-24)
4. Increases nitric oxide synthetase (NOS) that stimulates stem cell activation and release from the bone marrow - this begins within the first hour and active CD34 progenitor stem cells are found in the blood stream in increasing numbers the more oxygen dose is given. (21).

# Increase in NOS also causes microvascular vasodilation and an increase in tissue blood flow and tissue oxygen levels. (22-24)

# Special effects – depends on the tissues involved. Example: HBOT can reactivate “idling” neurons in a functional ischemic penumbra post brain injury (trauma, ischemia, hypoxia, stroke) (learning disorders, PTSD, autism, cerebral palsy, psychiatric illness partially through a redistribution of blood flow from lower flow areas to higher flow areas in the brain is noted after treatment sessions as demonstrated by SPECT (Single Photon Emission Computerized Tomography using Tc HM-PAO hexamethylpropyleneamine). (16)

# Increases gene transcription of certain genes, e.g., transcription factor NrF2 from the cytosol moves into the nucleus and binds to a DNA promotor. This initiates anti-inflammatory cytokine production. Examples of changes seen include increases in IL-1, IL-4, IL-10, IL-11, IL-13. (45-47)

# Increased up-regulation of *Inhibitory* NF-kB synthesis. (48)

# Decrease in synthesis of IL-1 (Interleukin 1), TNF alpha (tumor necrosis factor), other proinflammatory cytokines (via changes in gene expression that cause the decreased synthesis of TNF alpha, IL-1 and other proinflammatory cytokines. This occurs, in part also due to HBOT suppressing mitogen‐activated protein kinase (MAPK) signaling and mitochondrial apoptotic pathway. Suppression of MAPK signaling pathways by HBOT act as molecular target for it anti‐inflammatory response. Three major groups of distinctly regulated MAPK cascades are known that lead to altered gene expression: extracellular signal‐regulated kinase 1/2 (ERK1/2), c‐Jun N‐terminal kinase (JNK), and p38 MAP kinase. Phosphorylation of ERK1/2, JNK, and p38 MAPK results in the expression of genes mediating the inflammatory response factors, such as tumor necrosis factor‐alpha (TNF‐α) and NO. (49)

# Increase in superoxide dismutase, catalase, glutathione peroxidase (superoxide radical scavengers). However, in aggressive HBOT the oxygen radicals accumulating may not be able to be efficiently scavenged and these are involved with CNS toxicity. (50)

# Increases in hypoxia-inducible factor 1 (HIF-1) and stomal derived factor 1 alpha = improved “wound” healing and this include all neurologic “wounds”. HBO activates HIF-1α at several levels by increasing both HIF-1α stability (by a non-canonical mechanism) and activity (as shown both by induction of relevant target genes, (51,52)

# Increases ROS and this acts in conjunction with several redox systems involving glutathione, thioredoxin and pyridine nucleotides, and plays a central role in coordinating cell signaling and it causes an increase in stem cell production. (53)

# Increases hydrogel (Phase 4 “ordered” intrafascial water) and this causes an increases cellular electron resonation and efficiency of electron transport systems and torsional light emissions. (15)

# Improvements in blood flow, especially noted with mild pressure HBOT. (18,25,26)

# Increased solubility of O2 in solution with both mild & standard high-pressure chambers and see the following: Tissue pO2 increases in all tissue beds and red cells are fully saturated and increased ability to off load their oxygen molecules. (10-12)

# Red cells have increased flexibility and have less aggregation which improves blood flow is seen with mild and standard HBOT; and this is also seen with the ingestion of ERW as compared to the ingestion of regular water and especially with water containing chlorine or fluoride that is common in municipal water systems. (3,28)

# Plasminogen is activated to plasmin at endothelial level and this leads to less microthrombi formation and again improved flow. Adhesion molecule activation is also suppressed, and this also assists the rheology of blood flow in the micro-circulation. (3)

# Increased O2 tissue diffusion and pressure within cells also decreases mitochondrial dysfunction as tissue O2 increases from 20-40 to 40-60 mmHg min., i.e., doubles tissue oxygen thus raising tissue O2 p by 20 and this has been associated with decreases in infection rates and improves healing rates. (3, 54)

# Increases NOS and this leads to vasodilation based on the vasodilatory effects of the increased levels of nitric oxide that is the by-product of the increase in NOS. (55)

# Initially, depending on the concentrations of oxygen being used in the chamber, with 100% being standard, and the amount of added pressure within the chamber, i.e., psig, *vasoconstriction occurs*. The more the pO2 the more constriction at the arterioles is observed. This then causes a significant drop in capillary blood flow. (3) This is short-lived however because pO2 decreases within minutes after the patient is taken out of the chamber and pO2 is back into the pre-HBOT level. The more pressure the more oxygen is in the blood that is *dissolved in plasma*. At 1 ATA (760 mmHg) the per cent of oxygen (in volume %) that is in solution *in plasma* is 0.32. When breathing 100 % O2 at 1 ATA (normobaric) there is 2.09 vol. % O2 that is the plasma; at 1.5 ATA breathing air there is 0.61 vol % O2 in plasma; at 1.5 ATA breathing 100 % O2 there is 3.26 vol. % O2 that is in plasma; at 2 ATA (1520 mmHg) breathing air there is 0.81 vol % O2; and at 100 % O2 there is 4.44 vol. % O2 that is plasma, and this corresponds to a paO2 of 1520 mmHg. Because the average extraction by tissues is 5% this results in a remarkable preservation in oxyhemoglobin in the blood and a significant increase tissue oxygen tension. There is an inactivation of hemoglobin’s role in oxygen and CO2 transport. In tissues with a compromised circulation, because oxygen is now in such high amount in plasma, these tissues become well oxygenated again. It is thought by many that this is the main reason HBOT is effective in rescuing compromised hypoxic or ischemic tissues. However, this is only one of the reasons. (3)

# Decreases in cellular acidosis in low tissue pH conditions such as low – flow (shock) states as this supports both oxidative phosphorylation and cytosolic increases phosphofructokinase enzyme function that provides the beginning of glucose conversion. (3, 54)

# Improves vascular endothelial function through various mechanisms, decreasing edema and decreases inflammation. (55)

# Enhances the effects of certain antibiotic actions and is particularly effective with miroaerophilic and anaerobic infections caused by bacteria, rickettsial, and fungal organisms.

# Helps in the detoxification of animals poisoned by acetaminophen and possibly other agents. Further research is required in this area.

# Decreases, in some cases, the growth of malignant cells. Further research is needed also in this area but evidence at least does not show that HBOT enhances any tumor cell growth

# Supports the GI tract and especially the mucosal lining cells and is being effectively used in GI disorders; shock of all types including anaphylactic, septic, and hemorrhagic; post GI surgery, and hyperthermia related episodes.

# Decreases edema (intracellular and extracellular) and therefore supports blood and lymphatic flow.

**Physical Gas Laws w/ HBOT**

To better understand what is going on inside the chamber when gases are added to it (air, oxygen) we need to review the basic laws of physics that apply. There are ***primary effects***: Boyles Law explains the changing in *volume* of gas and fluid filled tissues w*hich is directly proportional* to the total barometric gauge *pressure* within the chamber; Charles Law and Guy Luissac’s Law deals with temperature inside the chamber as pressure is added. These are called “primary *gas effects”* because these are readily noticed by observation: as pressure is applied in the chamber the volume inside a surgical glove filled with air or water and tied off with a knot at the cuff, when inside the chamber gets smaller; and temperature within the chamber also increases. (19)

Boyle’s Law = Volume is proportional to the pressure. Simply stated the more the pressure that is exerted on a tissue, solid or hollow organ, the less the volume proportionality. Boyle’s law is quite noticeably demonstrated with visibly swollen tissues that become less swollen when HBOT is applied. The classic example I always refer to is the dog with a very swollen head and face following a snake bite injury. Here in Georgia, we have both Copper Head snakes and various types of rattle snakes and dogs (and sometimes cats) get bitten most often in the face and lip and occasionally in the tongue. We use HBOT quite frequently in these cases and are always amazed with the significant less swelling we notice even with just one treatment when the dog’s treatment is completed, and we open the chamber at the treatment’s conclusion. This is seen with both high or standard pressure or a mild pressure chamber. Treatment times with standard pressure chambers, using 14.7 psig (gauge pressure) generally vary from 30 to 45 minutes to a maximum of an hour. With mild HBOT, using a 4.4-5 psig treatment, times at pressure vary from 90 to 120 minutes. *I have had experience treating the typical snake bite case with both types of chambers and protocols and can honestly say I have a difficult time seeing a clinical difference in the amount of swelling decrease noted between the two*. (19)

When I worked at the Pet Emergency Clinic and Specialty Hospital (PECSH) in Thousand Oaks, CA we saw many more poisonous snake bites than in WI, NV, GA where I had access to a standard hyperbaric chamber. At PECSH we only initially had a mild pressure chamber. As an example, one season we treated 140 dogs with the mild hyperbaric chamber and the clinical improvement was quite noticeable. With standard pressure HBOT there also a similar effect. However, the tissues post HBOT do appear to have an increased red color. This is due to the plasma having more enriched with oxygen that occurs with the standard pressure chambers we were using as I said we were using 100% oxygen as the pressurizing gas in these chambers as opposed to compressed air supplemented with oxygen (providing only a 22-24% oxygen environment to possibly as high as 30% if the tip of the oxygen supply hose coming from the oxygen generator was very near the patient’s head).

Due to *Boyle’s Law* there is also a significant reduction in tissue edema that is visible post HBOT in *dog bite wounds, crush injuries, and in septic patients where there is a known increase in both extracellular and intracellular edema*. Following HBOT there is most often a rather marked decreased in the generalized edema commonly seen in these septic patients.

Another example of the effect of Boyle’s law is when HBOT is used in *patients with an obstructed bowel*. Radiographs commonly show a marked reduction in the amount of gas noted in the intestinal lumen post HBOT when compared to radiographs of the same animal prior to HBOT. In this case the bowel gas, mostly made up of air (nitrogen, oxygen, and CO2) is compressed and becomes less in volume and this commonly continues post HBOT too because if the next gas law, that of Henry’s Law or that of the Law of Solubility. (3,19)

Henry’s Law = Amount of *dissolved* gas is proportional to the *partial pressure* of the gas = increased pressure thus increases solubility = increasing O2 solubility = increases tissue O2 content. Example: in reverse a Coke bottle with CO2 gas under pressure - as the top is popped releasing the pressure in the bottle the CO2 off gases and bubbles are immediately seen as the solubility decreases and the CO2 comes out of solution, rapidly form bubbles. In one study with normal people investigators found that *only 50 minutes* of mild hyperbaric conditions (1.25 ata [an increase in atmospheric pressure of approximately 3.7 psi, per gauge pressure] with 36.0% oxygen) there was a marked increase in oxidative capacity in cells and tissues. The amount of dissolved oxygen increased by 2.76 times (an average of 0.864 mL/dL after exposure to mild hyperbaric oxygen verses 0.313 mL/dL under normobaric conditions (1.00 ATA [0 psi gauge pressure] with 20.9% oxygen) i.e., before mild hyperbaric therapy was provided. (3,19) xxx

Previous studies with 14.7 psi (2 ATA) of pressure and 100 % oxygen concentrations (higher than 40%) showed side effects such as enhanced levels of oxidative stress (3) and/or increased numbers of invasive inflammatory cells , while conditions of mild hyperbaric oxygen did not cause enhanced levels of oxidative stress (17-18) In addition, the same investigators previously observed in animal experiments that type 2 diabetes, diabetes induced cataracts, , hypertension, type II collagen-induced arthritis, and age-related decline in muscle oxidative enzyme activity were inhibited and/or improved by exposure to mild hyperbaric oxygen conditions after exposure to mild hyperbaric oxygen.(17-18)

Dalton’s law = Also called Dalton’s law of partial pressures describes the relationship of the pressure of individual gases in a mixture of gases to the total pressure of the gas mixture. It states that total pressure exerted by a mixture of gases is equal to the sum of the pressure of each individual gas in the mixture. It can be written in this way: pp gas (total) = vol % of each gas x pressure. Partial pressure = the total pressure exerted by a single gas within a mixture of gases. Example: 21% Oxygen (commonly the per cent O2 we are breathing at sea level @ 1 ATA (our standard atmospheric pressure at sea-level is 14.7 psi converted to mmHg is 760 mmHg x (1 atmosphere) x 0.21 = 159.6 mm. Round up to 160 mm Hg (3,19)

24% Oxygen @ 1.35 ata (commonly what is attained in a mild HBO chamber with supplemental oxygen is added at 10 LPM) = 760 x 1.35 = 1,026 x 0.24 = 246.2 mm Hg pp O2. Compare this to the partial pressure of O2 when a patient is in a standard HBO chamber breathing 100% oxygen = 760 x 2 = 1520 x 1.00 = 1520 mm Hg O2. OR 1520/246 = 6.17 times more oxygen with the standard pressure (14.7) and oxygen content FiO2 of 1 in a standard hyperbaric chamber.

Again 100% Oxygen @ 2 ata = 760 x 2=1520 mmHg x 1 = 1520 mmHg pp O2. This is 1520/246 = 6.1 x more pp of O2 than with a mild chamber.

Other pressure units that gases are measured in include Kpa, inch of water, inch of mercury, Torr, Millibars. 1 ATA or 1 ata or one atmosphere absolute = the following (including those already mentioned): 14.70 pounds per square inch (psi); 101.325 kilopascals (Kpa); 1,013.25 millibars; feet sea water 33 fsw; meters sea water 10 msw; dynes per square centimeter 1,013.25 x 103 Pleasedo not get all concerned with all the units and math. I was just trying to be thorough. Regarding pressures in the chamber the only thing that truly must be remembered is that the psi on the gauge is added to ONE atmosphere that is the atmospheric pressure we all live at or 14.7 psi. So, for example if the gauge pressure (psig) is reading 4 then the total pressure is 4 + 14.7 = 18.7 and this coverts to 1.28 ATA (or 18.7/14.7). Then take into consideration the % of oxygen the patient is inspiring (estimates commonly are used if anything but 100 % O2 is used to pressurize the chamber). So, if its 100% then PO2 in ATA is 1.28 X 1 = 1.28 ATA. If it is an air pressure chamber and fraction of inspired oxygen is 0.3 or 30% inspired oxygen, then PO2 in ata is 1.28 x 0.3 = 0.384 ATA. (19)

According to training I received as an ANDI hyperbaric chamber operator it is important to understand this *real oxygen dosage delivered* to a patient that receives a HBOT. It is the dosage that many subscribe too that is the *single-most important issue* when designing and delivering HBOTs.(19) Dosage = Inspired fO2 x P. Most mild pressure chambers use in the US do not measure the pp O2 or FiO2 so only estimations can be made. Fortunately, because of the low pp O2 compared to standard or high-pressure chambers *there is a significant amount of safety associated with their use.* (36,37,38)

Pascal’s Law = Liquid is a non-compressible state. Applying a force to one part of the liquid transfers that force equally and in all directions. Therefore, Pascal’s principal law is the reason that all body tissue compartments and internal bubbles experience the pressure changes the same as those occurring outside the body. (19)

**Indications for HBOT**

There are three levels of *indications for HBOT*: Those are:

1. “approved” (by the FDA and USHMS) (6)

2. “unapproved (by the same organizations) but clinical experience and/or research show that there is a positive effect” (6)

3. indications are considered “off label” with this description has been taken from the drug industry that suggests that there are some studies or clinical experience that has shown a positive effect, but in the minds of those that make the rules, there is not enough information to provide support for the professional if he or she chooses to treat a patient with one of these conditions. (6)

In my opinion this has seriously hampered the ability for all health care professionals from trying to help their patients with the use of HBOT (whether with standard or mild hyperbaric treatments). This is a serious mistake. I highly recommend to everyone who is serious about looking into this in more detail, to read the book that Dr. Paul Harch published in 2016 entitled “The Oxygen Revolution” 3rd Edition Hyperbaric Oxygen Therapy: Breakthrough Gene Therapy for Traumatic Brain Injury & Other Disorders”. He has been my pleasure to know Dr. Harch and the effort he is doing to make *HBOT a part of care for everyone who has a wound and the wound definition being a process of denegation caused by injury or illness ANYEHERE in the body.* (2)Thus, this would mean those involving every organ in the body. I share this idea with him and many others around the world. (1,4, 8,9, 10,11,14, 25).

Also, in my opinion, the lack of responsiveness by the FDA and USHMS has contributed to the cause of many deaths and serious complications that otherwise would have been reversed using HBOT. Example: In this last 13 months of the SAR-COv2 COVID-19 viral pandemic there have been 586,166 as per the resource accessed. <https://covidtracking.com/data/charts/us-daily-deaths>. This is the number based on this resource that had been tracking since Feb 29, 2000. The number of people that are still suffering post COVID infection is unknown, but from data published by the CDC, 57% patients (that tested positive and had clinical signs), that have continued to be affected with various types of health issues. Mainstream health care in the US and around the world does not recognize or even offer HBOT (mild or standard) as a possible treatment (sccm.org). I personally have experience with referring a friend to a chiropractor that has a *mild hyperbaric chamber*. He had a severe case of COVID-19 and was left with neurologic dysfunction. After approximately 30 treatments and has had a miraculous recovery, but this was *not observed* until he began the mild HBOT. The International Hyperbarics Association ([www.ihausa.org](http://www.ihausa.org)) is a charitable and educational organization that aims to meet the needs of the hyperbaric community. I highly recommend that everyone reading this manuscript also go online and research what they have written. It is an organization made up of medical hyperbaric center owners and professionals that work with hyperbaric therapy in patients on a daily basis from around the world. From individual hyperbaric chamber users to corporate chamber users, they have members from all facets of medical field. They also have a monthly newsletter, The Pressure Point, that provides current information on the use of HBOT, both standard and mild pressure, and publishes testimonials, scientific article summaries, etc., on HBOT. A recently made video on the use of HBOT for the treatment of COVID-19 is also available at their website that was generated by the International Board of Undersea Medicine. It is very well done and describes the scientific reasoning behind their recommendation that all COVID-19 patients should receive HBOT as well as those that are experiencing post COVID-19 diseases such as neurological sequala due to the virus. There are three reports where HBOT was used for hospitalized COVID-19 patients there were scheduled to be placed on an ICU ventilator and elected to try an experimental protocol regarding HBOT. All three reports showed a significant improvement following HBOT and while receiving HBOT their breathing became much less labored, and the majority fell asleep. There was approximately a 90% survival rate and most all did not ever require placement on a ventilator. (56-58)

Approved (by the Under Sea and Hyperbaric Medical Society [USHMS]). (6) These 16 indications are what have been documented to be specific indications for the use of HBOT. This is the basis for insurance agencies and Medicare regarding payment for its use. I question the entire “scientific process” by which the USHMS, FDA, and NIH give their “approval” or non-approval” to these indications. This question I have is also backed up by many other professionals using HBOT around the world and is affirmed by the Hyperbaric Medicine International Annual Conference I attended in 2018. (39) There I heard presentations by Dr. Paul Harch on HBOT in chronic TBI, a randomized trial, and the culmination of 30 years of treatment and research & Expanding and unifying hyperbaric medicine: dosing of hyperbaric therapy across the spectrum of hydrostatic pressure, hyperoxia, and medical gases. There were many indications that were discussed (that are not on the USHMS approved list) which were discussed at that scientific conference that were helped by HBOT, particularly many neurological conditions such as PTSD and Traumatic Brain Injury (TBI). (I will visit these indications in more detail later).

*My personal experience also reflects on the extremely poor scientific process being used to determine whether a particular indication is approved or not by the USHMS.*

**This is my story**: I had a very severe wound on the anterior aspect of my left chin that doctors told me the wound needed to be present and not healing *for at least 30 days before they would even consider me a candidate of HBOT*. I then investigated what they had said. They were right on what the rules said regarding what the indications for HBOT were for wounds that were published by various “wound experts and the federal government particularly the USHMS, Medicare, and others that make health care decisions in the US. (6) They also said the wound was in the *wrong location*, and that it had to be involving the foot. Again, I looked this up and they were again right. According to the approved indications the wound was in the wrong location. I was also literally astonished that our health care government agency requires that the wound must meet *all 3* principal criteria. These, regarding diabetic wounds of the lower extremities: patient must have type 1 or type 2 diabetes; have a lower extremity wound that is *due to the diabetes*; a wound classified as Wagner grade III or higher; have failed an adequate course of standard wound therapy. (44, 45) When I read these requirements I thought “no wonder so many diabetics have foot and leg amputations each year; our healthcare industry is so behind!”

Meanwhile the wound got worse (getting infected, deeper, and definitely getting more edematous and angrier looking) and being a diabetic I was concerned of its progression. I called a neurosurgeon friend of mine who was in another state who I had a high respect for. I gave him the details as to how the wound looked and that of my diabetes. He said, quite frankly, he was worried and that I could lose the battle and could have my leg amputated! So, I got down on my knees and prayed that I would find the right people that would be able to help me. It was a miracle I believe to this day, because as soon as I got up from praying to God our Father, I remembered that I had met a certified hyperbaric technician that operated a hyperbaric center within 30 miles of where I lived. I called him and he agreed that I could have the HBOT at his facility, and then I found physician (a plastic-reconstructive surgeon) that “approved the treatments”, and then the insurance agency also “approved the costs”. Truly all miracles in my opinion!

One of the effects I noticed after I got into the chamber and was receiving my first “dive” (as that is what each treatment is referred to as the *term is left over from the days of when the only approved condition HBOT was used for was decompression sickness* that divers would have if they rose to the surface too quickly and nitrogen bubbles would form within vessels and cause vascular obstructions), was an *immediate* decrease in pain as soon as I was “*brought to pressure*.”

As long as I was under the influence of the pressure the pain in my leg was *gone*. It was amazing. I received 12 standard hyperbaric treatments at 100 % oxygen and at approximately 2 ATA. Then I continued to treat with a mild chamber I had at home. I also continued to receive wound care by nurses and the plastic – reconstructive surgeon. After several weeks, the wound healed without grafting being needed. I also had had a PIC line that had been placed at the beginning of the therapy and had been receiving intravenous ampicillin and sulbactam when the HBOT’s were begun. On my last visit with the plastic reconstructive surgeon that had been caring for me, he gave me a “sign off” on the wound, saying that I did not need to see him any further (as the wound was nearing the completion of the healing), he informed me that I was the very first patient he had had that he has ever had HBOT. He was so glad I had come to see him. Then he said something I will never forget he said also had another patient like me at about the same time. This patient also had a wound infection in the leg and was also on similar IV antibiotics and diabetic, but he said that patient *had not had any HBOT*. He said, “*but that patient died*.”

Sad to say, but I had a similar second wound that occurred in the same place (left anterior shin) some years later. It also got infected. I received IV vancomycin, and then surgical debridement under general anesthesia in the OR of our local medical center. I was in the hospital overnight, Then I had a wound vac system applied. When I asked the doctors and surgeons caring for me if I could also begin getting HBOT, they said the same thing I had experienced before with the first wound on my chin. “Your wound does not qualify you for HBOT”. But this time I heard, “If you want this type of therapy, you can receive it, but the insurance company nor Medicare will pay for it.” I was 64, nearly turning 65 at the time. “It would cost $1,500.00 per HBOT”, the physician said, “if I truly wanted it!” I again prayed to God our Father for help.

I do not recall just how it happened, but I found a podiatrist with a monoplace chamber that used air as the compression gas and a nonrebreathing facemask to provide the oxygen. He began caring for my wound and giving me HBOTs and the cost was 200.00 per treatment! I would get a treatment every day 5 days a week. I agreed and began the treatments and paying the $200.00 per session (one hour at 2ATA breathing 100% oxygen via a non-rebreathing mask). I had just turned 65.

At the end of the first week of HBOT the doctor caring for me said he was able to get Medicare to reimburse me. Initially he had entered in the data asking for coverage and Medicare *had refused coverage as the wound was on the chin and not on the foot.*  I remember hearing that before with the first wound on my chin. But after he resubmitted the claim, it was approved (something to do with the diagnostic code he said). Again, I praised the Lord. And the wound healed! It took approximately 20 treatments at the podiatrist’s office and I also received 10 more at Erlanger, the University of Tennessee Medical School’s Teaching Hospital where I was placed in a Sechrist monoplace hyperbaric and received 2 ATA, 100% O2 for 1 hour at pressure, (there standard protocol for wounds).

As it can be seen, there is a significant need for veterinarians to use HBOT and this will not only help the animals we care for and provide HBOT but also, in my opinion, the entire health care industry as then owners may be helping their caring physicians accept the use of HBOT in their lives. Because we, as veterinarians, are not placed under the same restrictions as our human medical colleagues, we can take the lead and begin using HBOT in so many conditions (post injuries and diseases), frequently and much earlier, compared to our human medical colleagues. The scientific knowledge that has been published concerning the benefits of HBOT in cells, tissues, blood flow, stem cell production, wound healing (any wound), backs us up as to why we should be offering HBOT to our animal patients! It is hoped, through our use of HBOT, that it will broadcast the word out to the entire medical community, that HBOT should be offered to many patients that do not have it available now. Because of the slow response by the Under Sea and Hyperbaric Medical Society and the FDA, we must, in my opinion take the lead. The benefits we show them (our colleagues in the human health care area) that our animal patients are showing after receiving HBOT, will hopefully and eventually help them and all of us.

As another indication as to how poor our medical care is, regard not using HBOT where it should be, I provide you this: In the current crisis with COVID -19, HBOT has been *proven to be 90% plus effective in healing the lung and preventing the need for ventilator support, and preventing secondary neuro and cardiovascular effects,* But the FDA, NIH, WHO and most physicians, who only go by what the “established guidelines are” , do not even venture out and try HBOT. They are too afraid! That is even what one MD friend of mine said, as he was treating many critically ill COVID -19 patients. “I cannot go against the establishment, he said. “If the NIH said OK, and my hospital director said OK, then I would use HBOT. I know it would help them (his patients) but right now the answer is no.” But if you have a family member or loved on who is dying from COVID-19 I still implore you, to present the treating physicians’ articles of studies that prove HBOT’s effectiveness. *Here are three studies regarding HBOT that has been used for severe COVID* (56-58).

Other indications for HBOT that is NOT approved by UHMS: Comments were made by Harch, Deckoff-Jones, and Neubauer publicly, in response to an article published in Pediatrics by Nuthall that condemned the use of HBOT for children with cerebral palsy. (61) Dr Harch, et al, strongly reprimanded the UHMS and the entire medical profession for *not accepting many studies that provide proof for use in off-labeled conditions such as cerebral palsy*. From research done within the last 18 years it also has become apparent that much lower pressures and per cents of oxygen compared to standard HBOT also shows significant benefits, *and without complications* occurring in *over 35,000 treatments* done by Harch, Deckoff-Jones, and Neubauer. (62)

So, with this story being told, I recommend if anyone has a complicated wound ANYWHERE they should 1. Get down on your knees, repent, and ask Jesus for help. He will be there for you and help you. *And* 2. Find a physician that will provide the HBOT care you will need. *Please understand that now many physicians are recognizing that HBOT will help ANY WOUND ANY WHERE INCLUDING THOSE THAT ARE ‘INTERNAL’ such as a stroke (a wound in the brain), myocardial infarction (a wound in the heart), a stomach ulcer (a wound in the stomach), severe pancreatitis (a wound in the pancreas), chronic inflammatory bowel disease (a wound involving the mucosal lining of the GI tract), PTSD or traumatic brain injury (a wound in the brain), MS or muscle sclerosis (a wound involving muscle), post COVID neurological dysfunctions of any kind that would include “brain fog” seizures, Rheumatoid and degenerative joint disease (wounds involving the joints).So, as you might see, there is really NO inflammatory or degenerative conditions that HBOT is not going to help.* This is what I said at tow relatively recent presentations I gave. And I honestly believe that.(59) (D. Tim Crowe: Grand Rounds Presentation, College of Medicine, University of Tennessee, Chattanooga, TN. October, 2006)

With that in mind there are 16 only conditions that are currently “approved” here in the USA. (6) I passionately believe that there is a gap of knowledge between the medical professionals in the USA and what is known concerning HBOT. Example: Stroke patients are not being given HBOT as is done in many other countries including Israel, Russia, and China. I returned from a hyperbaric medical meeting that concentrated on the use of HBOT in neurological diseases and injuries and was impressed as to the documented beneficial effects HBOT had and that the sooner after the incident to more the positive effect. (59) Yet when I got home and was associated with friends that had a stroke, concussion, traumatic brain injury NONE of them were treated with HBOT by any of the emergency physicians or neurologists involved with their care. I believe a significant amount of training and revision of indications (increasing them) must be done.

This is the list of the 16 conditions being indicated of HBOT according to the Undersea and Hyperbaric Medical Society and the FDA (6) An older report that outlined what the indications were was published in 1992. In that report there were 12:

Air or Gas Embolism \*

Carbon Monoxide Poisoning \*

Carbon Monoxide Poisoning Complicated by Cyanide Poisoning and Smoke Inhalation \*

Decompression Sickness \*

Severe Anemia, Exceptional Blood Loss Anemia (and cannot receive transfusions) \*

Sensorineural Hearing Loss

Intracranial Abscess

Gas Gangrene (Clostridial Myonecrosis) \*

Crush Injury, Compartment Syndrome, and Other Acute Traumatic Ischemias \*

Central Retinal Artery Occlusion

Enhancement of Healing in Selected Problem Wounds \*

Necrotizing Soft Tissue Infections (Subcutaneous Tissue, Muscle, Fascia) \*

Osteomyelitis (Refractory) \*

Delayed Radiation Injury (Osteoradionecrosis) \*

Compromised Skin Grafts and Flaps \*

Acute Thermal Burn Injury \*

All those indications denoted with an \* were published as “approved” in 1992. Those that have been added since then are Central Retinal Artery Occlusion, Sensorineural Hearing Loss, and Intracranial Abscess. *No others have been added by the USHMS since then*. It is rather sad, in my opinion, and those of many other professionals that are members of the following organizations: International Hyperbarics Association, Hyperbaric Medicine International, and the American College of Hyperbaric Medicine (although some in this later organization are not bold enough to step forward as much as others would like).

In veterinary medicine, the Veterinary Hyperbaric Association and the Veterinary Medical Society are organizations that I believe are very positive in advancing the profession in HBOT but I have not been active in these organizations like I have in the first two, however I do not believe they recognize mild hyperbaric oxygen therapy from what I can determine from their websites nor do they recognize or recommend the use of HBOT in the treatment of all wounds (both internal and external) and cancer and all degenerative diseases as I have in this publication, but you, as the reader will have to seek their own opinion.

“Off-label” Studied Uses of HBOT – Here are at least some of conditions that have been designated “Off-label”: (6,)

Cerebral Palsy

Amyotrophic Lateral Sclerosis

Complex Regional Pain Syndrome

Fetal Alcohol Syndrome

Ischemic Brain Injury

Traumatic Midbrain Syndrome

Closed Head Injury

Lupus

Stroke

Myocardial Infarction

Autism

Lyme Disease

Migraine

Multiple Sclerosis

Hepatitis

AIDS

Brown Recluse Spider Bites

Heart Attack

Sports Injuries

Plastic Surgery

Near Drowning

Coma

As mentioned earlier, I have interviewed numerous neurologists in my local area, NONE of them have had any of their patients treated with HBOT for neurological conditions. They just have not had the knowledge, nor training they have told me. In fact, one of them said she had heard that HBOT is “vodo”. And she was told that by one of her instructors in medical school and until the FDA and USHMS have these conditions “approved” *they will not risk their patients to this “unproven” therapy.* In my mind it is so sad that medical doctors in the US and other countries that follow what the USA does do not read or investigate the use of HBOT. And in fact, I have a friend who is an adult intensivist that has been treating many COVID-19 patients who said to me, “Tim, I wish I could treat my COVID-19 patients with hyperbaric therapy but unless the NIH approves it and my director approves it I can not use it.” This is after I sent my friend two of the articles I references earlier, that proved, without a clinical doubt, of the lifesaving use of HBOT in COVID. (56-58) Unfortunately, then, our medical establishment’s mindset that they cannot go “outside the box” and practice medicine *as they feel that is best for their patients, rather* *they must follow what is a “standard of practice”.* As a note then: I am so glad, we as veterinarians, can *practice as we feel we need to, and to offer the care we know, through experience, and both clinical and research studies, will benefit our patients*.

**Hyperbaric Treatment Indications in Summary**

This is what I firmly believe in: All cases involved with edema, hypoxia, ischemia, inflammatory, or degenerative (locally or regionally). This generally then means just about every disease and injury will be benefited by HBOT. The following I have been particularly impressed with. With the treatment of respiratory compromise of the lungs (pneumonia); congestive heart failure; myocardial contusions and associated ischemia post CPR; Post GDV; parvovirus enteritis; post hyperthermia especially with GI signs; pancreatitis; post GI surgery; post orthopedic and neurosurgery; post Eye, Ear, Nose surgery such as post TECA or lateral ear canal resection; Intervertebral disc protrusion or rupture; head and spinal cord trauma, snake and spider bite envenomation; crush injuries; all major wounds (acute and chronic); burns; infected wounds; Lyme disease; Hemorrhagic gastroenteritis; osteomyelitis; dermatologic issues that are difficult to resolve; IMHA; ITP and other autoimmune RBC and platelet diseases, post blunt and penetrating trauma of all types and involving all organs.

**Recommendations**:

From all the research and experience I have done on HBOT over the last 25 years I am convinced that this modality is an immensely powerful tool that can and should be used by most all actively practicing small animal veterinarians in the US and the rest of the world.

If one is just the least bit interested in trying this modality in their practice but hesitant to place much time or expense into this you have four options:

1. Get a mild HBOT chamber such as Newtown Hyperbaric, OxyHealth, Summit to Sea, and others. These come with 1-2 air compressors to generate the 1.3 to 1.4 ATA pressure inside the chamber. Get an oxygen concentrator from them as well, if you have issues as to piping in the oxygen from the sources in your hospital and begin treating as many patients as you can. Take good clinical notes and if you have any questions as to a possible candidate or protocol or a concern, just call me. I will be happy to help you. I will be your consultant on any patient you would like. Cell Number 706-296-7020. You can call or text me. If I do not answer, just leave a voice message as well. If its urgent, say so and I will respond as quick as I can. But keep in mind mild HBOT is safe and effective in most patients. See closing note as well about the use of targeted pulsed electromagnet therapy (by Assisi Animal Health. Inc) as this PEMF coil also provides help for patients and performs some of the mechanisms of action as HBOT (mild and standard). I would combine the two modalities as this coil can be sent home with the client and they then continue to treat 2-3 times each day (supplementing the HBOT done at your practice).

2. Contact a supplier that will put a standard HBO chamber into your hospital and share the revenue. They will often have an agreement that requires you to agree to a base rental fee should a particular quota of cases not be met for each month. So, it is very worth the time and effort you put in to concentrate at least in making your monthly quota. They also provide the training that allows the safe use of the chamber to be followed. You will have the expense of getting the chamber installed regarding oxygen supply into the unit and the effluent of oxygen out of the unit that occurs as the unit is running. Chambers use from 6 to 60 LPM of oxygen. I would discuss this carefully with the supplier before you make this commitment. Often liquid oxygen doers are best to keep the costs for the oxygen as low as possible. Two suppliers of this type of “rental and share the income program” are Hyperbaric Veterinary Medicine, and Sechrist Veterinary Health. There also may be others. This is for small animal size chambers only.

3. Purchase a standard hyperbaric chamber (used or new) from suppliers already mentioned above or from ANDI Hyperbarics, Inc., They have both new and used chambers that use air as the principal gas for providing the compression in the chamber and these are provided by ANDI and they also provide the oxygen concentrators that are used to supplement oxygen to the patient.

For those interested in using HBOT in large animal or equine veterinary medicine I recommend you seek the advice of Dr. Dennis Geiser at the University of Tennessee College of Veterinary Medicine, Knoxville, TN.

**Targeted Pulsed Electromagnetic Field Therapy (as a supplement therapy for HBOT)**

In approximately 1970 a researcher at Columbia Presbyterian Hospital in New York found that a pulsed weak electromagnetic filed signal in the area of 20 MHz stimulated osteoclasts and osteoblasts to grow and for bone to be laid down in rodent fractures experimentally. This later lead to the development of the bone induction coil that was found to be successful in the causing the healing of non or delayed unions of fractures of the tibia. The coil became clinically available to support the healing of all fractures later. Fast forward 50 years. We now have several types of bone induction coils and coils (both portable) that also improve the blood flow of soft tissues and are FDA approved for the treatment of pain and edema. One in particular called the Assis Loop on the veterinary professional side and the SofPulse on the human professional side provide a very specific short wave radio signal called targeted Pulsed Electromagnetic Field therapy (tPEMF) also have been proven to be effective in increasing angiogenesis, decreasing inflammation, increasing anti-inflammatory cytokines, increasing tissue oxygenation levels, supporting cartilage, increasing the speed of healing and enhance healing in complex compromised wounds, with these including internal “wounds” of the CNS (brain and spinal cord), GI tract (including the esophagus, stomach, liver, gall bladder, and pancreas), kidneys, ureters and bladder, as well as more external wounds and injuries of the skin, muscles, fascia, joints, and bones. These are all indicated for treatment by both HBOT and tPEMF therapy. I use them, as I mentioned, together as their actions are synergistic. For further information on tPEMF please go to [www.AssisiAnimalHealth.com](http://www.AssisiAnimalHealth.com) and search for a video presentation I did specifically on the use of tPEMF in surgery, emergency and critical care in April 2021. The website also has a library of scientific references regarding experimental and human and veterinary clinical studies that have been published.

**Additional References Included for Further Study into Effects & Uses of HBOT**

I have included additional references on HBOT for further study regarding the effects and clinical uses of HBOT. (63-217) It is however not an exhaustive accumulation. At the conclusion I realize I have left out so many more scientific papers including the use of HBOT in pancreatitis, shock, ischemia, microaerophilic bacterial infections such as those of E. coli, anaerobic infections, and mycotic infections (as HBOT is highly effective) and many other conditions. There also many be older clinical and research reviews regarding HBOT that I have also left out. To all the researchers and authors of these publications, my apology.

**Final Comment – The Origin of Natural Hyperbaric Conditions**

I leave you with this thought: When God first made the world and He created earth’s atmosphere we read from Genesis, “And God said, “Let there be a vault between the waters to separate the water (oceans) from the water (an high atmosphere that was completely full of water)”. So, God made the vault and separated the water under the vault from the water above it. And it was so. God called the vault, “sky” (the atmosphere). And there was evening and there was morning – the second day. And God said, “Let the water under the sky be gathered to one place and let the dry ground appear.” And it was so. God called the dry ground “land” and the gathered waters he called “seas.” And God saw that it was good. Genesis 1:6-10 Scientists have discovered that the initial atmosphere that God made had an oxygen content approximately 30-33% (based on oxygen levels found in resin deposits deep within fossils) and an estimated atmospheric pressure of approximately 1.3 to 1.35 ATA. (The Institute for Creation Research. <https://www.icr.org>). So, it makes total cense that mild HBOT is good as a treatment for just about every disease and injury as God initially made it. Of course with the great flood the high atmosphere that was filled with water came raining down and destroyed all except Noah and his family and all the animals on the ark that he had with him. There is research that also supports this, as well as what is also said in the Bible in Genesis 7 and 8. Scientists that are geophysicists have calculated from fossils and sediment and the compression on the earth that was caused millions of gallons of water that flooded the earth, that the true age of earth is probably 12 to 16 thousand years old, no more. There are more scientific facts that have been found that support creation and what is said in Genesis, than evolutionists have been able to provide. Jesus is the answer. Please read the Gospel of John and then read the book of Genesis, and you will find God’s divine hand in it all. God bless you all, and happy will be all of you that elect to begin your journey into hyperbaric medicine.

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