

What is hyperbaric oxygen therapy?

Hyperbaric oxygen therapy (HBOT) is an approved form of treatment for humans and we are proud to offer this cutting-edge modality to our furry friends. HBOT allows the delivery of 100% oxygen at 2 to 3 times atmospheric pressure. This exponentially increases the amount of dissolved oxygen in blood and tissue fluids. As a result, extremely high levels of oxygen can be delivered to parts of the body with compromised blood supply. We are able to safely deliver this form of therapy utilizing a chamber specifically designed for pets. Cats and dogs up to 180 lbs. can be treated. LVS is among an exclusive network of veterinary facilities in the world to offer this revolutionary technology that enhances and hastens healing for pets. Our doctors and nurses are HBOT certified enabling us to understand appropriate applications and protocols.



Exploring HBOT Therapy: A Case Study

By Dr. Lindsay Schmidt

A 25 kg 12 year old female spayed pitbull cross was referred for hyperbaric oxygen therapy for treatment of a progressive non-healing wound on the right tarsus and calcaneus. Two months prior to presentation, the patient developed pressure sores over the lateral aspect of the right tarsus and calcaneus. She was seen by her primary care veterinarian and empirically treated with courses of oral doxycycline, enrofloxacin and topical antibiotics. Daily wound cleaning with a dilute betadine solution and bandage changes were performed at home by the client. Various topical wound treatments including manuka honey, calcium alginate and hydrocolloid gels were used with no benefit reported.

During this time, the wounds became larger and more severe. The patient was started on gabapentin for pain management and referred for further treatment. Upon presentation to Lancaster Veterinary Specialties, multifocal wounds were present around the tarsal region, which included a full thickness wound over the calcaneus, partial thickness wound on the cranial tarsal region and multifocal punctate partial to full thickness wounds around the remaining circumference.

Treatment options were discussed, and hyperbaric oxygen therapy (HBOT) was elected.

A five consecutive daily treatment protocol was elected. The day of consultation, 3 view thoracic radiographs were performed which were unremarkable. A CBC and comprehensive chemistry panel was performed which showed mildly elevated ALT. All other values were normal. Two hours prior to treatments, the patient received oral gabapentin to reduce confinement induced anxiety. The existing dressing was removed and the area lavaged with sterile saline. The wounds were covered with pure cotton dressing immediately prior to each HBOT treatment. The patient was placed in an airtight veterinary HBOT chamber. Upon sealing, the chamber was filled with 100% pure oxygen to replace the room air. The chamber was pressurized to 1.5-2 ATA (atmosphere absolute) for a treatment time of 85-100 minutes (45-60 minutes under pressure) under the direct observation of an HBOT certified technician. After treatment, the patient was monitored for several hours prior to discharge. The patient tolerated all treatments well with no adverse reactions noted other than mild anxiety that was managed with gabapentin.

How can hyperbaric oxygen therapy help your patients today?

HBOT sessions will be used in conjunction with a comprehensive review of your patient's specific case history, blood work, and test results.

HBOT is useful in a variety of clinical situations and immediately provides high levels of oxygen to compromised tissues that have marginal blood flow.

This allows tissues to heal faster and more efficiently. Conditions that benefit from HBOT include trauma, smoke inhalation, non-healing wounds, pancreatitis, autoimmune disorders, cancers, snake bites, burns, and other inflammatory diseases just to name a few. **HBOT is affordable and is also covered by most pet insurance companies.**

Hyperbaric oxygen therapy services are available by appointment only.

Please call us at (717) 347-0838 to speak with a scheduling specialist to make an appointment.



Pre Treatment

Following treatments, overall wound size decreased significantly with marked improvement of periwound edema and tissue viability. Images above include views of the calcanean wound prior to treatment, after 3 treatments and after 5 treatments.

Hyperbaric oxygen therapy is a noninvasive treatment modality that has been available in the United States since the early 1900's.¹⁻³ Initially developed for the treatment of decompression sickness in divers, years of use and research has shown many additional benefits and indications of HBOT. These include wound management, infections and various medical conditions. Recently, this modality has made its way into the veterinary field following the development of veterinary specific treatment chambers, with the first chamber being available in 1998.¹

Many pathologic conditions result from dysfunctional, damaged, and traumatized tissue. These alterations inhibit oxygen delivery to diseased tissue resulting in progressive tissue destruction. HBOT works by increasing oxygen tissue concentration. During HBOT sessions,



After 3 Treatments

the combination of high oxygen concentration and increased atmospheric pressure improves oxygen delivery to tissue through several mechanisms.⁴

“Initially developed for the treatment of decompression sickness in divers, years of use and research has shown many additional benefits and indications of HBOT.”

First, when pure oxygen is used, more oxygen is available for gas exchange. Complete saturation of hemoglobin molecules is more easily achieved. Under normal pressure, approximately 98% of oxygen in circulation is bound to hemoglobin with the remaining 2% dissolved in plasma, resulting in a normal plasma oxygen concentration of 3 ml/L. At 3 atmospheres, oxygen is able to more effectively dissolve into plasma, reaching a concentration of around 60 ml/L as determined by Henry's Law of Gas.³ Therefore, enough oxygen is present in plasma to fulfil the oxygen requirement in resting tissue (approximately 60 ml/L) without



After 6 Treatments

dependence on hemoglobin for oxygen delivery to tissues and cells.⁵⁻⁷ Under the circumstances created during HBOT and principles of Fick's Law of Gases, oxygen is able to diffuse much further from capillaries into the interstitial space compared to normal atmospheric pressure. This is particularly beneficial in chronic nonhealing wounds where tissue is hypoxic due to pathologic changes.³ Pressurization also shifts body tissue third space free water content from the interstitial space into intravascular space, which is most helpful in the reduction of edema and vasculitis.⁷

Under normal circumstances, the presence of oxygen is a limiting factor in cellular metabolism. Oxidative phosphorylation, the preferred cellular metabolic pathway for production of ATP, is oxygen dependent. HBOT increases the oxygen diffusion gradient, therefore improving cellular metabolism.⁷⁻⁹

The physiologic effects, including cellular and biochemical benefits of HBOT, have been well studied and documented. HBOT has been shown to promote angiogenesis and wound healing, kill certain anaerobic organisms, prevents growth of

species such as *Pseudomonas*, prevents production of clostridial alpha toxin, restores neutrophil mediated bacterial killing in previously hypoxic tissues, reduces leucocyte adhesion in reperfusion injury, preventing release of proteases and free radicals which cause vasoconstriction and cellular damage.^{7,10-16} HBOT has also been shown to induce the production of endogenous intracellular antioxidants, induce temporary arteriole and venule vasoconstriction and modulate vasodilatory effects of nitric oxide.¹¹ Secondary effects such as anti-inflammatory, antimicrobial, immunomodulatory and angiogenic properties have also been demonstrated.^{3,17-18}

In humans, HBOT has been approved for the treatment of many conditions.^{19,20} These include carbon monoxide poisoning or smoke inhalation,²¹⁻²³ air or gas bubbles/embolism and decompression sickness,²⁴ sudden or traumatic inadequate arterial blood flow,²⁵⁻²⁷ ischemic necrosis, select

wound healing, skin grafts and flaps,^{28,29} nerve damage, CNS disease/trauma,³⁰⁻³⁵ osteomyelitis, delayed radiation injury, malignancy,³⁶⁻⁴⁰ necrotizing/chronic infections, inflammatory conditions,⁴¹⁻⁴³ non healing diabetic wounds as well as the treatment of severe anemia from blood loss in which appropriate blood products are not available or transfusion is declined due to religious reasons.^{4,5,7,19,44}

In veterinary patients, exact treatment indications are not as clearly defined. Veterinary specific studies have evaluated bone healing using autogeneous cancellous grafts,⁴⁵ skin flap viability,⁴⁶ post cardiac arrest,⁴⁷ necrotizing fasciitis⁴⁸ and equine rehabilitation.⁴⁹ Rats have also been used as experimental models for many other conditions including CNS/pain models⁵⁰⁻⁵⁴ and bone healing.^{55,56} Improved healing was reported in patients treated with HBOT. Additional anecdotal reported uses for HBOT include compressive and vascular myelopathies, crotalid

envenomation, surgical and traumatic wounds, atypical/anaerobic infections, refractory osteomyelitis, reperfusion injury, and myocardial ischemia and pancreatitis,¹⁷⁻²⁰ although additional studies are necessary.

“Client education is essential.”

Due to the severity of potential complications, careful patient selection, pre-treatment screening, as well as appropriate technician training/administration and client education are essential. Some of the most severe potential complications and contraindications include:

Pulmonary diseases (bullae/bleb):

When the chamber is pressurizing, the bulla or blebs collapse due to the increased pressure. Upon depressurization, re-expansion can result in rupture, causing a tension pneumothorax. Prior to HBOT therapy, thoracic radiographs looking for pulmonary abnormalities are recommended.



LEARN MORE

Find us online:

At Lancaster Veterinary Specialties, we are committed to treating every referred client and pet as members of our own family. Through mutual trust and communication, we build lifelong relationships with our pet parents and veterinary service providers.

Specialists in acupuncture, cardiology, internal medicine, oncology, radiology, and surgery provide your patients state-of-the-art, compassionate medical and surgical care. We are sure to provide all available options, empowering clients to make decisions that best fit their needs.

- Consultations by Appointment
- Advanced Diagnostics including Ultrasound, Echocardiograms, ECG, Holter Monitors, Computed Tomography, Endoscopy, Laparoscopy
- Advanced Chemotherapeutics, Immunotherapy, and Targeted Therapies
- Specialized Surgeries and Procedures
- Critical Care Management, HBOT, & More

Clinical Indications for HBOT:

Neurological

- Hypoxic brain insult (e.g. stroke)
- Head trauma
- Compressive spinal cord disease
- Peripheral nerve disease

Wounds

- Fractures
- Crush injuries
- Non-healing wounds
- Skin grafts
- Spider and snake bites

Infectious Diseases

- Septicemia
- Septic arthritis
- Osteomyelitis
- Anaerobic infections

Metabolic

- Severe pancreatitis
- Immune mediated hemolytic anemia
- Thromboembolic disease

Cardiovascular

- Post shock therapy
- Cardiopulmonary infarction
- Pulmonary edema

Hypoglycemia: HBOT results in a decrease blood sugar level. Hypoglycemia exacerbates seizure thresholds. At risk patients (diabetic and neonates) should have their glucose levels checked before and after treatment. Those patients will require closer monitoring or treatment may be deferred.

Oxygen toxicity: Due to increased production of free radicals, intrasessional grand mal seizures have been reported. Oxygen toxicity is generally reversible with gradual decompression and post treatment monitoring.⁵⁹⁻⁶¹

Hyperthermia: HBOT has been shown to maintain and raise body temperature during treatment.⁶² Other mechanisms including increase oxygen metabolism may also play a role in temperature elevation during treatments.³⁹ As so, it is recommended that patients with core body temperatures of 103.5 or greater not receive treatment.

Occult heart disease or renal dysfunction: HBOT causes a fluid shift from the interstitial to intravascular space. In patient with occult heart or renal disease, this fluid shift can exacerbate underlying heart disease when the heart must handle this additional fluid.⁷

Fire and combustion risk: Because pure oxygen under pressure is used, any ignition source could have catastrophic consequences. As so, extensive grounding of the machine and proper maintenance and monitoring is essential. Additionally,

the use of any combustible, heat or spark generating substance must be prohibited, including synthetic dressing materials, petroleum-based ointments/topical and exposed metal implants.

“Treatment protocols vary greatly based on the patient, condition being treated and treatment logistics.”

Patients receiving HBOT should be closely evaluated prior to and after treatment by an HBOT certified technician, with continuous patient monitoring during the entirety of therapy. Lancaster Veterinary Specialties has a number of certified nurses that have passed special testing and continue to obtain HBOT specific continuing education. Treatment protocols vary greatly based on the patient, condition being treated and treatment logistics. In humans, specific treatment protocols including frequency and number of treatments have been established. At LVS, treatments are typically performed Monday through Thursday during normal business hours. Lancaster Veterinary Specialties is one of the few facilities in the state to offer veterinary patients HBOT. Additionally, our chamber is specifically designed for veterinary patients. Minimal complications, a non-invasive treatment modality, combined with good patient tolerance and outcomes makes HBOT an exciting, adjunctive treatment modality for veterinary patients.



Meet the Author: Dr. Lindsay Schmidt

Dr. Schmidt joined the Surgery team at Lancaster Veterinary Specialties in September 2020. Originally from Montana, she obtained a Bachelor of Science in Zoology and Doctor of Veterinary Medicine from Washington State University in 2008. Dr. Schmidt brings over 10 years of clinical experience, spending several years in general practice prior to completing surgical internships in St. Louis, Chicago, and Baltimore, followed by a surgical residency at Hope Veterinary Specialists in 2019. Upon finishing her residency, Dr. Schmidt worked as a surgeon in Maryland before joining LVS.

Our practice is fully equipped and staffed to perform a wide range of surgical procedures in cats and dogs, from common to complex. Dr. Schmidt is well-versed in a variety of surgical procedures with special interest in soft tissue, oncologic, minimally invasive, orthopedic, and neurologic procedures.

In her free time, Dr. Schmidt enjoys traveling, gradening, and spending time with family and her furbabies.

Do you have questions about HBOT or another case? We encourage all of our referring partners to call us to discuss any cases that they feel would benefit from specialty care. We promise to work with you in a collaborative fashion to help promote the success of your practice and successful outcomes for your patients.



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