Veterinary HBOT Clinical Rounds and Case Studies

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The Use of Hyperbaric Oxygen in Small Animal Internal Medicine

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Peace Love Pets Veterinary Care and Insight Veterinary Concepts
Commack, New York, USA
Special Thanks to ...

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Plumb’s Therapeutics Brief
Veterinary Hyperbaric Oxygen Therapy: A Critical Appraisal
Lindsay Hochman, DVM, MPH University of Florida
Justin Schmalberg, DVM, DACVN, DACVSMR, University of Florida
June 2017 Peer Reviewed

Treatment Overview
There is a paucity of data about use of HBOT in veterinary medicine, and no randomized, controlled clinical trials for any condition have been published. Thus, veterinarians must rely on the comparatively more robust human literature.

There are currently 48 Hyperbaric Veterinary Chambers in the United States in both private and university hospitals.
Small animal monoplace chamber (exact standards as a human chamber or a human chamber). Can fit in the space where our washer and dryer were previously located.
Oxygen supply can be simple

- We use containers called Dewars and a back up K tank
- Simple use, not bad expense, small footprint.
- Our space is VERY limited so we are happy the equipment is relatively small.
Effects from Direct Pressure in HBOT

• At 2.8 atmospheres, any bubble volume reduces by almost two thirds.
• Dissolution of gas in solution prevents the formation of new bubbles.
• An inert-gas bubble will easily dissolve in 100% O₂ by replacing the inert (nitrogen) gas
  ○ in the bubble with oxygen, which is then rapidly metabolized by the tissues.

Compression in a chamber will decrease gas from

- ileus
- bloat or severe intraluminal gas accumulation.
- useful in perioperative gastrointestinal obstruction
- gas gangrene
- emphysematous biliary or urinary bladder tissues
- Subcutaneous emphysema

Due to:
• Reduction in gas volume
• Nitrogen, hydrogen, methane and CO₂ diffusion into tissues and blood
• High gradient for gas removal via respiration
  • The decrease in pressure from gas in tissues or cavities results in less injury from vascular compromise, decreased bacterial translocation, necrosis, pain and swelling.
Hyper-Oxygenation

Besides bringing oxygen to damaged tissues in a high concentration....

- Tissues become more dense from pressure creating a larger overlap of oxygen rich tissues
- Oxygen tensions remain elevated up to 4 hours after therapy, results last longer

Oxygen induces vasoconstriction without causing hypoxia

- Oxygen induces smooth muscle contraction in all muscularized vessels (arterial and venous) not capillaries or lymphatics
- This decreases bleeding/oozing from vessels
- Several animal models of hyperoxic vasoconstriction suggest that O2 tension may influence one or more of the endothelium-derived factors, such as NO, endothelin, and vasoactive PG.
- It has been demonstrated that both hyperoxia and oxidative stress may stimulate increased production of the endothelium-derived vasoconstrictor endothelin.
Hyper-Oxygenation

**Reduction of swelling and edema**

- **HBOT** decreases filtration of fluid from the capillary to the extracellular space due to vasoconstriction while reabsorption of fluid at the capillary level and into lymphatics is maintained. Enhanced diffusion of fluid into lymphatics and capillaries.

- Reducing edema decreases capillary diffusion distances, increasing oxygen perfusion.

- Fluid reabsorption helps inflammatory cells remove cell debris and micro-organisms.

**The decrease in pressure from edema reduction results in less injury from vascular compromise, decreased bacterial translocation, necrosis, pain and swelling.**
Immediate post-op debridement of necrotic pancreatic tissue; had reaction to plasma transfusion. No steroids given.
One Hour Post HBOT: (1 Hour, 2 ATA)

Effects of HBOT are prolonged. Gas and tissue levels of O$_2$ decrease rapidly after HBOT, but are still elevated for at least 4 hours. Many effects last much longer.
Diane’s Mantra for hyperbaric oxygen therapy

The decrease in pressure from reduction of gas in tissues or cavities and reduction of edema results in less injury from vascular compromise, decreased bacterial translocation, necrosis, pain and swelling.

Dayenu
- Reduction of reactive oxygen species
- Decreased inflammation - decreases likelihood
- Of thrombosis by protection of microcirculation
  - Significant rapid decrease in discomfort
  - Reduced time to eating again and hospitalization
  - Reduction in pancreatic edema/size on ultrasound
  - Treat for 1-3 days unless severe necrotizing pancreatitis
Urinating blood,
Lethargic 6/2/17, DIC, Hyperthermia causing necrotizing pancreatitis with septic peritonitis and multiple organ failure (kidneys, liver) E.coli 4+ (abdomen)
Treatment: ICU, Fresh frozen plasma, PRP,Hetastarch, IV Unasyn and Baytril, Fentanyl, HBOT 1.5 ATA 30 min
6/6/17

“Chance”

Released Home!! 5 DAYS!!

All biochemical abnormalities – nearly normal

Clotting factors – normal

HBOT 5 sessions

6/2, 6/3, 6/3, 6/4, 6/5
5 day history of vomiting and anorexia, severe dehydration and seizures

Intestinal perforations with septic peritonitis. Four enterotomies and 21 perforation repairs. Patient began HBOT immediately post-op after recovery.
3 DAYS LATER
Eating well
Released to Mom!

HBOT 2.0 ATA
30 min.
5 Sessions
beginning immediately
post-op
Every 12 hours
Necrotizing Fasciitis (Day 1, Presentation)

Severe pain, swelling, induration, poorly defined margins, fever, severe necrosis and sloughing of tissues.
Mantra: The decrease in pressure from reduction of gas in tissues or cavities and reduction of edema results in less injury from vascular compromise, decreased bacterial translocation, necrosis, pain and swelling.
Necrotizing Fasciitis (Day 2)

Pasturella - facultative anaerobe. Dead tissue: Great place for bacteria to flourish.

With HBOT
- Edema reduced 50%.
- Marked reduction in swelling.
- Fever resolved.
- Tissue necrosis stabilized, margins are defined.
- Increased blood flow and $O_2$ to tissues.
- Stopped bacterial growth.
- Pain diminished.
Necrotizing Fasciitis (Day 3)

- Hyper-oxygenation
- Vasoconstriction
- Edema reduction
- HBOT Enhances efficacy of leukocytes
- Reduces intravascular leukocyte adherence
- Direct antibacterial and antifungal
- Antibiotic synergism
- Toxin inhibition
- Facilitates healing
- Reperfusion attenuation
He received daily HBOT 1.5 ATA 30 min. 4 treatments then every other day along with wet to dry wound bandages. Wound surgically closed after 10 days.

November 9, 2015
Complete wound healing 10 HBOT sessions within first 14 days.
HBOT Immediately Post-Op
1.5 ATA 30 min.
HBOT  Daily 1.5 ATA 30 min combine with LASER Therapy
"Alfie" Dorta-Duque

July 27, 2017

July 31, 2017 (Presented July 18)
Episode of acute onset forelimb paresis occurred night before.
After diagnosis, 1 hour post first dose of amlodipine. This video is immediate post first treatment with HBOT. 1 hour, 1.5 ATA
Episode occurred 4 nights prior; 1<sup>st</sup> tx was 3 days ago (Friday), 2<sup>nd</sup> tx, 2 days ago (Sat), 3<sup>rd</sup> tx today (Monday). Each treatment: 1 hour at 1.5 ATA.
“Tyson” Howarth

4 yr. MN Boxer
9/26/16
Presentation: Lethargy, inappetence, frank bloody diarrhea
Diagnosis: Intestinal Pythium
Pythium insidiosum

Critical Clinical Points

- **Oomycetes** organism found throughout the south

- Closely related to *algae*, diatoms and seaweed.

- Antifungals and antibiotics largely ineffective

- Subcutaneous and gastrointestinal forms causing severe locally invasive **granulomatous/eosinophilic** masses

- Significant morbidity and mortality
Treatment Options:

• Wide surgical resection if possible

• Minocycline

• Mefenoxam (herbacide used to treat crops)

• Prednisone

• HBOT 3 sessions week 1, 2 sessions week 2, 1 session weeks 3 and 4
“Tyson” Howarth

Treatment Protocol:
11/7/2016 Initiated

• Minocycline 10 mg/kg PO SID x 2 months
• Mefenoxam 8 mg/kg PO SID x 3 months
• Prednisone 1 mg/kg PO SID x 1 month
• HBOT 1.5 ATA 30 min 17 sessions
  3 x per week (weeks 1 & 2)
  2 x per week (weeks 3, 4, 5, 6)
  1 x per week (weeks 9, 10, 11)
• LASER Therapy
  (photobiomodulation) accompanied each HBOT session
“Tyson” Howarth

Feb. 23, 2017 Seroconverted – Negative
No clinical signs or US findings of disease.
Clinical Case:

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Oncology:
- Post-operative healing
- Pre and post radiation therapy
- Palliative care for neoplasia, pain and swelling
- Radiation burns/necrosis
- Osteoradionecrosis
- Soft tissue radionecrosis
- Doxorubicin extravasation
- Metabolic Therapeutics
Effects of doxorubicin extravasation in humans

Only treatments are dexrazoxane (Zinecard), sargramostim, and hyperbaric oxygen for doxorubicin extravasations.
Ein Nichols lymphoma: Jan 17th 2013 got Adriamycin

- Jan 17: got Dexrazoxane-10 times adriamycin dose
- Jan 18: got Dexrazoxane-5 times Adriamycin dose
- Jan 28 one treatment with HBOT
- Seemed better but worsened over next 30 days
- Started BID HBOT on 3/5 (7 weeks later)
The day we began: 7 weeks post chemo
Day 1

Day 3  6 Treatments

Day 6  11 treatments
He wore his nails from knuckling due to nerve entrapment/compartment syndrome. Knuckling has stopped.
Still some induration in the armpit but no pain
Day 34  treatment 37

More of Ein- with HBOT: We switched to mitoxantrone instead of doxorubicin  Survived 22 months after diagnosed with LSA

All better  Day 52  treatment 46
Snake and Spider envenomation

- Envenomation - Brown Recluse Spider
Brown Recluse spider bite without HBOT intervention

This patient caused significant self mutilation damage
6 YEAR OLD FEMALE  Insect bite: 3 sessions, once daily at 2 ATA for 45 minutes
A trio of dogs attacked a 5 foot Canebrake rattlesnake. The snake fought back. All three presented with neurological signs and this one also had bad soft tissue swelling. These snakes have both a neurotoxin, hemotoxin and myotoxin that cause severe tissue necrosis, sloughing, DIC and death.

Peter Brofman, DVM, MS, ACVIM (neurology and internal medicine)
Veterinary Specialty Care  South Carolina
The pictures are at presentation then 24 hours after HBOT (only 2-3 treatments 2.0ATA 45min). Without antivenin this is very rapid and impressive improvement.

Peter Brofman, DVM, MS, ACVIM (neurology and internal medicine)
Veterinary Specialty Care South Carolina
Suspected snake bite but not witnessed: 4 treatments were given within 2 ½ days

In this case he was obviously more comfortable after the first treatment, and each subsequent treatment.
Left untreated they will continue to swell severely likely causing airway obstruction and severe necrosis in other swollen areas. The process is immediately reversed here.
Renal diseases

Renal Diseases

- Nephrotic syndrome
- Ischemia reperfusion
- Inflammation
- **Acute Renal Failure**
- Possible PLN in conjunction with therapy for underlying disease
- Lyme nephritis

Inflammatory/infectious

Inflammatory, infectious and immune mediates diseases

- Allergic reactions/anaphylaxis
- GME
- RMSF induced vasculitis/meningitis/arthritis
- Immune mediated polyarthritis
- IMHA / ITP
- Osteomyelitis
- Septic arthritis
- Septicemia

- Endotoxemia
- **Hyperthermia**
- Aspergillosis, Mucormycosis,
- **DIC**
- Lyme disease
- Anaerobic infections:
  - Actinomyces, clostridium (gas gangrene), etc
- Intracranial and abdominal abscess

**Embolic nephritis from endocarditis**

**vasculitis**
“Joe” Bowen 4 yr. MN Border Collie Presentation: ADR 12/9/16 Acute Renal Failure

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On 12/13 Initiated HBOT 2 ATA 30 min once daily for 4 sessions
**“Joe” Bowen 4 yr. MN Border Collie Presentation:**

**ADR 12/9/16 Acute Renal Failure**

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January 19, 2017

3 HBOT sessions every other day
Caustic ingestion/bee or spider
Normal

One day after presentation
Our patient on presentation

When air cannot move through – needed tracheostomy to survive....
When stable next day... HBOT

PRE

Post first HBOT tx

Post first HBOT tx
2 days after presentation- abs and HBOT only

Breathing through mouth and nose now