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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Veterinary Concepts
Commack, New York, USA

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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.
Hydroxy-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.
Effects of HBOT are prolonged. Gas and tissue levels of O₂ 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

פיִּנְגַנְטֶה
- 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
“Chance” Grieco 10 yr. MI Boston Terrier

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
3 yr MN DSH
June 16, 2017
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.
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
“Charlie Brown” Thompson
6 yr MI Dachshund Mix

October 31, 2015  BDLD
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.

November 13, 2015

November 23, 2015
“Alfie” Dorta-Duque 4 yr FS Jack
Russell Terrier
July 18, 2017

BDLD

HBOT Immediately Post-Op
1.5 ATA 30 min.
“Alfie” Dorta-Duque

July 20, 2017

HBOT Daily 1.5 ATA 30 min combine with LASER Therapy
“Alfie” Dorta-Duque

July 27, 2017

July 31, 2017 (Presented July 18)
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\textsuperscript{st} tx was 3 days ago (Friday), 2\textsuperscript{nd} tx, 2 days ago (Sat), 3\textsuperscript{rd} tx today (Monday). Each treatment: 1 hour at 1.5 ATA.
4 yr. MN Boxer
9/26/16
Presentation: Lethargy, inappetence, frank bloody diarrhea
Diagnosis: Intestinal Pythium
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
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
Feb. 23, 2017 Seroconverted – Negative
No clinical signs or US findings of disease.
**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

All better Day 52 treatment 46

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

Day 1

Day 2

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.

Peter Brofman, DVM, MS, ACVIM
(neurology and internal medicine)
Veterinary Specialty Care South Carolina
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 and immune mediates diseases
- Allergic reactions/ anaphylaxis
- GME
- RMSF induced vasculitis/ meningitis/arthritis
- Immune mediated polyarthritis
- IMHA / ITP
- Osteomyelitis
- Septic arthritis
- Septicemia

Inflammatory/infectious

- 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
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