Value And Impact of Hyperbaric Medicine In The Treatment of Brain and Spinal Cord Injuries in Veterinary Patients

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Veterinary Hyperbaric Chambers

Class C – Animal Chamber
**Approved Uses In Humans**

**14 Approved Indications by Undersea Hyperbaric Medicine Society (UHMS)**

1. Air or Gas Embolism
2. Carbon Monoxide Poisoning • Carbon Monoxide Poisoning Complicated By Cyanide Poisoning
3. Clostridial Myositis and Myonecrosis (Gas Gangrene)
4. Crush Injury, Compartment Syndrome and Other Acute Traumatic Ischemias
5. Decompression Sickness
6. Arterial Insufficiencies: Central Retinal Artery Occlusion, • Enhancement of Healing In Selected Problem Wounds
7. Severe Anemia
8. Intracranial Abscess
9. Necrotizing Soft Tissue Infections
10. Osteomyelitis (Refractory)
11. Delayed Radiation Injury (Soft Tissue and Bony Necrosis)
12. Compromised Grafts and Flaps
13. Acute Thermal Burn Injury
14. Idiopathic Sudden Sensorineural Hearing Loss
Russia, China, South Korea, Japan, Europe

- Much Wider Accepted Application
- Over 175 Uses!
- Limitations In US
  - #1 Insurance
  - #2 FDA Studies
  - Can’t Patent Oxygen
  - $$$$$$$$

Less Limitations On Vet Medicine
# Veterinary Use

**Indications for Hyperbaric Oxygen Therapy**

### Central Nervous System
- Cranial/spinal cord trauma
- Cerebral/global ischemia
- Compressive cord diseases
- Fibro-cartilagenous emboli
- Cortical blindness
- Tetraparesis
- Peripheral nerve injury

### Musculoskeletal
- Athletic injuries
- Tendonitis
- Desmitis
- Periostitis
- Fracture
- Laminitis
- Myositis
- Crush injuries

### Cardiovascular
- Hypotension
- Shock (all causes)
- Cardiac infarction
- Acute anemia
- Reperfusion disease
- Carbon monoxide/cyanide toxicity
- Smoke inhalation
- Lymphangitis

### Respiratory
- Exercise induced pulmonary hemorrhage
- Pleuritis
- Sinusitis
- Pulmonary edema

### Wounds
- Thermal burns
- Compromised grafts/flaps
- Envenomation-spider, snake

### Infectious Diseases
- Osteomyelitis
- Septic arthritis
- Septicemia
- Endotoxemia
- Blastomycosis
- Lyme disease

### Gastrointestinal
- Ileus
- Pancreatitis
- Peritonitis
- Ulcers
- Reperfusion
Best Termed “Complimentary”
- Surgery
- Regenerative Medicine
- Physical Rehabilitation
- Oxygen Used As A Drug
- Over 60 Years of Research and Science Support Its Use
- US Navy
- Animal Models

Google Scholar Search:
- >136,000 HBOT Papers!
- >29,000 HBOT/Head Trauma
- >17,000 HBOT/Spinal Cord
- >14,000/HBOT/Stems Cells
Complimentary Treatments.... Rehab

South Paws
Veterinary Surgical Specialists
Physical Rehabilitation and Sports Medicine
Major Effects On Neurological Tissues

- Vasoconstriction
- Swelling
- Edema
- Inflammation
- Stem Cell Recruitment
- Neuronal Cells - O₂ Dependent
- *EpiGenetics : Gene Therapy
  - Humans: 8001 Genes
  - ↑ Growth Hormone and Factors
  - ↓ Inflammation
  - ↓ Cell Death
  - ↓ Reperfusion Injury
Reperfusion Injury – Neuronal Tissue

- HBOT ↓ Reperfusion Injury
  - Restoration of Blood Supply
  - Inflammation And Oxidative Damage
  - Induces Oxidative Stress
  - ROS And Interleukins
  - Cell Wall Damage
  - Neutrophil Flags → Stick→ Leave Vessel
  - Reactive Proteins and Free Radicals → Tissue Damage
  - Supplemental O2 Exacerbates

- HBOT - Oxygen Paradox
  - Nitric Oxide ↓ ROS Formation
  - ↓Cox-2
  - ↓MMP 2-9
Common Neurological Issues

1. Intervertebral Disc Disease
   * Hansen Type I - 90%
   * Hansen Type II – 10%

2. Fibrocartilagenous Emboli (FCE)

3. Neoplastic Disease

4. Spinal Cord / Head Trauma
   * Fractures
   * Concussion

5. Meningitis
   * GME, Steroid Responsive Meningitis
   * Primary Secretory Otitis/OEMI
Intervertebral Disc Disease

• Hansen Type I
  • Dorsal Annulus Failure
    • Thin
    • Easily Stressed
  • Disc Extrusion
    • Degenerated Nucleus Pulposus
  • Two Effects:
    • Compression
    • Initial Impact and Velocity
    • Combination of Both
Acute Spinal Cord Injury

IVDD

- Compressive Vs’ Concussive
- Can Address Compression
  - Hemilaminectomy /V-Slot Decompression
- Concussive – Largest Contributor To Neuronal Death
  - Swelling, Edema, Inflammation
  - Decreased Blood Flow
  - ↓ Oxygen Tension
  - Contusion/Bruising
Pre and Post Hyperbaric Treatment

1.5 - ATA

- 1 Treatment Prior to Surgery
- 3-9 Additional Postop Treat Until Plateau
- Low Pressure 1.5-ATA
  - Oxygen Paradox
  - ↓ Free Oxygen Radicals and Reperfusion Injury
  - ↓ Risk of Central Cord Malacia (High Pressures)
What Have We Found?

Avg. Return To Ambulation 6.2 Days Faster Vs Non-HBOT

Avg. Return to Voluntary Urination 4.2 Days Faster Vs Non-HBOT

Decreased Need For Opioids

Deep Pain (Sensory) Negative Patients
  - With Deep Pain 85-90%
  - Typical Prognosis 10-50% (Time Dependent) Return To Ambulation
  - 14/18 – 77% Return To Ambulation
  - IVDD Cases Only
IVDD Case Example : Kai

Kai, 3yo, Male Mix
- Presentation: UMN, Non-Ambulatory Paraplegia
- Analgesic in Both Pelvic Limbs
- 6 Hours Duration
- Hemilaminectomy
- 10 HBOT Treatments
IVDD Case Example: Kai

Day 2 Postop Discharge: Deep Pain Returned, No Voluntary Motor (3 HBOTs)
IVDD Case Example: Kai

1 Week Post Op: Weakly Ambulatory, Moderate to Severe Ataxia, Voluntary Urination (5 HBOTs)
IVDD Case Example: Kai

2 Weeks Post Op: Ambulatory, Mild Proprioceptive Deficits, Voluntary Urination (8 HBOTs)
IVDD Case Example: Kai

8 Weeks Post Op: 10 HBOTs Total
95% Neurologically Normal
T-L IVDD Example: Maya

- Maya, 7yo, female Pekinese.
- UMN Non-Ambulatory Paraplegia
- No Voluntary Motor in Pelvic Limbs
- Sensory Negative
- Panniculus Lost L2
- Withdrawl Reflex Intact
- Lesion Localized T3-L3
Ollie, 5yo, Dachshund

- UMN, Non-Ambulatory Paraparesis
- No Voluntary Motor Function
- Severe T-L Hyperpathia
- Pain Sensation Intact
- Imaging: T13-L1 IVDD

Treatment:
- Hemilaminectomy T13-L1
- 1 Preop HBOT/3 Postop HBOT
- Class IV Laser
- Rehabilitation.
Sam is 7yo, Male Shibu Inu.

- UMN, Non-Ambulatory Paraparetic
- Minimal Voluntary Motor
- *Superficial Pain Absent
  - Dermatomes and Tail
- Withdrawl Reflex Intact
- Panniculus Absent L2
- Severe T-L Hyperpathia.
- Hemilaminectomy T12-13
- HBOT
  - 1 Preop and 3 Postop
Cervical IVDD

- ~15% of IVDD Cases
- Dachshunds, Toy Poodles, Beagles
  - More Common Than T-L IVDD in Beagles
- 4-8 Years of Age
- C2-3 Most Common
  - Decreases Caudally
Cervical IVDD

- Neck Pain
  - Stiff Gait
  - Lowered Head
  - “Neck guarding”
  - Shoulder/Neck Muscle Spasms
- Nerve Root Signature
  - Up to 50%
  - Confused as Lameness
- Paralysis, Paresis
  - Lateralization
  - Pelvic Limbs > Thoracic Limbs
Cervical IVDD Treatment

- Preoperative HBOT
- Ventral Slot - Cord Decompression
- 2-3 Postoperative HBOT
- 95% Success Rates
  - Alleviation of Pain
  - No Neurological Deficits
Cervical IVDD Example: Sammy

Sammy, 9yo, male Dachshund
- UMN Non-Ambulatory Tetraparesis
- Voluntary Motor
- Superficial and Deep Intact
- Severe Cervical Hyperpathia.

Treatment:
- Ventral Slot
- 10 HBO Treatments
- Aggressive Rehabilitation
Sammy At 5 Months!
Cervical IVDD Example: Fiona

Fiona, 3yo, Female Dachshund. Presented With:
- UMN, Weakly-Ambulatory Tetraparesis
- Left Radiculopathy
- Severe Cervical Hyperpathia

Treatment:
- Ventral Slot
- 9 HBOT Treatments Over 2 Weeks
Fibrocartilagenous Embolic Myelopathy (FCE)

Embolization of the Arterial or Venous Supply Of Spinal Cord
- Emboli – Fibrocartilage From Nucleus Pulposus
- Large Breeds More Commonly Affected
- Age - <3 years
- Typically Asymmetric
Axel is a 2yo/Male, Boykin Spaniel

- Acute, UMN Tetraparesis
- Minimal Motor Function
- No Spinal Hyperpathia
- Normal Cervical ROM
- Withdrawl Reflex Intact
- No Cranial Nerve Signs
- C1-C5 Localization
FCE Example: Axel

Treatment:
- 10 HBO Treatments
- Class IV Laser
- Physical Therapy
Severe Otitis Externa/Media

Otitis Externa-Media-Interna (OEMI)
- Accumulation of:
  - Sebaceous Debris/Mucous
  - Occluded Canal (scar tissue)
  - Infected Bulla Epithelial Lining
  - Diseased Temporal Bone
  - Neck Pain/Head Tilt
  - Jaw Pain
  - Ruptured Tympanic Membrane
Case Example: Queen Elizabeth – OEMI

- Queen Elizabeth is 5yo, F/S, CKC- Presented With:
  - Severe Otitis Externa Media
  - Right Sided Head Tilt
  - Cervical Hyperpathia
  - Mild Ataxia
  - Circling To Right
  - Depressed Mentation
  - Hyperesthesia
Case Example: Queen Elizabeth – OEMI

Middle Ear Disease
Suspected Possible COMs/
Syringohydromyelia

MRI
COMS and Syrinx Formation at C2–C4

Severe OEMI

Middle Ear Disease
Suspect Secondary Meningitis
Medulla/Cerebellum
Case Example: Queen Elizabeth – OEMI

Treatment:
- Total Ear Canal Ablation and Bulla Osteotomy
- Rocephin Initially
- Culture Ear and CSF
  - + MRSP
- Amikacin IV SID X 14 Days
- 12 HBO Treatments SID
  - 1.5 ATA
- Class IV Laser of Surgical Site
Max is a 12-yo Labrador Retriever

- Acutely, Lateral Recumbent, UMN, Non-Ambulatory Tetraparetic
- Mentally Depressed
- Circling, Loss of Balance

CT – Chronic C6-C7 Disc Moderate Compression

Referred To MS State Neurology

- Worsening Mental Deficits
- High Field MRI
Case Example: Brain Stroke - Max

- MS State
  - Diagnosed Hypothyroid
  - Myxedema and Cerebrovascular Infarct
Case Example: Brain Stroke - Max

Treatment

- Levothyroxine
- HBO Treatments X 20
- Physical Rehabilitation

Max had a stroke to his Brain
Case Example: Brain Stroke - Otis

- Referral From Local Neurology Service
  - Acutely Tetraparetic
  - Vision Loss
  - Incoordination
  - MRI
    - Vascular Infarct

- Treatment
  - 10 HBO Treatments
  - Aggressive Rehabilitation
Head Trauma

- Cerebral Contusion
  - Swelling / Edema
- HBOT ↓ Intracranial Pressure
  - Vasoconstriction of Vessels
  - $\uparrow$ $O_2$ In Plasma Diffuses to Neuronal Cells
    - Very Oxygen Sensitive Tissues
    - ↓ Lactate
    - $\uparrow$ Aerobic Metabolism
- Decreases Small Vessel Injury
  - Reperfusion Injury

1.5-ATA : 5-10 Treatments
Case Example – Head Trauma - Louie

Louie, 8-yo Male mix

- Coyote Attack
  - Left Eye Proptosis
  - Nasal Bleeding
  - Depressed Mentation
  - Multiple Bite Wounds Head and Neck
  - Non-Ambulatory
  - Torticollis, Tetraparetic
  - Unable To Stand or (Hip Flip)
Case Example – Head Trauma - Louie

**Diagnostics**
- CT Head
  - Left Depression Fracture
  - Displaced Skull Fracture - Fontanelle

**Treatment**
- Mannitol and Hetastarch (Colloid)
- BP Maintained 80-100mmHg
- IV fluids
- 12 HBOT – 1.5 ATA, 45-minutes
  - 2 Treatments/Day – 48 Hours
    - Significant Improvement 48 Hours
  - Eye Enucleation Day 3
  - 1 Treatment/Day 8 Days
So How Do We, As Veterinarians, Prevent Head Trauma In Our Patients?
Lagniappe Case – “Hollywood”

Hollywood, 4yo, Shiloh Shepherd

- Severe Frostbite To Carpal Joint

Treatment

- Wound Debridement
- 31 HBO Treatments
- Surgery 1: Digital Amputation
- Surgery 2: Carpal Pad Transposition
- Surgery 3: SIS/BMAC StemCell/PRP Graft
Questions........