HYPERBARIC OXYGEN AND ITS USE IN MEDICAL CONDITIONS

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OUTLINE

• Definition
• History
• Physics
• Physiology
• Mechanism
• FDA Approved
• Off Label
HYPERBARIC OXYGEN THERAPY

A medical treatment in which a patient breathes 100% oxygen under increased atmospheric pressure

- “Hyper” – more
- “Baric” – atmospheric pressure
- Hyperoxygenation – “high dose”
HISTORY

1662
First documented use of compressed air by an English clergyman

1775
Discovery of oxygen

1800
Hyperbaric spas constructed throughout Europe “Air baths”

1834
Pulmonary disease treated with compressed air in France

1870
First mobile hyperbaric operating theater

1891
Introduction of hyperbarics to U.S. for “nervous disorders”
**HISTORY**

1928

Largest hyperbaric chamber constructed for various maladies

1937

100% O2 first used in hyperbarics for decompression sickness

1938

Used for treatment of leprosy in Brazil

1938

Used in USA to treat experimental CO poisoning in animals

1950

Used by UK to enhance tumor radio-sensitivity

1959

Boerema proved life can be sustained in absence of blood flow
HISTORY

1960s
Effectiveness shown for stroke, MS, MLS, brain ischemia, CO poisoning, gas gangrene, etc

1970’s
Majority of US hyperbaric chambers were military

1980
Hyperbaric community began to develop with various organizations and certifications

1991
The National Board of Diving and Hyperbaric Medical Technology (NBDHMT) formed

2002
International Hyperbaric Medical Association (IHMA) formed
Henry’s Law of Gas Solubility

The solubility of a gas in a liquid is directly proportional to the partial pressure of the gas above the liquid.

Increasing the atmospheric pressure increases the amount of gas that is dissolved into a fluid. (Oxygen → Blood Plasma)
Clinical Hyperbaric Pressures

- 7 – 22 psi
- 10 – 15 normal amount of oxygen
- Bypasses body’s normal system of transporting oxygen

What Gets Hyper-Oxygenated?

- Blood Plasma
- Cerebrospinal Fluid
- Lymph Fluid
HIGH DOSE OXYGEN

- Classified as drug by the FDA
  - Produces physiological changes in the body
  - Toxic at high doses – (oxygen toxicity)

**DX:**
- Disease or injury causing low oxygen levels/poor perfusion in the tissues

**Results:**
- Enhance and speeds up the body’s natural healing process
• Limits ischemic damage, cell death, inflammation
• Promotes collagen synthesis (fibroblast stimulation)
• Decreases lactate production and tissue acidosis
• Aids in oxygen dependent killing of bacteria – WBC
• Limits leukocyte adhesion and degranulation
• Decreases tissue edema
• **Stem Cell Mobilization**
  
  • Causes mobilization of CD34+ progenitor cells from bone marrow
  
  • University of Pennsylvania study

• **Angiogenesis**
  
  • Promotes neovascularization of poorly perfused tissue
  
  • Unique action

**MECHANISM OF ACTION**
POOR BLOOD FLOW = POOR OXYGENATION = TISSUE DAMAGE
HYPERBARIC CONDITIONS

- Increase in the diffusion distance into the tissue
- Blood vessel
- Restriction (occlusion) of the blood vessel reduces blood and oxygen flow
- Red blood cells block off the blood flow
- Diffused oxygen
- Plasma can carry 100% oxygen under pressure
- 100% oxygen under pressure diffuses from the plasma up to three times further into the tissues
“Although there may be insufficient stimulus to initiate angiogenesis under normal conditions, by increasing the local oxygen delivery the oxygen gradient is magnified ….resulting in a stronger signal for the repair mechanism.”
- Diabetic Wounds*
- Osteomyelitis*
- Delayed Radiation Injuries (Soft tissue/bone)*
- Compromised skin grafts/flaps*
- Decompression sickness
- Carbon monoxide poisoning
- Intracranial abscess

- Acute Arterial insufficiency
- Thermal burns
- Crush injuries, acute trauma
- Necrotizing soft tissue infections
- Exceptional blood loss anemia
- Gas gangrene

*Represent 95% of all hospital treatments
DIABETIC WOUNDS
Patients with diabetic lower extremity ulcer

Patient has failed a 30-day course of standard, conventional wound therapy

Treatment Protocol – 2.4ATA/90 minute x 20-40 treatments adjunct to standard wound care
Pre-Hyperbaric Wound

Partial Wound Closure
20 HBOT Tx
4 Weeks

Complication Resolved
Full Healing
35 HBOT Tx
7 Weeks
Required incision, drainage and debridement

After 10 Tx / 2 Weeks granulation tissue

After 20 Tx / 4 Weeks

After 35 Tx / 7 Weeks
DIABETES
WOUNDS
DIGITAL
AMPUTATION

Initial Visit

After 10 Tx / 2 Weeks

After 15 Tx / 3 Weeks

After 30 Tx / 6 Weeks
DELAYED RADIATION INJURIES
Delayed Radiation Injuries

- Symptoms may develop 3-24 months after radiation therapy
- 5-10% of irradiated patients

<table>
<thead>
<tr>
<th>Soft tissue radiation injury – ulcers/non-healing wounds</th>
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<tbody>
<tr>
<td>Osteoradionecrosis – mandibular</td>
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<tr>
<td>Radiation cystitis</td>
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<td>Radiation proctitis</td>
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<td>Radiation enteritis</td>
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VASCULAR INJURY

- Injury to the underlying vasculature and arteriocapillary fibrosis
- Tissue vascular density is greatly diminished
- Loses ability to heal itself
ANGIOGENESIS IN IRRADIATED TISSUE

Response to 20 treatments @ 1 ATA/90 min. with 100% O2

Response to 20 treatments @ 2.4 ATA/90 min. with 100% O2
MANDIBULAR OSTEORADIONECROSIS

Initial Visit - Bone Exposed

After 25 Tx - 5 Weeks

After 10 Tx / 2 Weeks

After 40 Tx - 8 Weeks
New tissue over bone
DAMAGE TO OSTEOCYTES FROM RADIATION THERAPY

Mandible has least redundant blood supply & muscle coverage

<10% of patients receiving head & neck radiation therapy have complications:

- Weakens bone, predisposing to fracture
- Often painful, broken down mucosal coverage
- Decreases blood flow, difficult to fight infection
• Significant fibrotic changes in bone and marrow
• Reduction in caliber and number of feeding vessels
• Periosteal and mucosal damage → bone necrosis
RADIATION SOFT TISSUE NECROSIS

Initial Visit

After 10 Tx / 2 Weeks

After 20 Tx / 4 Weeks

After 35 Tx / 7 Weeks
STSG AFTER RADIATION NECROSIS

2 months post-surgery

After 20 Tx / 4 Weeks

10 days following spilt thickness graft
COMPROMISED SKIN GRAFTS
PROBLEM WOUND WITH SKIN GRAFT FAILURE

Diabetic patient, 6 month non-healing wound, one failed graft

Initial Visit

25 HBOT Tx / 5 Weeks

Split thickness graft placed - 100% acceptance
DEGLOVING ACCIDENT - FAILED FLAP - LEFT DORSAL FOOT

Initial Visit

After 10 Tx / 2 Weeks

After 15 Tx / 3 Weeks

After 30 Tx / 6 Weeks

3 Weeks post HBOT

Final HBOT Visit
SKIN NECROSIS - TOTAL KNEE REPLACEMENT

Initial Visit

After 10 Tx / 2 Weeks

After 15 Tx / 3 Weeks
WHAT DOES HBOT BENEFIT?

Any kind of injury or disease in which poor tissue perfusion is either causing or complicating the situation.

• underlying vascular injury
  • edema/swelling
  • trauma
“OFF-LABEL” USES - WORLDWIDE

- Orthopedic Injury/Post Surgery
- Lyme Disease
- Traumatic Brain Injury/PCS
- Stroke – Ischemic
- Cerebral Palsy
- Autism
- Bells Palsy
- Crohn’s Disease/IBD
- Chronic Fatigue Syndrome
- CRPS/RSD

- Diabetic Retinopathy
- Post Surgery Recovery/Healing from laser or traditional types of cosmetic surgery
- Arthritis (Osteo and Rheumatoid)
- Macular Degeneration
- Migraine and Cluster Headache
- Multiple Sclerosis (Acute, Relapsing, Remitting, Chronic)
- Osteonecrosis – Avascular, Aseptic, and Ischemic Bone Necrosis
- Non-healing fractures – Non Union
- Peripheral Neuropathy
- Psoriasis
- Lupus
- Immune System Support
- Cancer w/Keto
• Promotes greater tissue strength
• More rapid tissue growth & covering larger areas
• Resulting tissue integrity is stronger
• Enhances the growth of new blood vessels
SPORTS INJURIES

• Reduces swelling
• Blunts the inflammatory process
• Improves range of motion earlier/ PT
• Increases and enhances tissue growth – fibroblast and osteoblast proliferation
• Improves Bone Regeneration-Faster and Stronger Fracture Repair
  • Non-Union fracture, complicated Fractures, AVN
CASE STUDY

- Injured on January 5th 2009
- Shearing fracture, surgically repaired
- High risk for Non-Union
- “Season Ending”

- Started HBO January 7th 2009
- 30 tx over 6 week period
- Cleared to ski March 3rd 2009

“Fastest healing I’ve ever seen in a injury this significant”
-Orthopedic Surgeon
Twelve NFL teams own chambers

- “Ward using hyperbaric chamber to accelerate recovery”
  USA Today

- “Football superstar Terrell Owens used hyperbaric oxygen therapy to hasten his recovery from an ankle injury so that he could play in the Super Bowl.”
  Fox Sports

- Cincinnati Bengals defensive tackle Bryan Robinson says “hyperbaric oxygen therapy was the catalyst in getting a nagging ankle injury to heal.”
  Cincinnati Inquirer

- “Linebacker Kevin Burnett credits hyperbaric oxygen therapy for helping him get back onto the playing field quickly after surgery to repair cartilage damage in his knee.”
  Dallas Cowboys Official Weekly
Portable hyperbaric chamber at Olympic Track and Field venue: 2012 - London

China: HBOT is included as a routine therapy in sports medicine; there are now over 4000 facilities.
LYME DISEASE

• Fastest growing vector-borne infectious disease in the US
• Reported annual cases increased nearly 25-fold since 1982
• No tests available to prove that the organism is eradicated or that the patient is cured
“THE GREAT IMITATOR”

• 5 subspecies of borrelia burgdorferi, over 100 strains in the US, and 300 strains worldwide
• Evades the immune system and antibiotic therapy, leading to chronic infection
• The Elisa screening test is unreliable
• Symptoms can be easily mistaken for other illnesses
Lyme disease is known as “anaerobic”: it cannot exist in oxygen.

- Reduces harmful bacteria.
- Herxheimer response, which includes symptoms such as fever, chills, headache, flushing, and more.
  - Endotoxins that are released as the harmful bacteria dies.
  - Lasts only a few hours to days.
TRAUMATIC BRAIN INJURY

- Inflammatory reaction resulting from tissue injury:
  - Edema
  - Reduced blood flow
  - Reduced oxygen
  - Excitatory amino acids
  - Free radical damage
  - Lipid peroxidation
  - Cell death
In one month of HBOT = Significant improvement in symptoms

- 15 point increase in full scale IQ
- Significant increase in cognition
- 30% decrease in PTSD; 8/14 no longer met criteria for PTSD
- 51% reduction in depression
- 38% reduction in anxiety
- PBNR (cog., phys., emot.) +33-90%

HBOT AND THE BRAIN

- Induces neuroplasticity
- Increases tissue oxygenation
- Generates new capillary networks
- Restores blood supply
- Increases stem cells in the blood
• 2 hours = 3x amount of stem cells **circulating stem cells in your blood**
• 20 sessions = 800% more stem cells **circulating stem cells in your blood**

• Migrate to damaged tissues and help them regenerate
• Essential to healing nerve and brain tissue
RECAP

100% oxygen under increased atmospheric pressure
In use since the 1800’s
Henry’s Law of Gas Solubility
Oxygen → Plasma
Considered a drug
Reduces inflammation
Mobilizes stem cells
 Increases angiogenesis
Promotes greater tissue strength
Enhances the growth of new blood vessels
Treats traumatic brain injury (TBI) patients by combining regenerative therapies: HBOT, stem cells, PRP, and nutritional therapies.  

www.tbitherapy.com

Treats chronic pain and major medical problems using natural and alternative medicine whenever possible.  

www.aspenintegrativemedicine.com