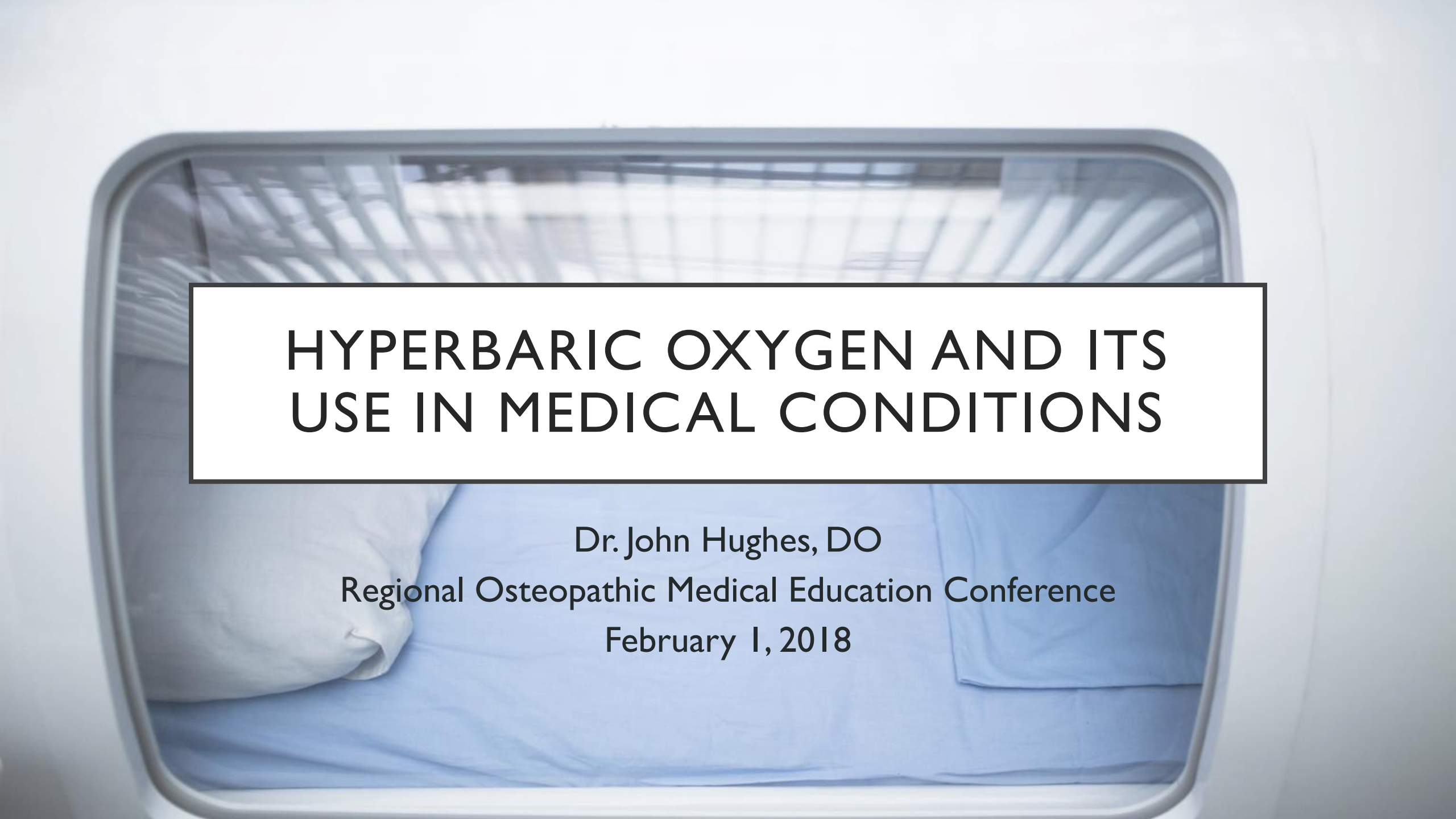


HYPERBARIC OXYGEN AND ITS USE IN MEDICAL CONDITIONS

Dr. John Hughes, DO

Regional Osteopathic Medical Education Conference

February 1, 2018

OUTLINE

- Definition
- History
- Physics
- Physiology
- Mechanism
- FDA Approved
- Off Label

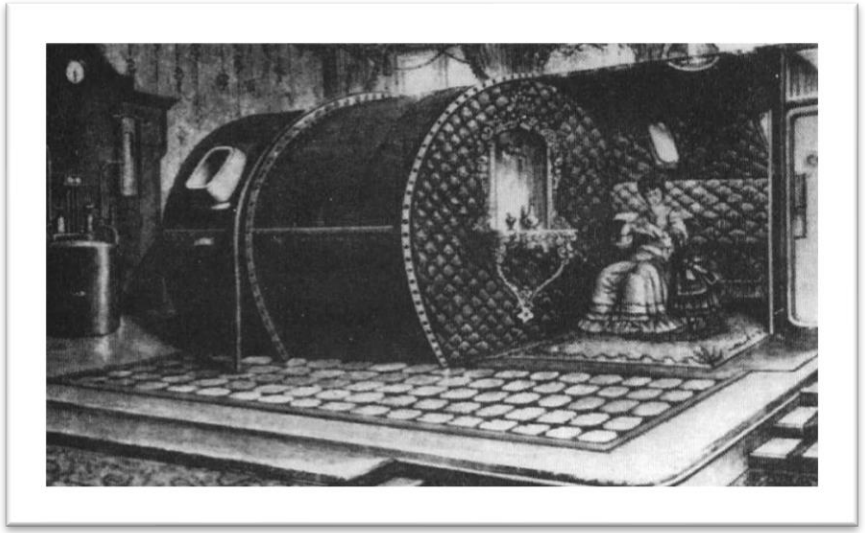
HYPERBARIC OXYGEN THERAPY

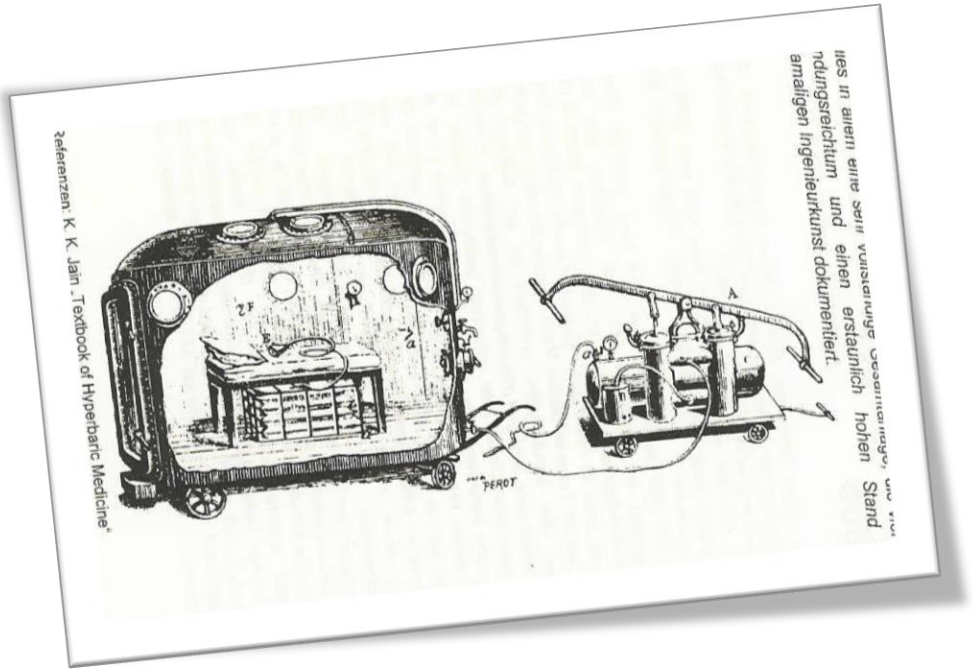
A medical treatment in which a patient breathes 100% oxygen under increased atmospheric pressure

- "Hyper" – more
- "Baric" – atmospheric pressure
- Hyperoxygenation – "high dose"

HISTORY

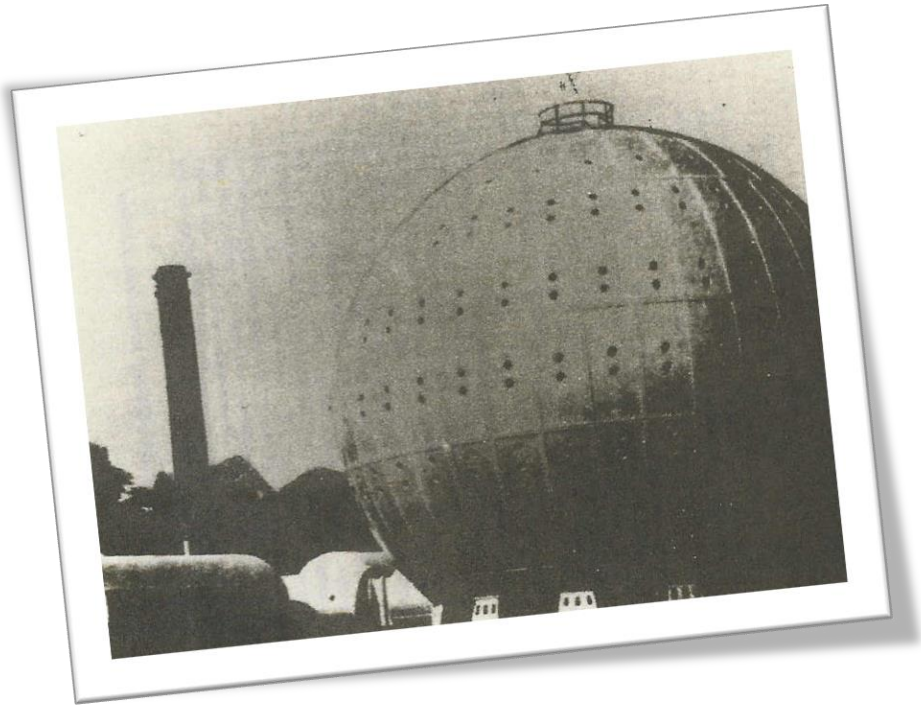
- **1662** First documented use of compressed air by an English clergyman
- **1775** Discovery of oxygen
- **1800** Hyperbaric spas constructed throughout Europe "Air baths"
- **1834** Pulmonary disease treated with compressed air in France
- **1870** First mobile hyperbaric operating theater
- **1891** 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 stoke, 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

American College of Hyperbaric Medicine
2476 Bolsover, Box 130 · Houston, Texas 77005
713.528.0657

UNDERSEA & HYPERBARIC MEDICAL SOCIETY

CERTIFIED DIVER MEDIC

CERTIFIED HYPERBARIC TECHNOLOGIST

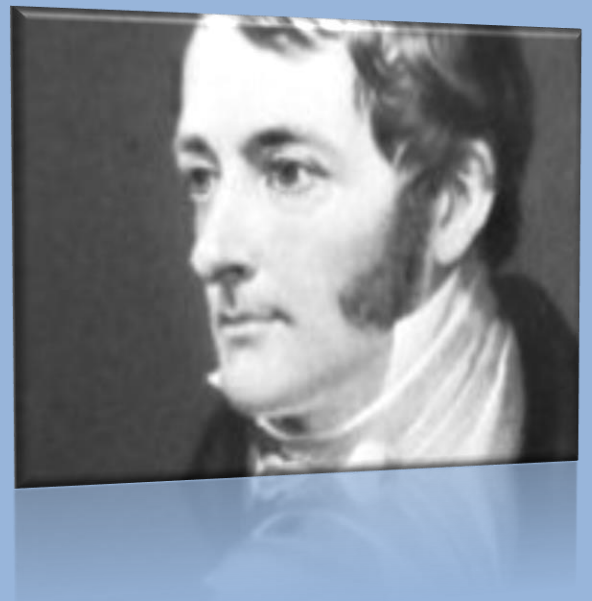
CERTIFIED HYPERBARIC REGISTERED NURSE

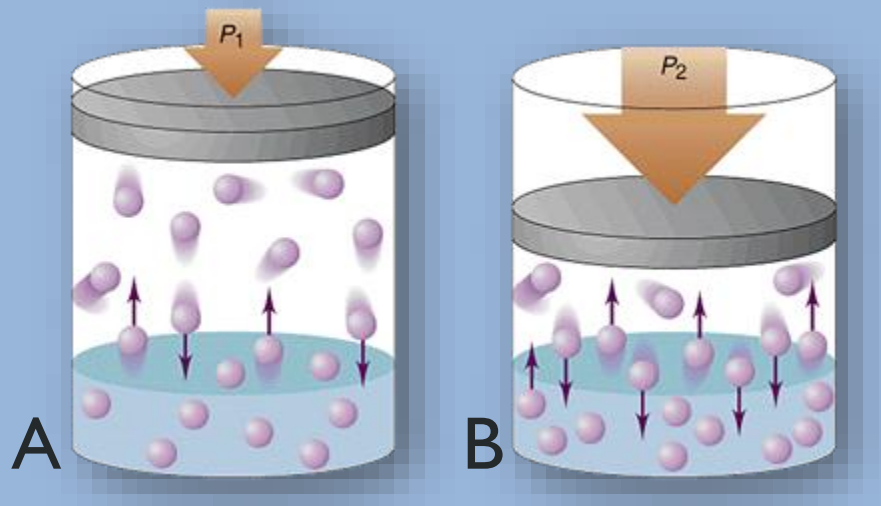
CERTIFIED Hyperbaric Technologist - Veterinary

PHYSICS

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.



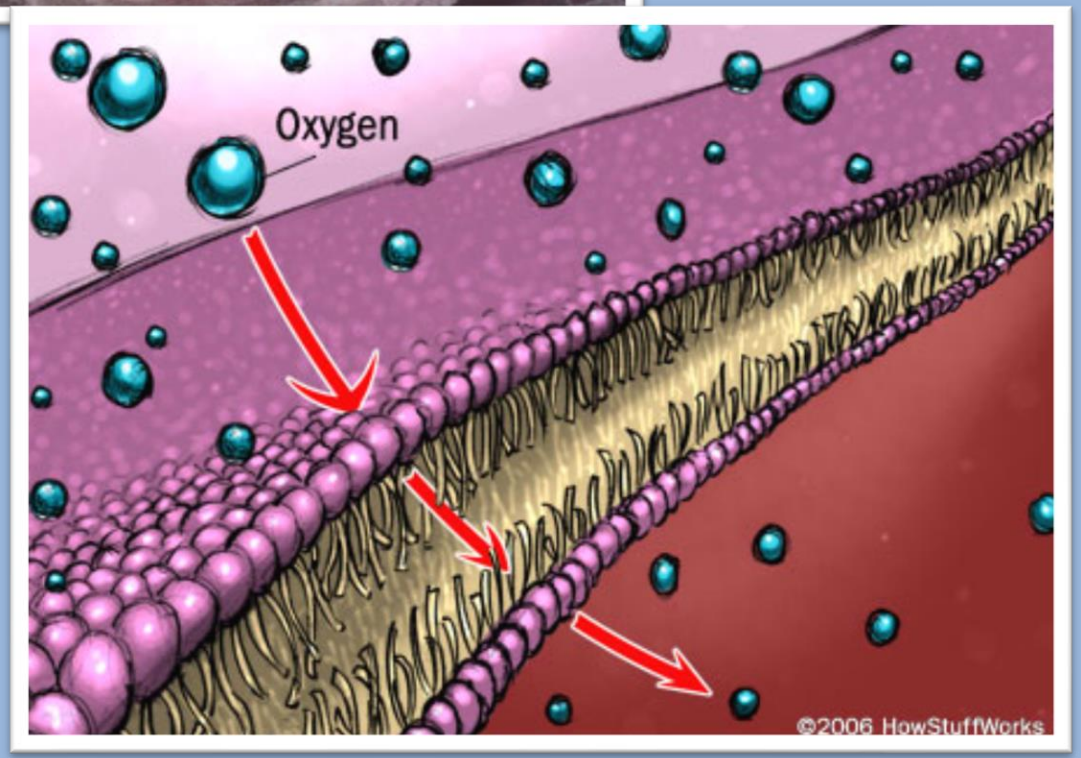


Increasing the atmospheric pressure increases the amount of gas that is dissolved into a fluid.
(Oxygen → Blood Plasma)

PHYSIOLOGY

What Gets Hyper-Oxygenated?

- Blood Plasma
- Cerebrospinal Fluid
- Lymph Fluid



Clinical Hyperbaric Pressures

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

HIGH DOSE OXYGEN

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

DX:

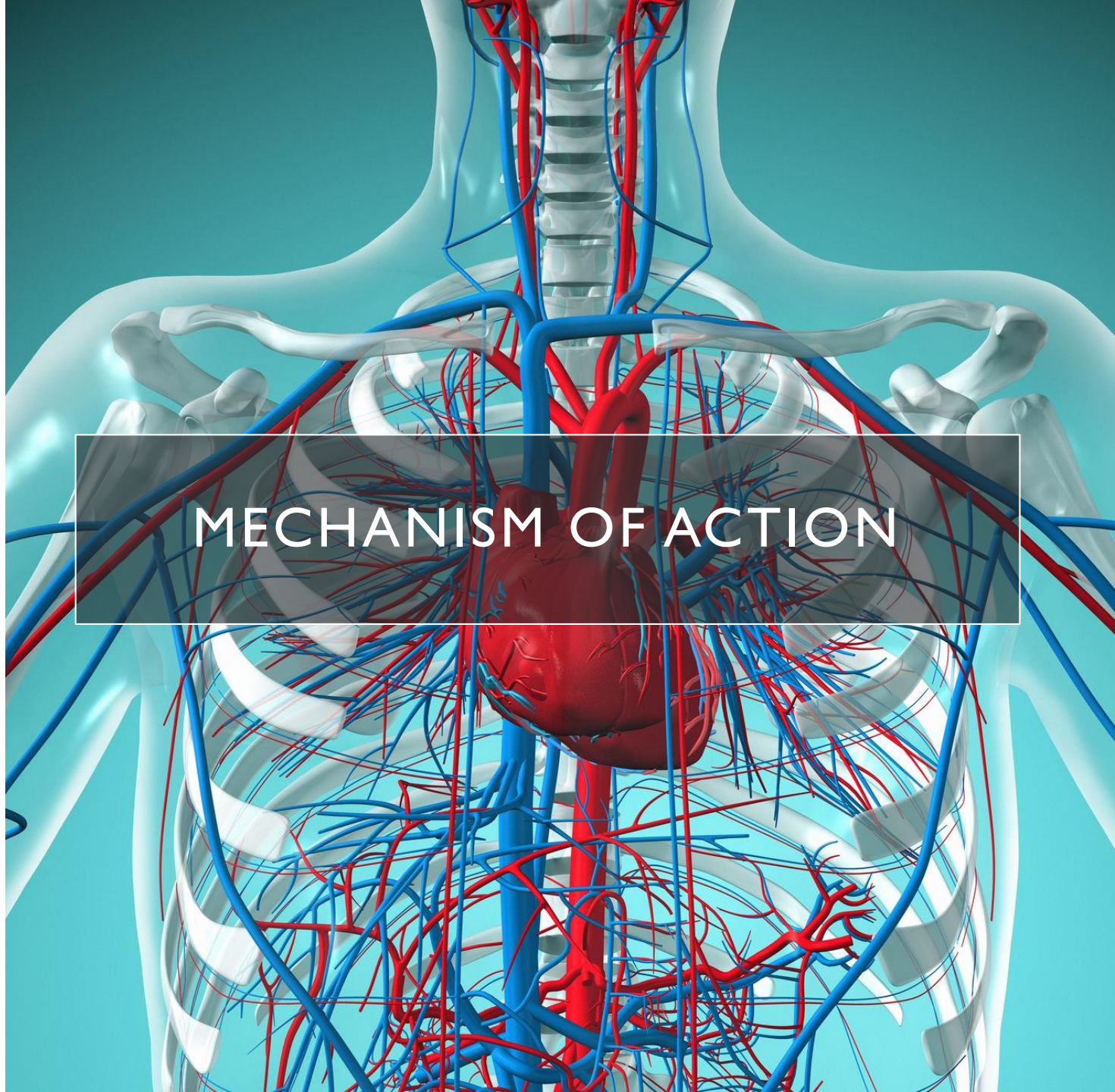
- Disease or injury causing low oxygen levels/poor perfusion in the tissues

Results:

- Enhance and speeds up the body's natural healing process

MECHANISM OF ACTION

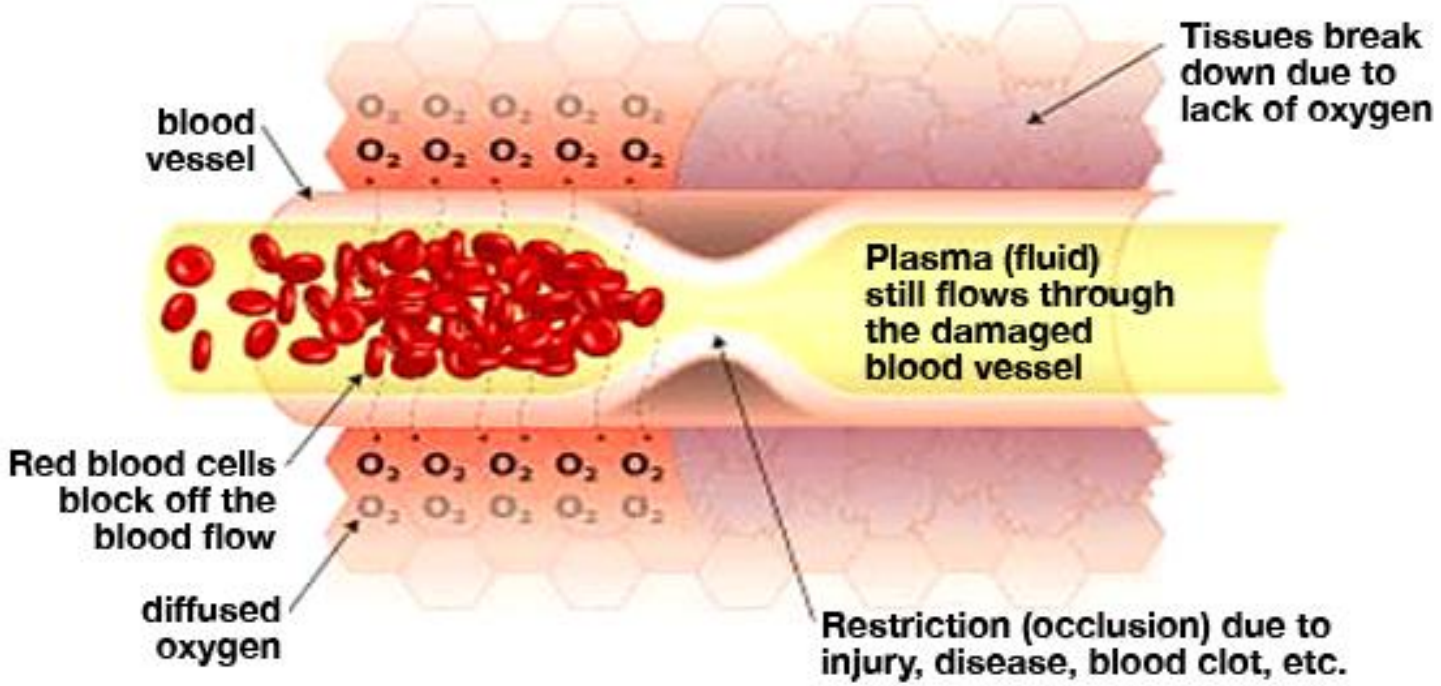
- Limits ischemic damage, cell death, inflammation
- Promotes collagen synthesis (fibroblast stimulation)
- Decreases lactate production and tissue acidosis
- Aids in oxygen dependent killing of bacteria – WBC
- Limits leukocyte adhesion and degranulation
- Decreases tissue edema



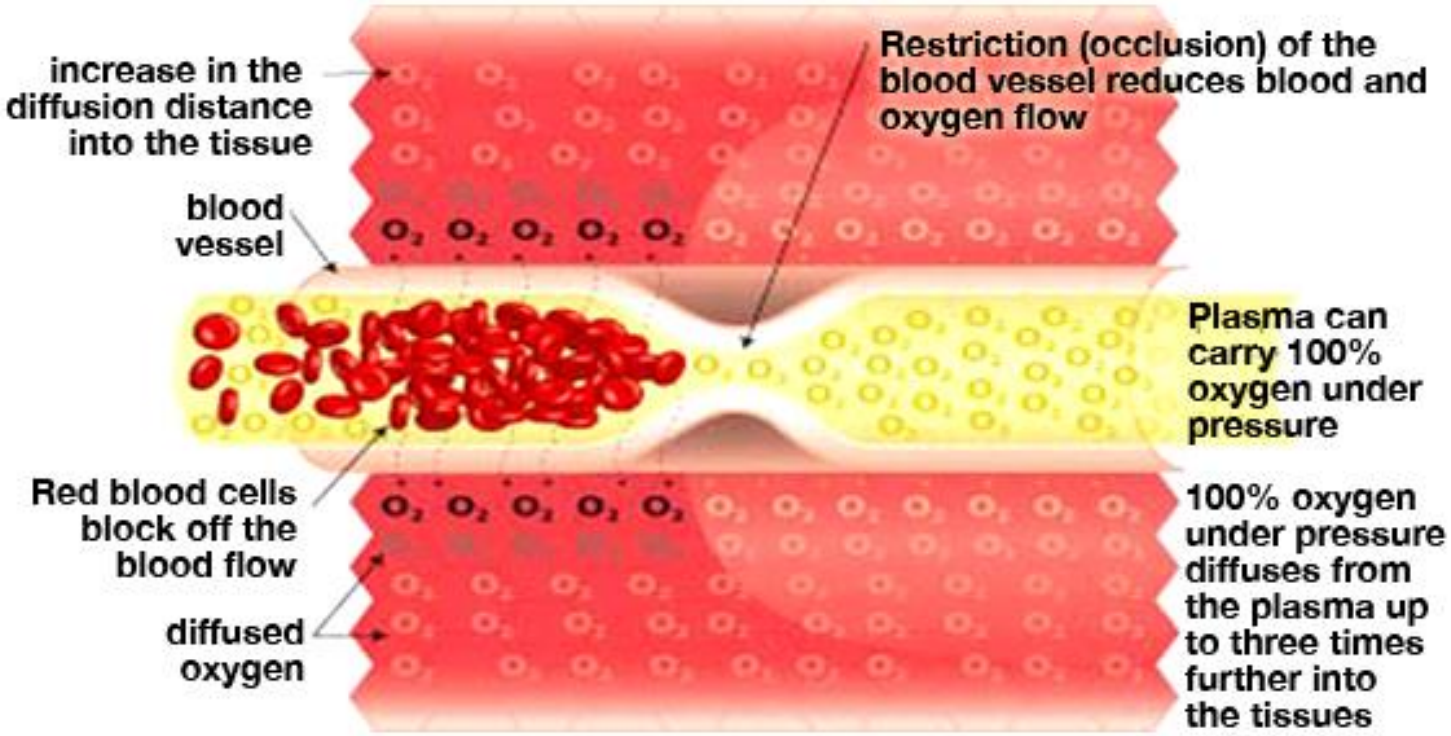
MECHANISM OF ACTION

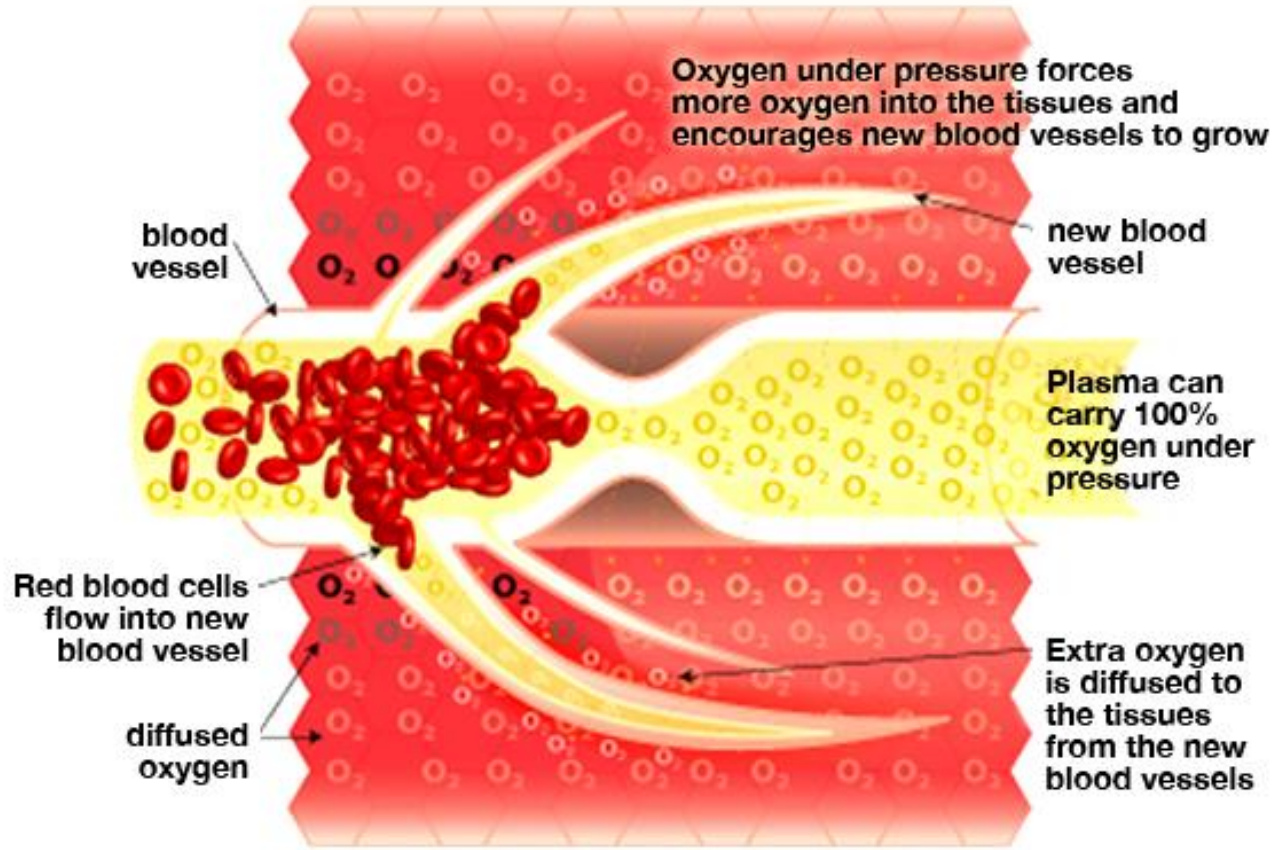
- **Stem Cell Mobilization**
  - Causes mobilization of CD34+ progenitor cells from bone marrow
  - University of Pennsylvania study
- **Angiogenesis**
  - Promotes neovascularization of poorly perfused tissue
  - Unique action

POOR BLOOD FLOW
=
POOR OXYGENATION
=
TISSUE DAMAGE



HYPERBARIC CONDITIONS





ANGIOGENESIS

"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."

FDA-APPROVED USES

- 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

DIABETES WOUNDS

LOWER EXTREMITY

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

DIABETES WOUNDS

REFRACTORY OSTEOMYELITIS

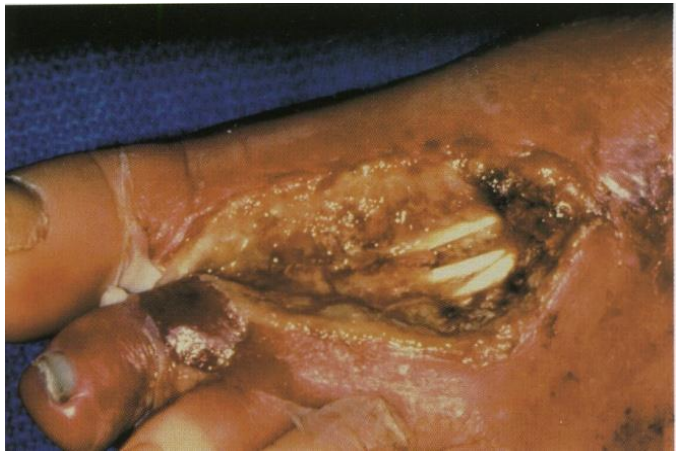
Pre-Hyperbaric Wound

Partial Wound Closure
20 HBOT Tx
4 Weeks

Complication Resolved
Full Healing
35 HBOT Tx
7 Weeks

DIABETES WOUNDS

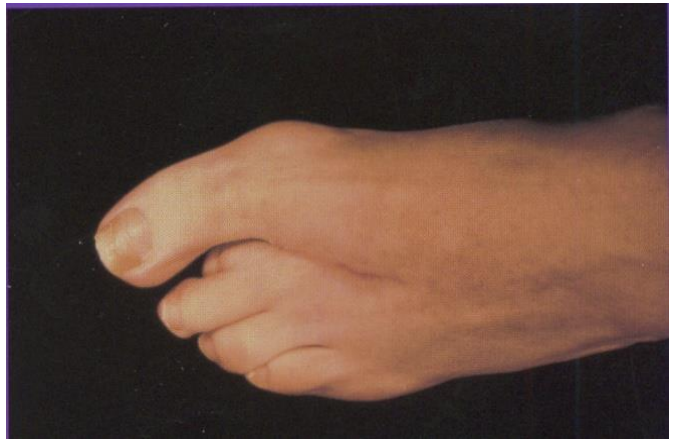
EXPOSED TENDON



Required incision, drainage and debridement

After 10 Tx / 2 Weeks granulation tissue

After 20 Tx / 4 Weeks



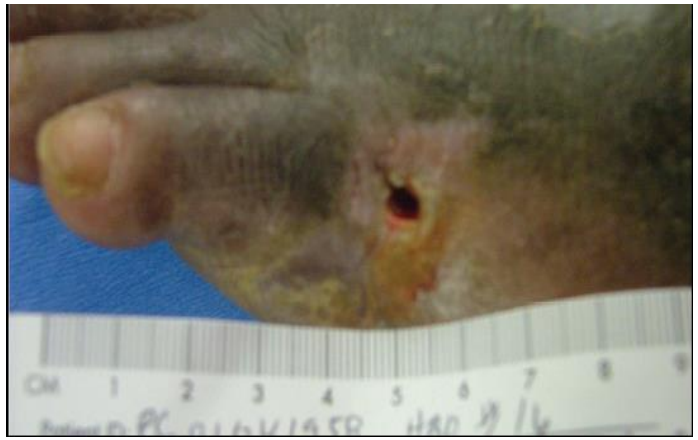
After 35 Tx / 7 Weeks

DIABETES WOUNDS

DIGITAL AMPUTATION

Initial Visit

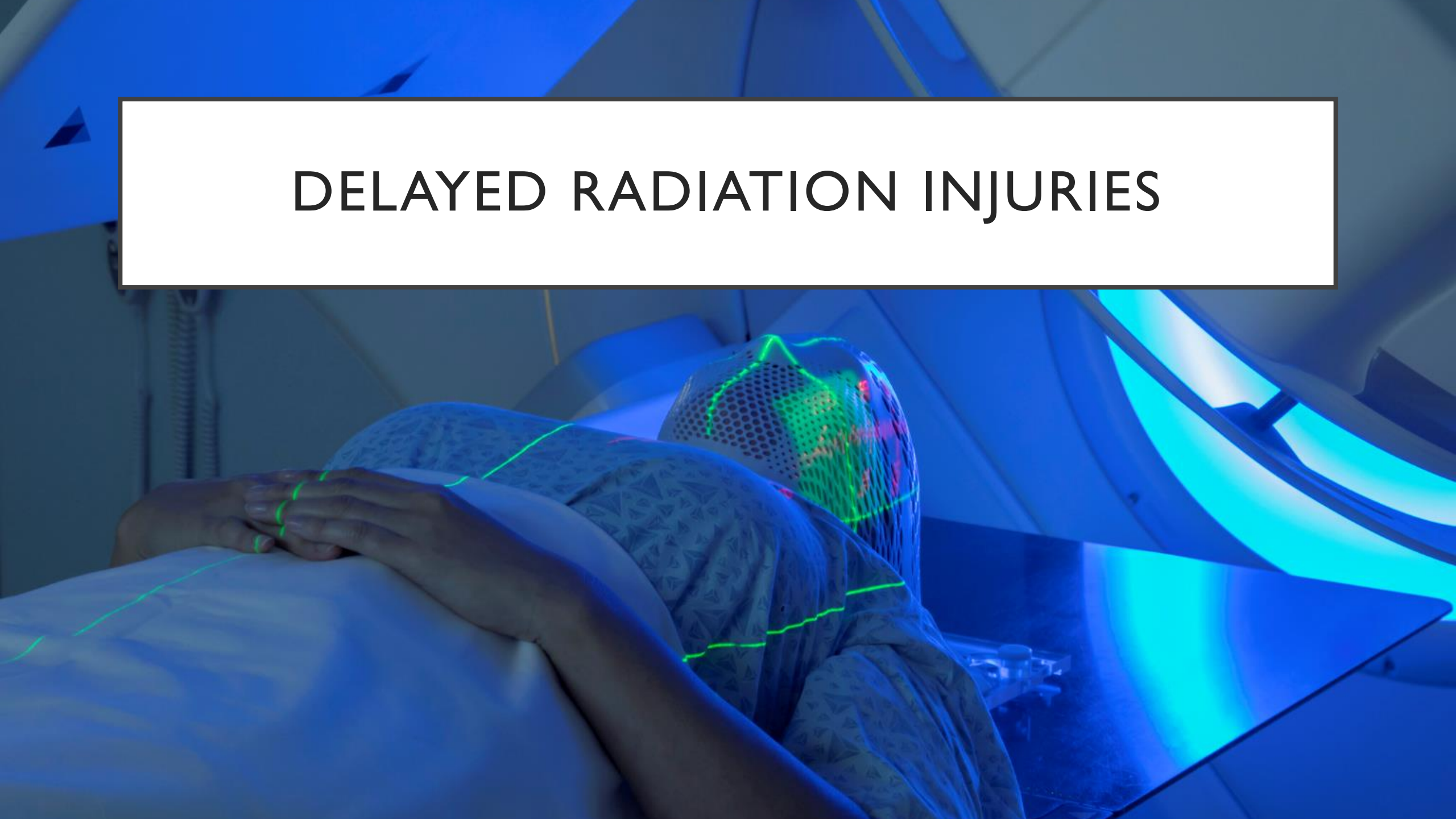
After 10 Tx / 2 Weeks



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

Soft tissue radiation injury – ulcers/non-healing wounds

Osteoradionecrosis – mandibular

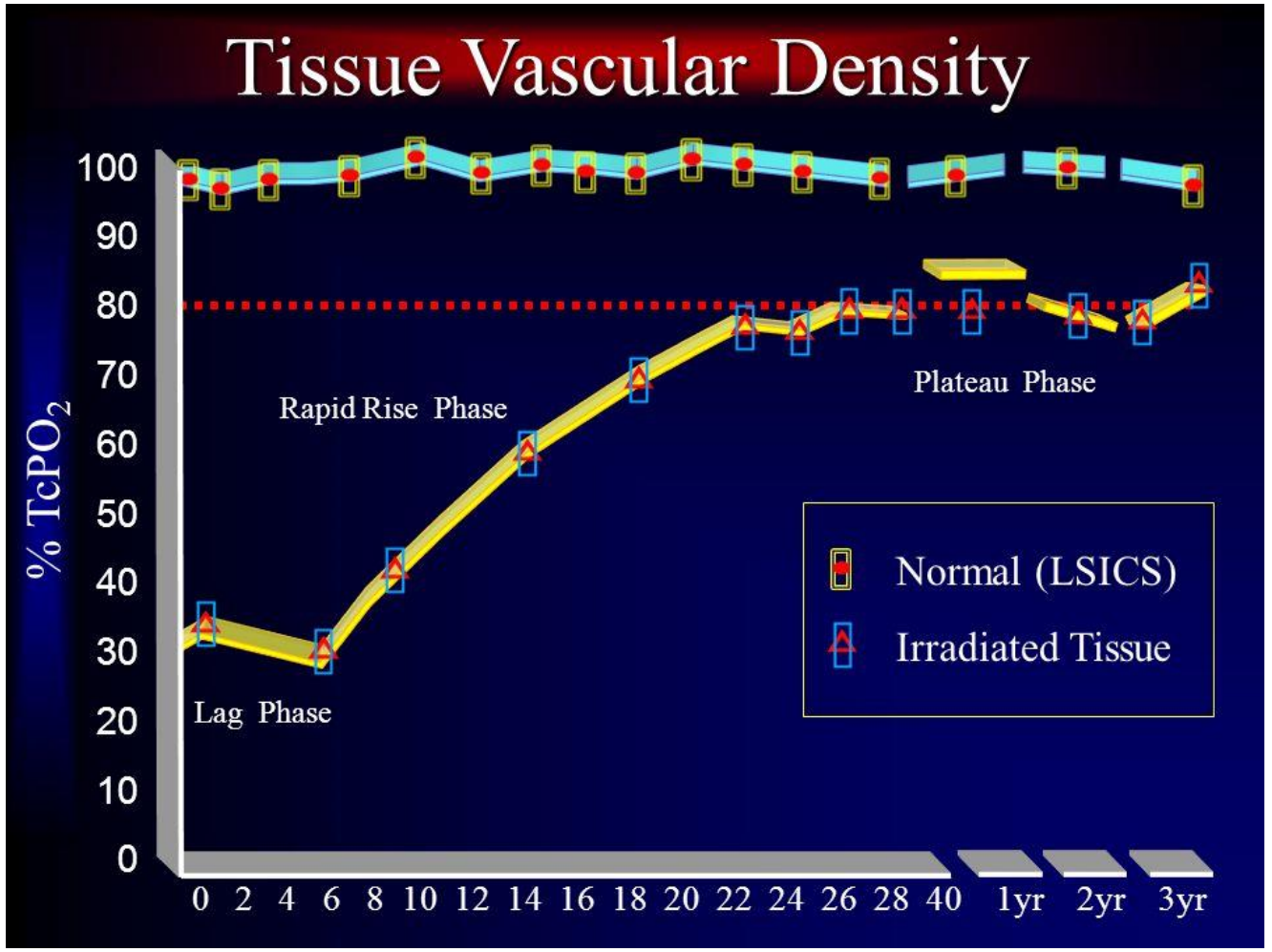
Radiation cystitis

Radiation proctitis

Radiation enteritis

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 10 Tx / 2 Weeks

After 25 Tx - 5 Weeks

After 40 Tx - 8 Weeks

New tissue over bone

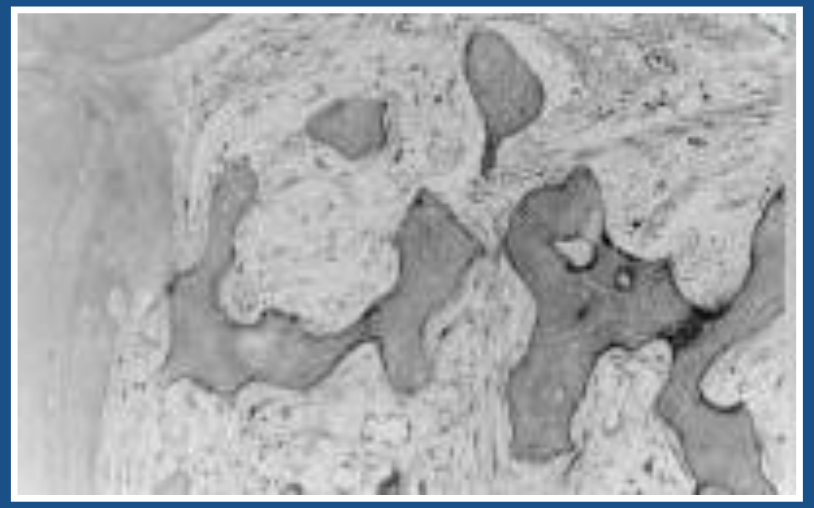
DAMAGE TO OSTEOCYTES FROM RADIATION THERAPY

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

ORN X-ray – Mandible



ORN Histology - Mandible

PATHOPHYSIOLOGY

- 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

QUALITY OF HEALING

- 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

Vail Valley Medical Center
PROCEDURE DATE: January 5, 2009
PATIENT: #411344[redacted]
PHYSICIAN:[redacted]

TV/DOCUMENTATION
MED IMAGES, INC.
(47IDGP)

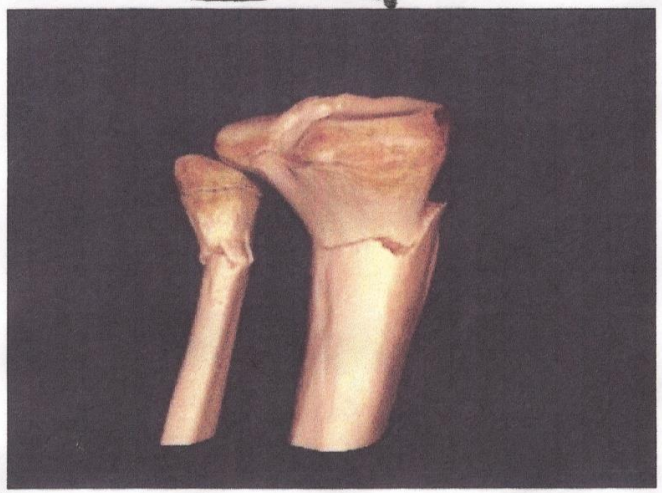
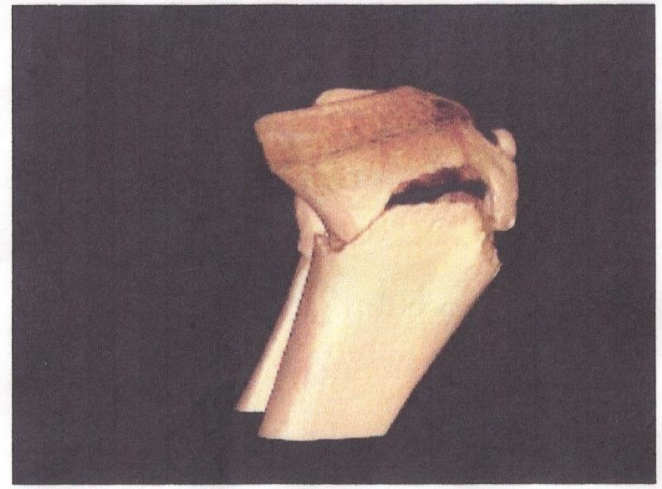


Image 1



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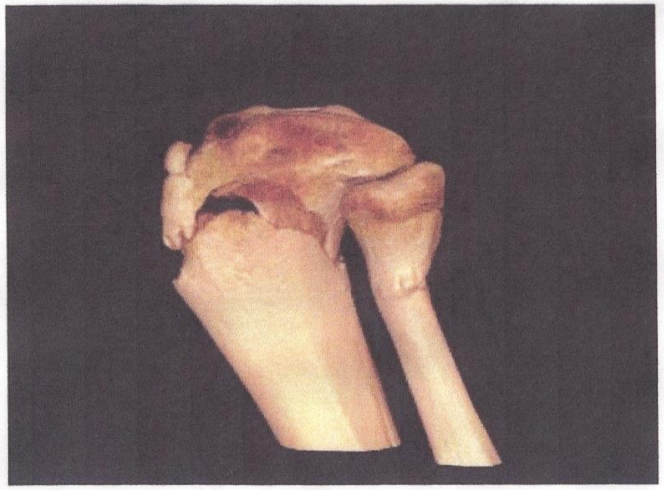


Image 3

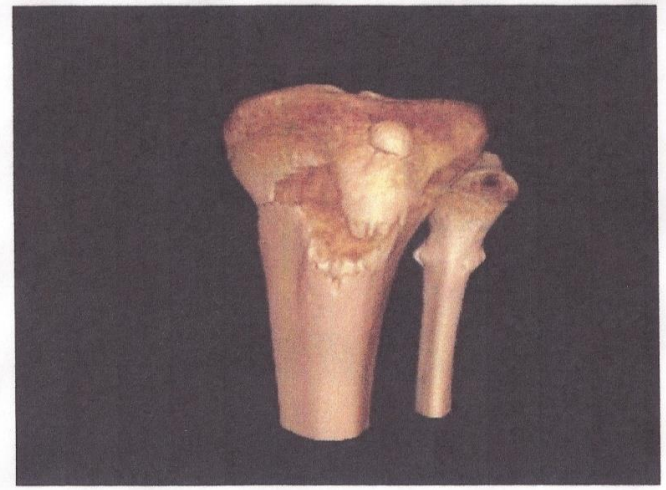


Image 4

WIDELY USED IN PROFESSIONAL SPORTS

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

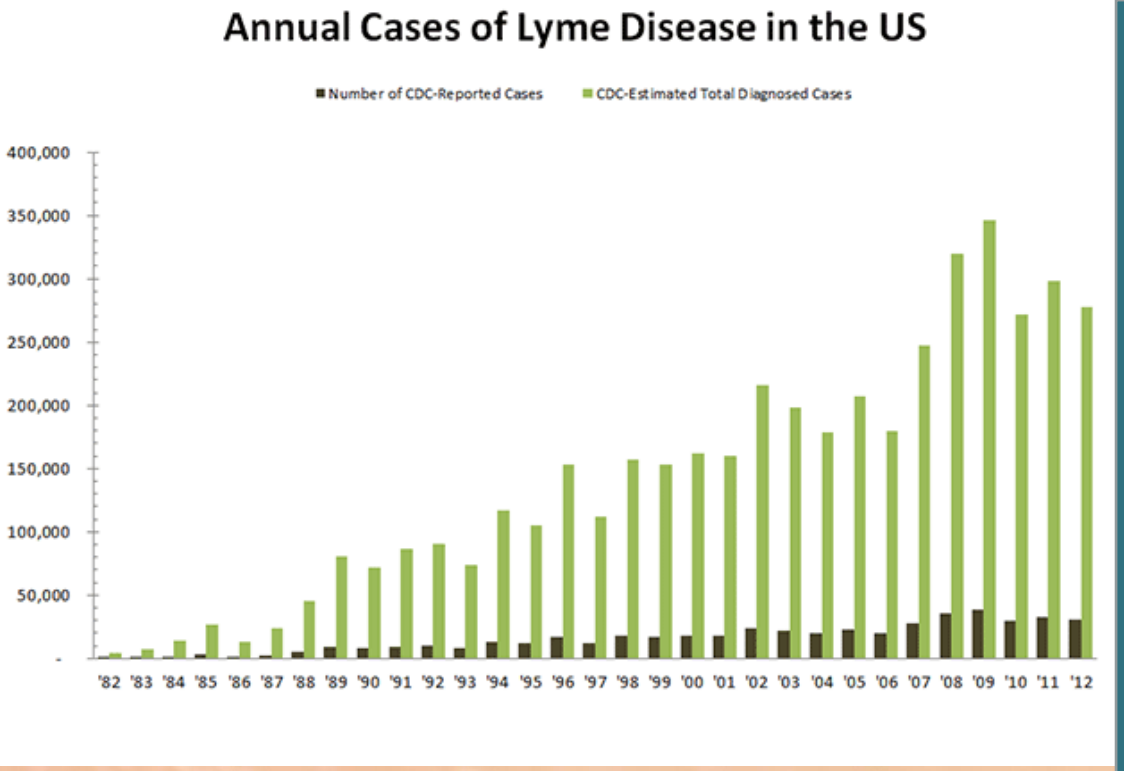
- *"Linebacker Kevin Burnett credits hyperbaric oxygen therapy for helping him get back onto the playing field quickly after surgery to repair cartilage damage in his knee."*

  Dallas Cowboys Official Weekly

Portable hyperbaric chamber at Olympic Track and Field venue: 2012 - London

HBOT IN SPORTS AROUND THE WORD

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



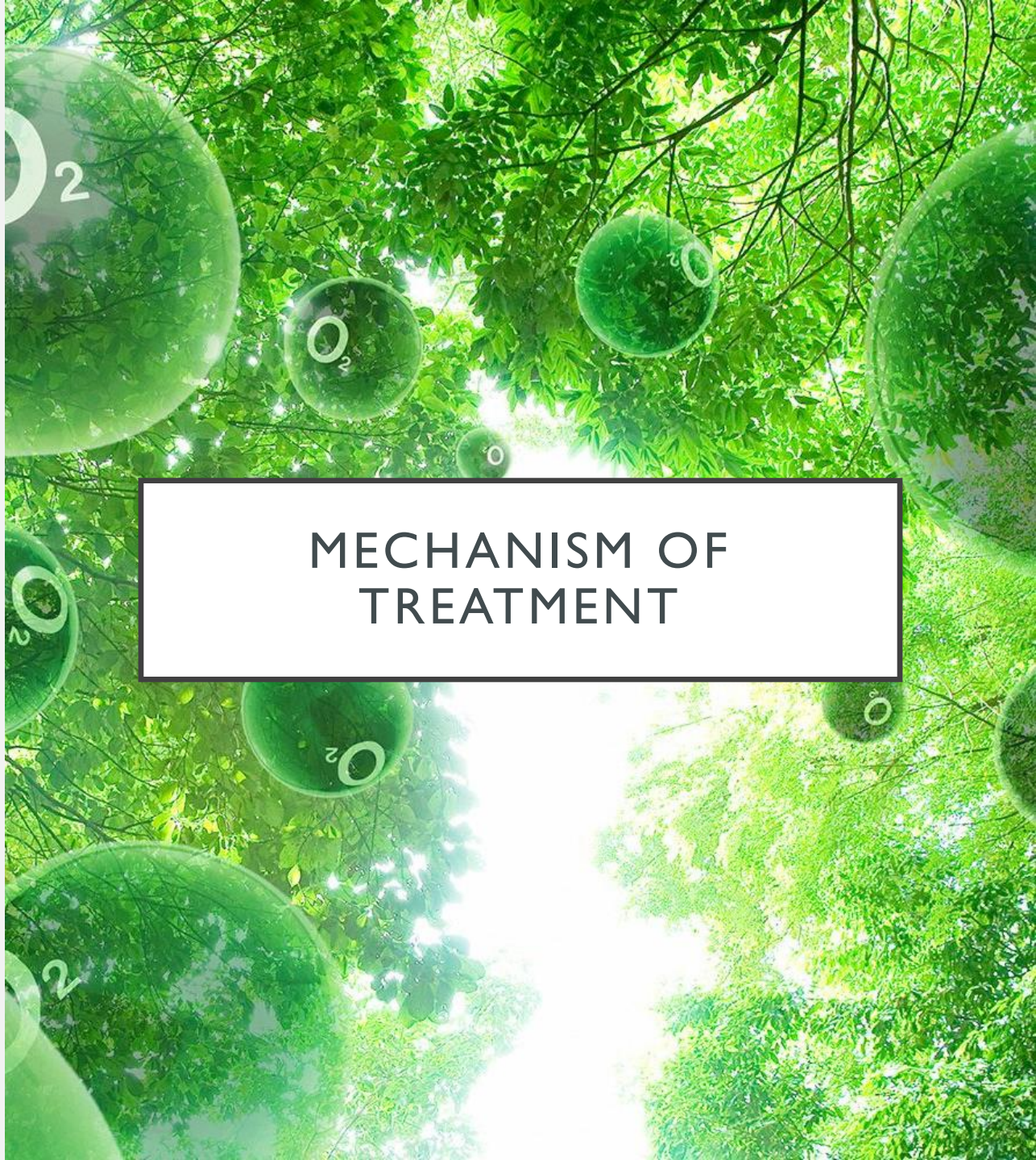
LYME DISEASE

- Fastest growing vector-borne infectious disease in the US
- Reported annual cases increased nearly 25-fold since1982
- No tests available to prove that the organism is eradicated or that the patient is cured

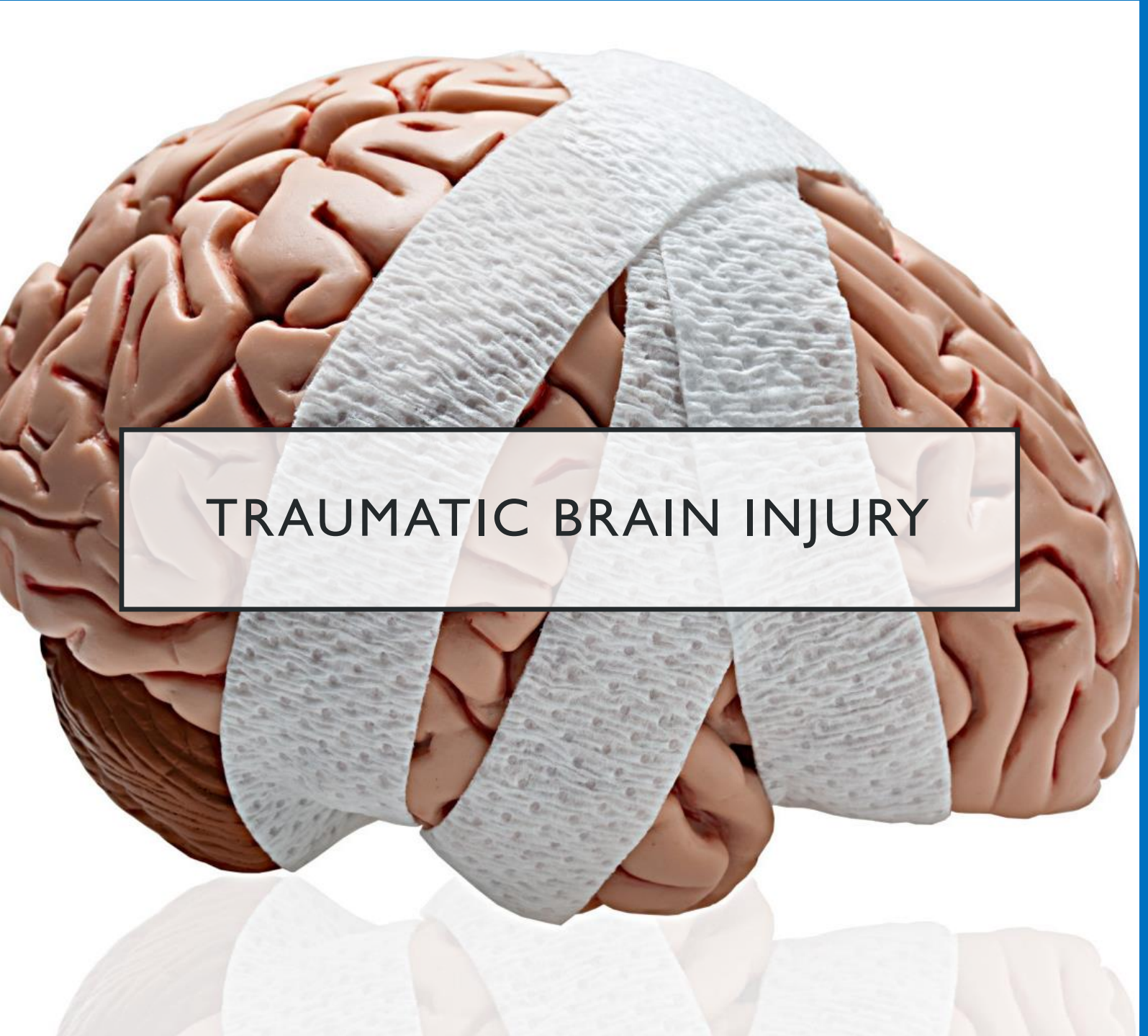
"THE GREAT IMITATOR"

- 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



MECHANISM OF TREATMENT



TRAUMATIC BRAIN INJURY

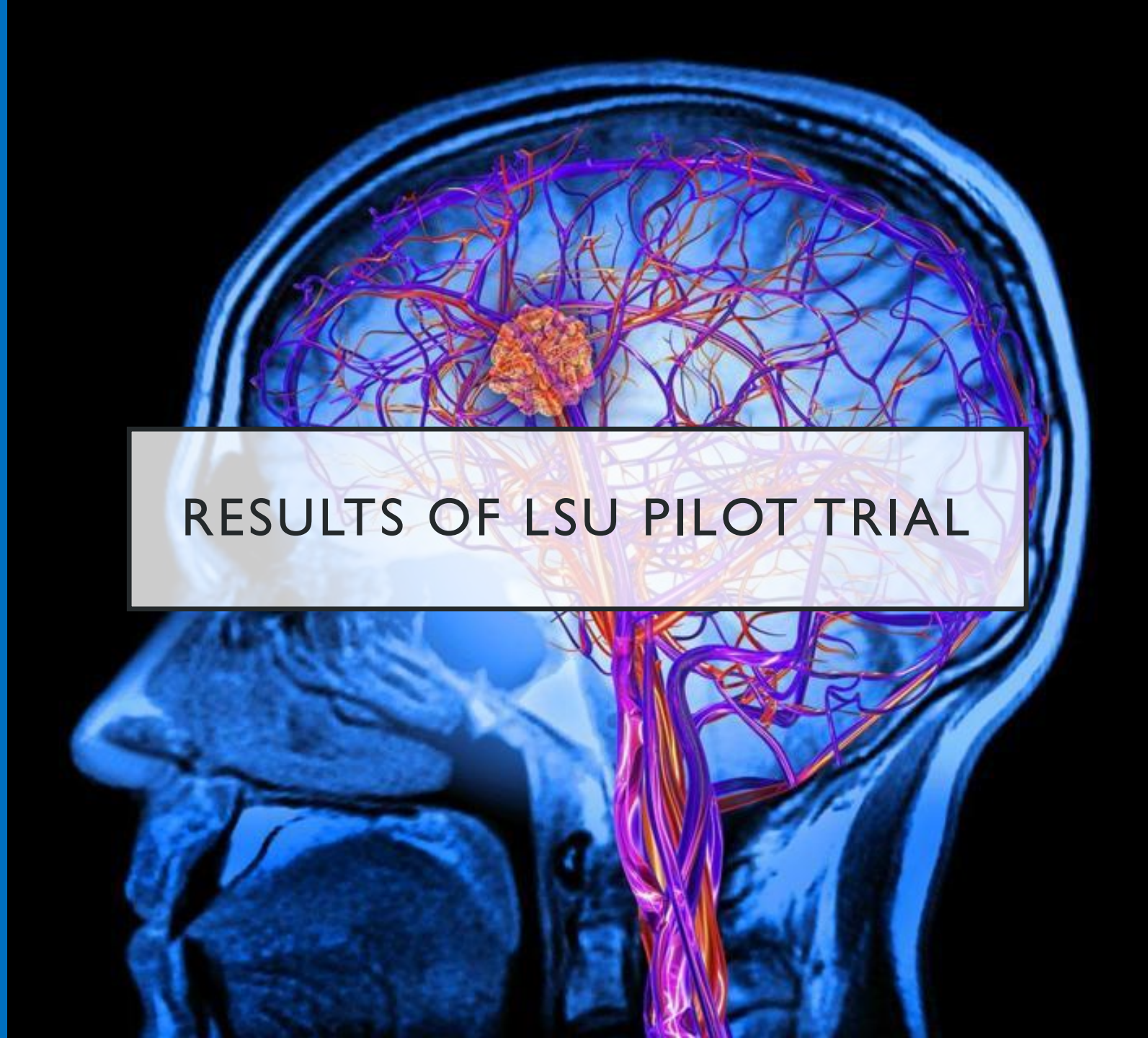
- Inflammatory reaction resulting from tissue injury:
  - Edema
  - Reduced blood flow
  - Reduced oxygen
  - Excitatory amino acids
  - Free radical damage
  - Lipid peroxidation
  - Cell death

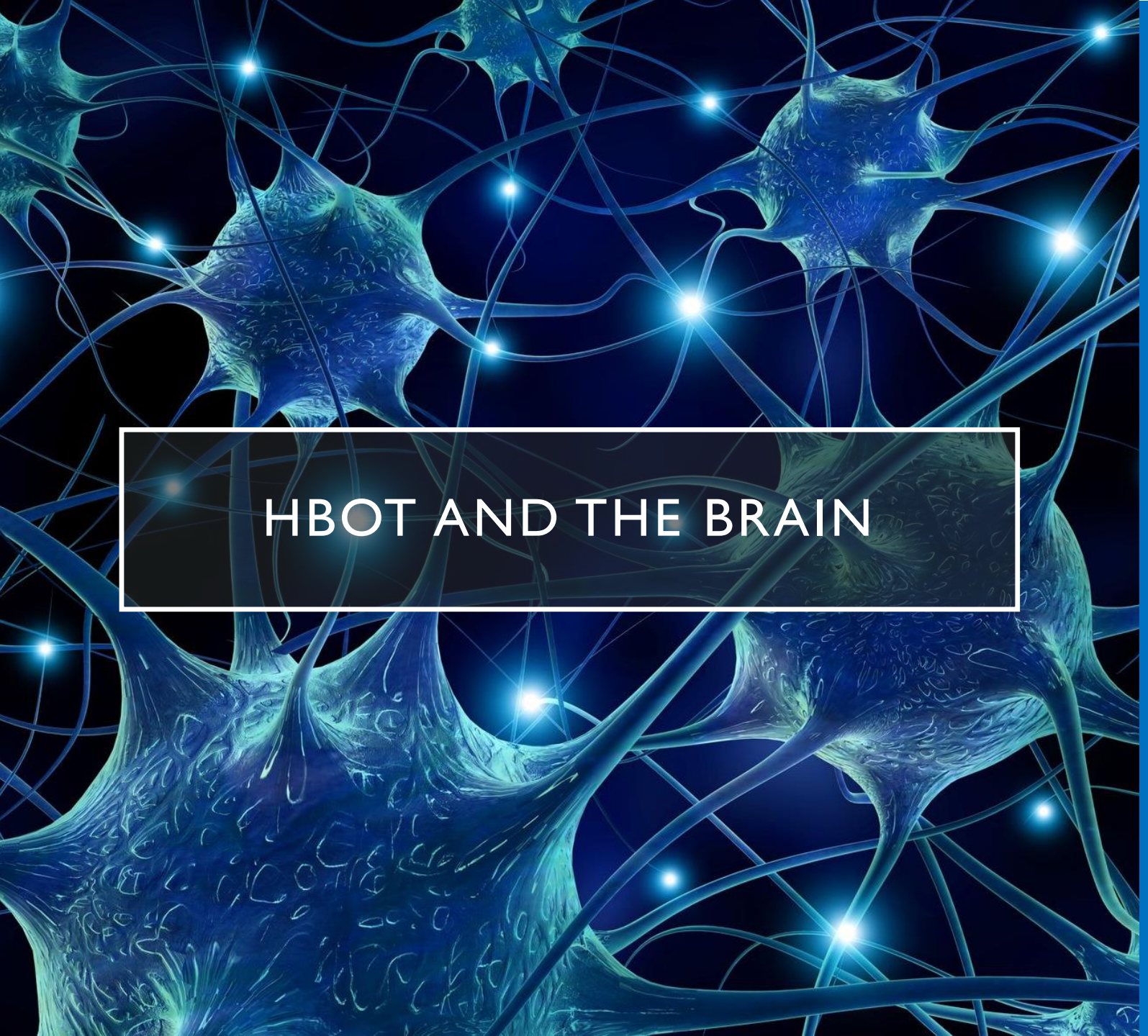
RESULTS OF LSU PILOT TRIAL

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%

Harch, et al. J Neurotrauma, 2012:29(1):168-185.





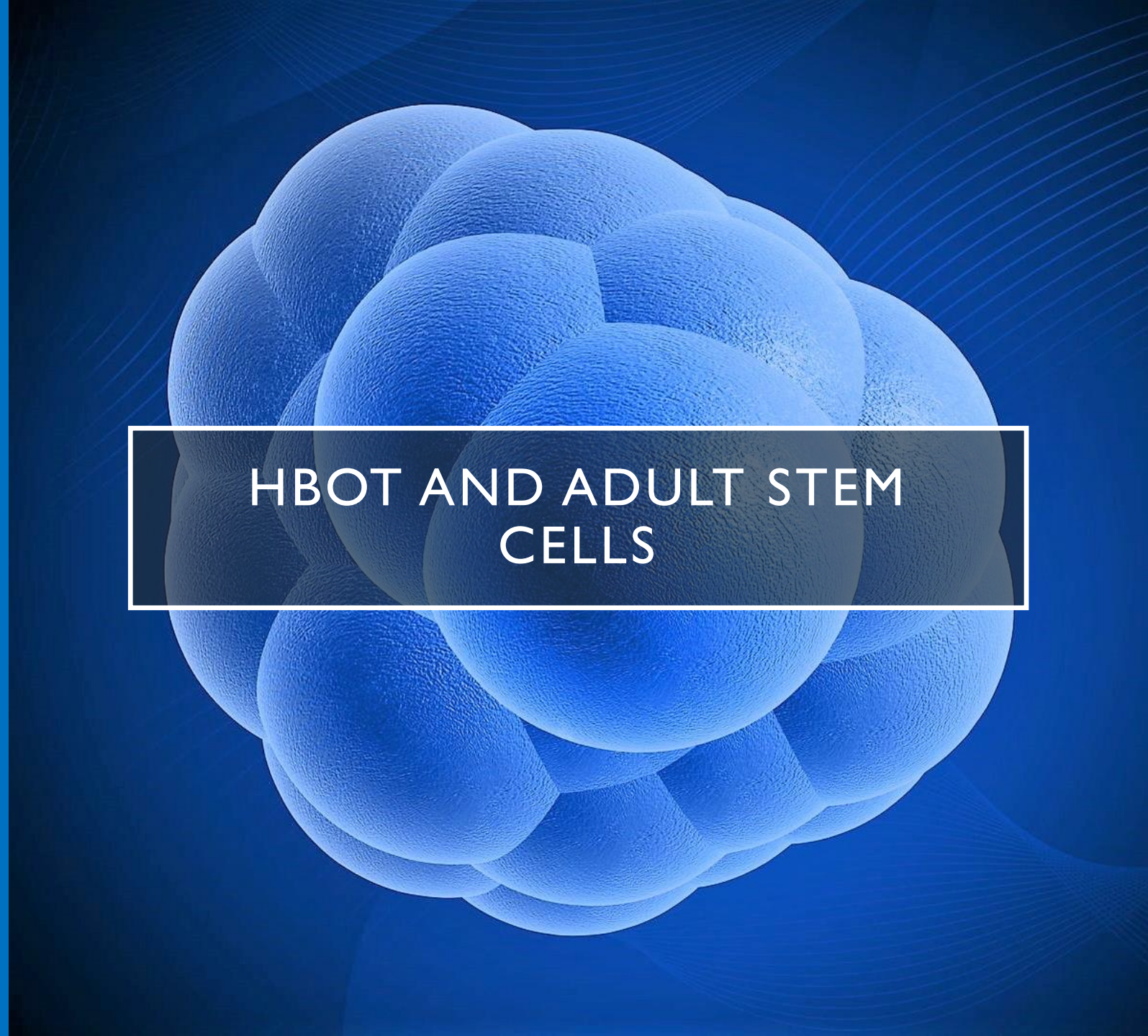
HBOT AND THE BRAIN

- Induces neuroplasticity
- Increases tissue oxygenation
- Generates new capillary networks
- Restores blood supple
- Increases stem cells in the blood

HBOT AND ADULT STEM CELLS

- 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

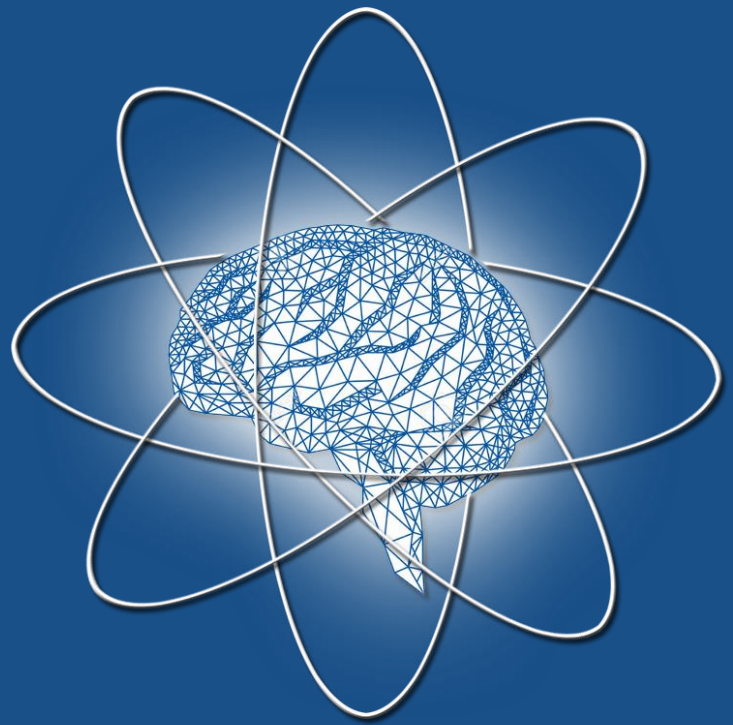
Increases angiogenesis

Promotes greater tissue strength

Enhances the growth of new blood vessels

Colorado Center for Hyperbaric Medicine

www.cohyperbarics.com



TBI Therapy

Treats traumatic brain injury (TBI) patients by combining regenerative therapies: HBOT, stem cells, PRP, and nutritional therapies.

www.tbitherapy.com

ASPEN INTEGRATIVE MEDICINE

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

www.aspenintegrativemedicine.com