CURRENT INDICATIONS FOR HYPERBARIC OXYGEN THERAPY

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Current Indications for Hyperbaric Oxygen Therapy

- The Hyperbaric Oxygen Therapy Committee of the UHMS recognizes 14 indications for HBOT. These should be considered appropriate for third party insurance coverage.

- CMS intermediaries do interpret coverage of these indications differently.

- Private insurances seem to approve and disapprove HBO indications at will.
Hyperbaric Oxygen Therapy

...is the use of 100% oxygen breathed at increased atmospheric pressure.

It requires that...

• The patient be enclosed in a pressure vessel.
• Subjected to an atmospheric pressure at least 1.5 x sea level or ambient pressure.
• And be breathing 100% oxygen.
Topical Oxygen Administration Is NOT!
Hyperbaric Oxygen Therapy is one tool in a comprehensive wound care program that can benefit a select group of patients.
Hyperbaric Oxygen Therapy

- Useful as an adjunct in select wounds and conditions in conjunction with comprehensive wound management
- Not a stand alone therapy
- Physician must be specifically trained and credentialed to deliver HBO therapy
  (Operation Committee Report, UHMS)
In Selected Wounds and Conditions we know that

- Hyperbaric Oxygen Therapy
  - Elevates oxygen tensions in ischemic/infected wounds
  - Enhances fibroblast replication
  - Enhances collagen synthesis
  - Enhances neutrophil antibacterial activity
  - Promotes neovascularization
Hyperbaric Oxygen Therapy

- Enhances the effect of some antibiotics
- Inactivates a number bacterial toxins
Approved Indications for HBO

- Gas Gangrene
- Crush Injury, Compartment Syndrome, and Other Acute Traumatic Ischemias
- Compromised Skin Grafts and Flaps
- Acute Thermal Burn Injury*
- Problem Wounds
- Necrotizing Soft Tissue Infections
- Refractory Osteomyelitis
- Delayed Radiation Injury (Soft Tissue and Bony Necrosis)
- Decompression Sickness
Approved Indications for HBO

- Intracranial Abscess*
- Severe Anemia*
- Air or Gas Embolism
- Carbon Monoxide Poisoning
- Arterial Insufficiencies: CRAO, Enhancement of Healing in Selected Problem Wounds
- Idiopathic Sudden Sensorineural Hearing Loss (New Oct. 8, 2011)*
Physiological Benefits of Hyperbaric Oxygenation in Necrotizing Infections

- Correction of tissue hypoxia
- Suppression of toxin production
- Enhanced host response to local infection
- Vasoconstriction with edema reduction and preservation of oxygenation
- Prevention of ischemic / reperfusion injury syndrome
- Stimulation of endothelial cells and support of angiogenesis
- Stimulation and support for tissue growth
Enhanced host response to local Infection

- Direct toxic effect on anaerobic bacteria
- Improved leukocyte killing of phagocytized bacteria
- Suppression of exotoxin production
Enhanced Host Response Synergism with Certain Antibiotics

- Aminoglycosides
- Clindamycin
- Penicillins
- Sulfonamides
- Rifampin
- Quinolones

Clostridial Myonecrosis
The preferred treatment for clostridial myositis and myonecrosis (gas gangrene), spreading clostridial cellulitis with systemic toxicity, or a presumptive diagnosis of either is a combination of surgery, antibiotics, and hyperbaric oxygen ($\text{HBO}_2$).
Natural History of Clostridial Infection

- Onset begins 1-6 hrs after injury
- Severe, sudden pain in infected area
- Rapid progression from shiny to dusky skin color
- Development of hemorrhagic bullae
- Rapid advancement of infection, edema, tissue gas and toxemia
Diagnosis of Clostridial Myonecrosis

Clinical Evaluation
Myositis
Myonecrosis
Gas on x-ray (may or may not be present)
Gram stain positive for gram positive short, club-shaped rods
Positive blood or tissue cultures
Clostridial Nine Exotoxins

**Toxins**
- Alpha toxin
  - Phospholipase C (lecithinase)
    - Necrotizing and lethal
- Theta toxin
  - Cytolysin
    - Direct vascular damage
- Kappa toxin
- Mu toxin
- Nu toxin

**Aggressins**
- Fibrinolysin
- Neuraminidase
- “Circulating factor”
- “Bursting factor”
The Advantages of Early HBO

- Oxygen tension above 250mm Hg stops alpha toxin production
- Is life saving, reducing the need for heroic surgery in seriously ill patients
- Is limb and tissue saving, clarifying the demarcation between viable and non-viable tissue.
“HBO therapy is an accepted adjunct to surgical and antibiotic treatment for necrotizing soft tissue infections. Such conditions may result from a single or a mixed population of organisms. They may be aerobic or anaerobic. Some necrotizing infections appear to be the result of a synergistic combination of organisms. Such infections appear in a wide variety of clinical settings, particularly after trauma, surgical wounding and/or around foreign bodies. The host is frequently compromised in some way, often with diabetes, vasculopathy, or both.”
Necrotizing Fasciitis

- Crepitant Anaerobic Cellulitis
- Progressive Bacterial Synergistic Gangrene
- Necrotizing Fasciitis
- Nonclostridial Myonecrosis
Progressive necrotizing infection

Not your typical diabetic foot infection
Treatment of necrotizing soft tissue infections

- Surgical debridement
- Appropriate antibiotics
- Optimal oxygenation of the infected tissues
Physiological Benefits of Hyperbaric Oxygenation in Necrotizing Infections

- Correction of tissue hypoxia
- Suppression of toxin production
- Enhanced host response to local infection including improved phagocytic function of leukocytes
- Vasoconstriction with edema reduction and preservation of oxygenation
- Prevention of ischemic/reperfusion injury syndrome
- Stimulation of endothelial cells and support of angiogenesis
- Stimulation and oxygen support for tissue growth
“Refractory osteomyelitis is chronic osteomyelitis which has

- Persisted or recurred after appropriate interventions have been performed, or where
- Acute osteomyelitis has not responded to accepted management techniques

Patients with refractory osteomyelitis frequently suffer from coexisting local and systemic factors that compromise their responsiveness to infection.”
Classification of Osteomyelitis

ACUTE
OSTEOMYELITIS is a suppurative infection of bone accompanied by edema, vascular congestion, and small vessel thrombosis.

CHRONIC OSTEOMYELITIS results when a nidus of infected dead bone or scar tissue remains and is accompanied by a surrounding ischemic soft tissue envelope and a chronic clinical course.
REFRACTORY
OSTEOMYELITIS is a chronic osteomyelitis which has persisted or recurred after appropriate interventions or acute osteomyelitis which is not responding to accepted management techniques.
HBO$_2$ Mechanisms in Osteomyelitis

- Hyper oxygenation
  - Increased medullary oxygen tensions
- Vasoconstriction
  - Medullary / Soft tissue edema reduced
- Stimulation of angiogenesis
  - Increased delivery of O$_2$, ABx, and WBC to Host/Organism interface

Mader JT et al; J Infect Dis. 1980;142:915-922
HBO$_2$ Mechanisms in Osteomyelitis

Altered Cellular Function

- Osteoclast mediated microscopic debridement of dead and infected bone
- Improved neutrophil function
- Increased fibroblast function (collagen production and quality)
- Improved Antimicrobial effect
- Direct anti-anaerobe effect

Mader JT et al; J Infect Dis. 1980;142:915-922
HBO in Malignant Otitis Externa


Stage I: Infection of ear canal and contiguous soft tissue

Stage II: Extension to include osteitis of the skull base or multiple cranial neuropathy

Stage III: Further extension intracranially; meningitis, epidural empyema, subdural empyema, or brain abscess

HBO for Stage II and III cases, in recurrent cases, and in cases where the process has become refractory to appropriate antibiotic treatment.
“The term “intracranial abscess” (ICA) includes the following disorders:

- Cerebral abscess
- Subdural empyema
- Epidural empyema

These disorders share many diagnostic as well as therapeutic similarities and, frequently, very similar pathophysiologic origins.”
HBO in Intracranial Abscesses

- Category includes cerebral abscess, subdural empyema, epidural empyema

- Overall mortality from intracranial abscesses has declined

- Review of outcome data 1986-1996 suggests average mortality 18 to 20%

- Combined series of 48 patients treated with HBO 2% mortality (1 patient)
HBO in Intracranial Abscesses

At present time HBO is recommended as an adjunct to surgical drainage and appropriate antibiotic therapy in cases of:

- Multiple abscesses
- Abscesses in a deep or dominant location
- Abscesses in a compromised host
- In situations where surgery is contraindicated or where the patient is a poor surgical risk
- When there has been no response or with further deterioration in spite of standard care
HBO$_2$ for Neurosurgical Postoperative Infections

- Follow up of 36 patients after craniotomy or laminectomy wound infections treated with HBO therapy.
- Successful results in 27 of 36 with retention of bone flaps and acrylic cranioplasties or without removal of spinal fixation devices.
HBO for Sternal Wounds
HBO for Compromised Flaps or Grafts
HBOT for DFU

Nearly 100,000 amputations are performed in the United States each year as a result of diabetes. Twenty-four million people in the United States have diabetes and 57 million are pre-diabetic. Amputations are a dreaded complication of diabetes. A chronic wound is present on nearly 85% of amputated limbs making it the one of most common reasons for amputation.
HBO in Diabetic Foot Ulcers

Infected Diabetic Ulcer

Treatment must be comprehensive
• Debridement
• Optimization of blood flow
• Topical antimicrobials
• Implanted antibiotic beads
• Systemic antibiotics
• HBOT
Diabetic Foot

- Classic Diabetic Triad
  - Arterial disease
  - Neuropathy
  - Infection
HBO in Diabetic Foot Ulcers
HBO in Diabetic Foot Ulcers
Two Drivers for HBO in DFU

1. Wound predicted not to heal based on critical ischemia/hypoxia without addition of HBO ($\text{PtcO}_2 < 30 \text{ mmHg}$)

2. Wound might heal without HBO but will take $> 12$ weeks ($\text{PtcO}_2 30-50 \text{ mmHg}$)

The earlier HBO is applied in these situations the greater the likelihood of providing benefit to the patient in question.

The more consistently HBO treatment is applied (i.e., adequate treatment pressure based on achieving an in chamber PtcO2 value of at least 200mmHg and avoiding interruptions in treatment.)
CMS Coverage Indication: HBO for Diabetic Foot Ulcer:

- Type I or Type II DM, lower extremity wound due to DM
- Wagner Grade III or higher
- Failed standard wound care (no measurable signs of healing for 30 days)
- Wound must be re-evaluated every 30 days during HBOT course
- Continued HBOT will not be covered if there are no measurable signs of healing during the 30 day period
Conclusions… In people with foot ulcers due to diabetes, HBOT significantly reduced the risk of major amputation and improves the chance of remaining healed at 1 year. The application of HBOT to these patients is justified where HBOT facilities are available.
1. Hyperbaric oxygen therapy as an adjunct to medical and surgical treatment of diabetic lower extremity wounds has been shown to be cost effective in limited reviews, especially when compared to major lower extremity amputation.

2. Preventing a below the knee amputation by salvaging a ray resection or transmetatarsal amputation of the foot or preventing an above the knee amputation by preserving a below the knee amputation represents a satisfactory outcome in these high risk patients.

3. Wounds healed with adjunctive hyperbaric oxygen treatment have also demonstrated excellent durability.
Diabetic Foot Ulcers and the Definition of “Success” with HBO

- Healing of the primary wound is NOT the only possible good outcome
- Cost of HBO easily justified if it actually prevents a major amputation...BKA or AKA and lets you keep a partial foot amputation
- Preserving a TMA over a BKA, or a BKA over an AKA should be considered a therapeutic success
- This is just as important for the patient with an existing limb amputation
Diabetic Foot
Concluding Thoughts

- Improve glycemic control
- Identify & treat vascular disease
- Protect & off-load the neuropathic foot
- Aggressively treat infections
- Suspect osteomyelitis
- Suspect osteomyelitis
- Debride the ulcer
- Perform good wound care
- Educate the patient
Non-Healing Wound

- Pressure
- Oxygen
- Perfusion
- Nutrition
- Osteomyelitis
- Growth Factor Function
- Systemic Healing Ability
- Compliance
- Wound Environment
- Edema
- Soft Tissue Infection
HBOT Benefits

- Benefit to the Patient
  - Improved healing outcomes
  - Reduced amputations
  - Less suffering
  - Less time in healthcare facilities
  - Better quality of life
  - Remain more independent
  - Decreased mobility and mortality
HBOT Benefits

- Benefit to the Physicians
  - Extended resources
  - Interdisciplinary Team working together
  - All services and support in one place
  - High standard of care in wound management
  - Savings across the system
  - Assist the PCP, Surgeon, Specialists
  - Focus on best outcome for the patient
HBOT Benefits

- Benefit to Managed Care Organizations
  - Reduced financial impact of non-healing wounds
  - Management of costly problem
  - Extended resources through collaboration
  - Access to trained specialists
  - Enhanced product offering to increase enrollment
There is ongoing research on HBOT for other conditions and for expansion of its use in other common WCC conditions such as: arterial insufficiency ulcers, ulcerative colitis and Crohn’s disease, acute coronary syndrome, and stroke. Also, traumatic brain injury both acute and chronic (think service men and women and football players), reflex sympathetic dystrophy, and of course cerebral palsy and autism...and on and on.
But really, it makes the most sense in conditions that have hypoxia, ischemia, or edema causing the symptoms. Acute conditions are probably where the best evidence may be found in the treatment of neurological disease. We are hopeful that HBO will be proven useful in new conditions in the future. Other countries have expanded use of HBOT.
Comprehensive Wound Care in WCC
A Wise Physician said - The best medicine for Humans is LOVE. Someone asked if it doesn't work? He smiled and answered increase the dose :)  

-Unknown
Hyperbaric Oxygen Therapy

Thank You