AN OVERVIEW OF HYPERBARIC OXYGEN THERAPY

19th Annual VIA Symposium
Staying Up-To-Date with the Latest Treatment Modalities
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October 25, 2025

DISCLOSURE

- Disclosure
  - No financial relationships with commercial interests.

- Accreditation Statement

Speaker Bio

- **Regional Medical Director**
  RestorixHealth, Midwest / MidAtlantic Regions
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- **Undersea and Hyperbaric Medical Society**
- **Past President Michigan Vascular Surgery Society**
- **Past Member of the CMS Carrier Advisory Committee**
- **Past Member Mich State Med Society Third Party Payers Committee**

OBJECTIVES

1. Define HBO_2 and its healing mechanisms.
2. Briefly review the history of HBO_2.
3. Review patient considerations for HBO_2.
4. Review clinical case scenarios demonstrating HBO_2's role in amputation prevention.
5. Review more recent indications where HBO_2 offers opportunities for improved outcomes.

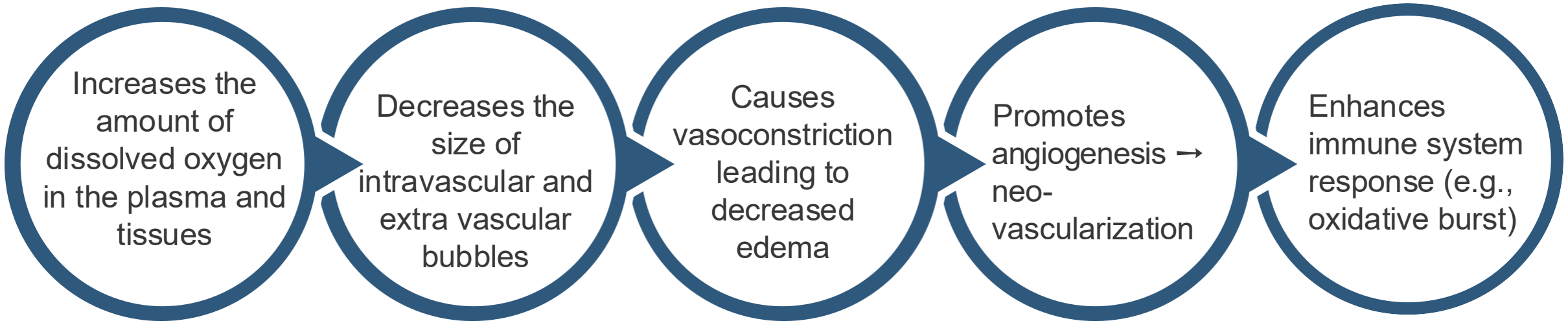
DEFINITION OF HYPERBARIC OXYGEN THERAPY (HBO_2 OR HBOT)

- Breathing near 100% oxygen intermittently while inside a hyperbaric chamber that is pressurized to greater than sea level pressure (1 atmosphere absolute [ATA]).
- For clinical purposes, the pressure must equal or exceed 1.4 ATA while breathing near 100% oxygen.

Undersea Hyperbaric Medical Society. *Hyperbaric Oxygen Therapy Indications,* 14th ed. (R. Moon, Ed.) Best Pub; 2019.

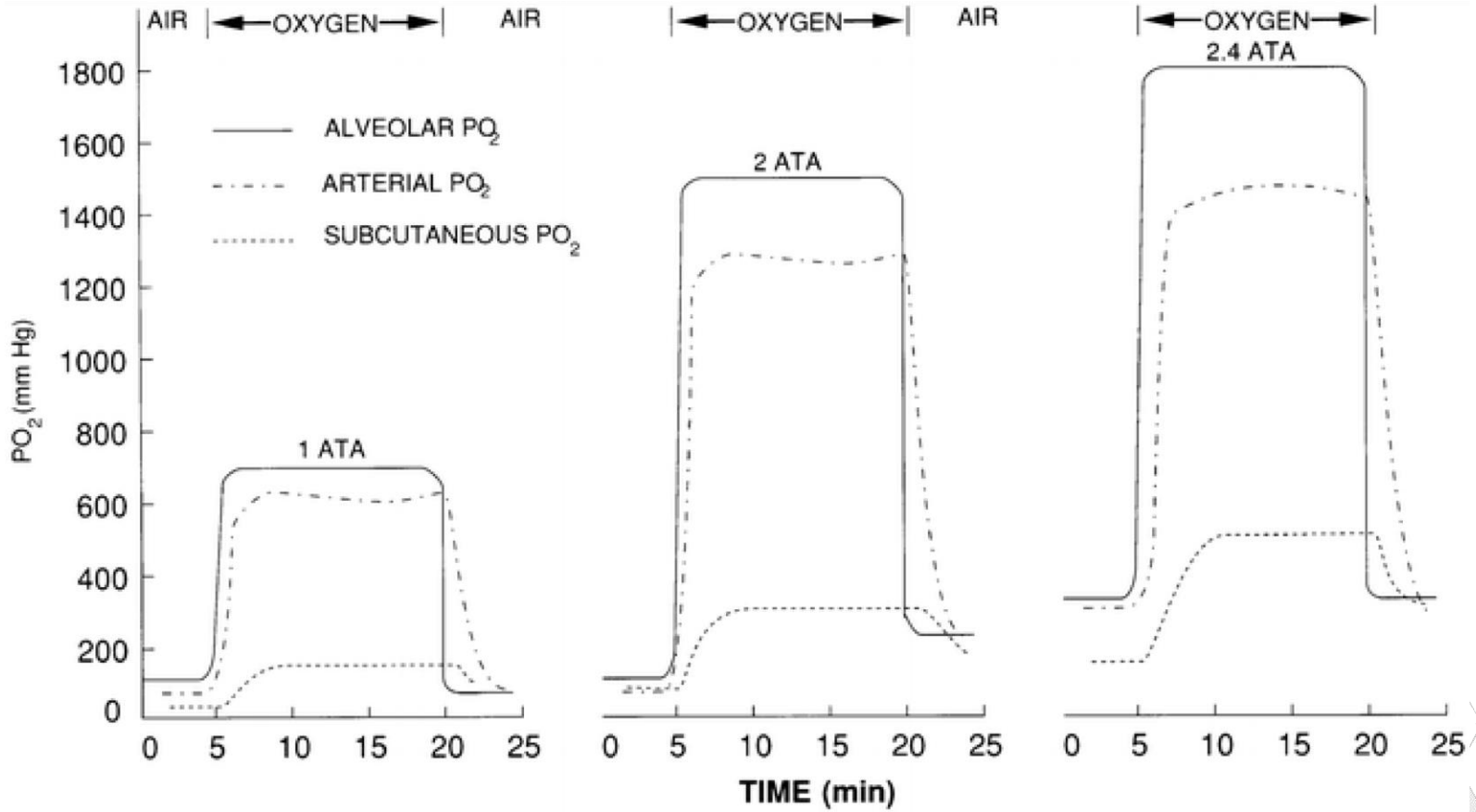
HBO_2 MECHANISM

Governed by laws of physics: Higher atmospheric pressure allows for higher oxygen saturation of patient.



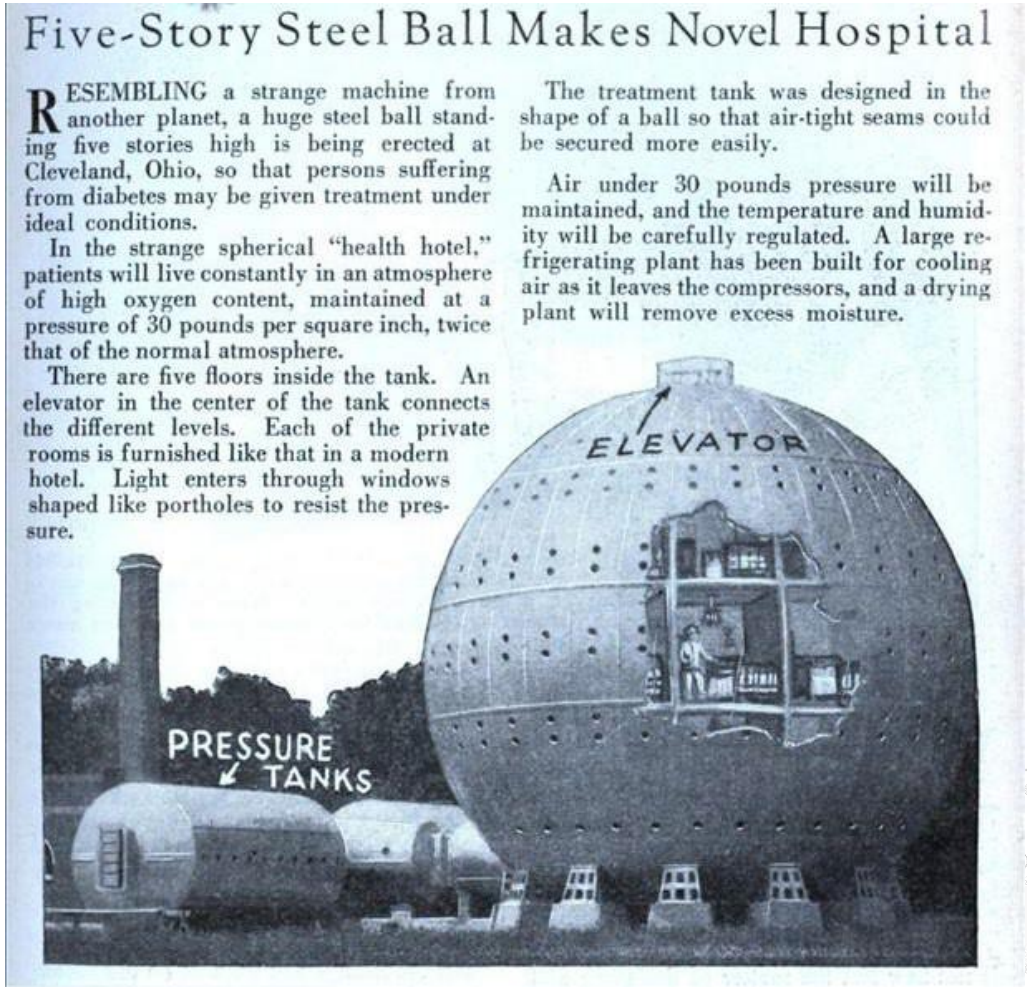
Whelan HT, Kindwall EP. *Hyperbaric Medicine Practice,* 4th ed. Flagstaff, AZ: Best Pub; 2017.

HBO_2 BENEFITS



IS HBO_2 NEW OR EXPERIMENTAL?

- No, hyperbaric oxygen therapy is not a new phenomenon.
  - Compressed gas as treatment for disease has been employed for hundreds of years (since the 1600s…even before oxygen was discovered!) and was used by the navy for decompression sickness starting in the 1930s.
- Clinical hyperbaric chambers are approved by the FDA.
- Hyperbaric indications are covered by Medicare and many commercial payers.



Five-Story Steel Ball Makes Novel Hospital

RESEMBLING a strange machine from another planet, a huge steel ball standing five stories high is being erected at Cleveland, Ohio, so that persons suffering from diabetes may be given treatment under ideal conditions.

In the strange spherical "health hotel," patients will live constantly in an atmosphere of high oxygen content, maintained at a pressure of 30 pounds per square inch, twice that of the normal atmosphere.

There are five floors inside the tank. An elevator in the center of the tank connects the different levels. Each of the private rooms is furnished like that in a modern hotel. Light enters through windows shaped like portholes to resist the pressure.

The treatment tank was designed in the shape of a ball so that air-tight seams could be secured more easily.

Air under 30 pounds pressure will be maintained, and the temperature and humidity will be carefully regulated. A large refrigerating plant has been built for cooling air as it leaves the compressors, and a drying plant will remove excess moisture.

Timken's Tank, Cleveland, Ohio, Built 1928

MONOPLACE VS MULTIPLACE

Monoplace

- Single occupant (patient)
- Filled with pure oxygen
- HBO_2 chamber operator outside chamber (direct line of sight to patient)
- More cost effective than multiplace chambers, easier to install in hospital or outpatient building

Multiplace

- Multiple occupants
- Filled with air (patients wear hoods which provide oxygen)
- HBO_2 staff inside chamber with patients
- Can be useful for decompression sickness, air embolism, or mass carbon monoxide events

ASPECTS OF THERAPY

	Medical clearance and consent by an HBO_2 therapy trained provider
	Daily attendance of therapy (usually 5 days per week)
	Most treatments are 2-2.5 hours long
	Total number of treatments can vary by indication and patient response
	Personal care and observation by a certified hyperbaric technologist (CHT) during entire treatment
	Entertainment options such as cable TV or DVDs

ARE THERE ANY SIDE EFFECTS?

Most patients experience no major side effects from HBO_2 therapy.

Some minor side effects that have been reported include, but not limited too:

Ear discomfort | Lightheadedness | Sinus pressure

HOW TO REFER AN HBO PATIENT

When in doubt, contact your local hyperbaric center.

You don't need to be an HBO_2 expert to refer, it's okay to ask questions.

In most cases, patients can also self-refer.

Center staff will evaluate patient's medical records to determine whether they are appropriate for HBO_2 therapy (or any other care measures provided at center).

If required, the center staff will contact patient's insurance for pre-authorization.

HBOT and Amputation Prevention

Macrovascular – Every Patient With a Wound Is Evaluated For Arterial Insufficiency

- Lower Extremity Ankle Brachial Index (ABI)
  - Less than 0.8 - Refer For Vascular Evaluation
  - Conventional Angiogram/ CT Angio/ MRA

Microvascular – Patients Who Have Been Revascularized or ABI Was Originally >.8

- Many Diabetics Have Microvascular Disease and Even After Being Optimized With Angioplasty, Stenting, Atherectomy, or Bypass Have Wounds That Fail to Heal or Heal Very Slowly

If A Wound Has Not Reduced in Surface Area > 50% After 4 Weeks Std Wound Care

- If Microvascular Disease/ Ischemia Are In The Differential Diagnosis
- HBOT Should Be Initiated

Decreased Days To Healing

Decreased Opportunity of Cellulitis and Infection

Decreased Office Visits, Increased Quality of Life, PREVENTION OF AMPUTATION

COMPROMISED FLAPS & GRAFTS

Key points

- HBO_2 may be warranted for graft tissue that is compromised but still viable, or when prior history of graft failure is a concern for repeat procedure.
- When indicated, HBO_2 therapy should be started as soon as possible (time is tissue).
- Trauma related large flaps may not follow classic length-to-width ratio resulting in poor perfusion and warrant HBO_2 referral.

Rationale

- \+ Increase neovascularization
- \+ Reduce edema
- \+ Amelioration of ischemia-reperfusion injury
- \+ Maximize viability of the compromised tissue while revascularization takes place

Undersea Hyperbaric Medical Society. *Hyperbaric Oxygen Therapy Indications,* 14th ed. (R. Moon, Ed.) Best Pub; 2019.

CLINICAL EXAMPLE

Compromised flap

- 68 yr old female presents to wound center status post TMA prior week; now with dehiscence and dusky appearance.
- Indicate that a flap closure was performed (MD operative report).
- Gradual necrosis of plantar tissue flap with dehiscence of the surgical incision and advancing cellulitis; risk of complete flap failure!
- Recommended for HBO_2 therapy.

DIABETIC FOOT ULCER

Key points

- HBO_2 only warranted for Wagner 3 and above (presence of exposed structures, abscess, gangrene, osteomyelitis).
- Must demonstrate 30 days of appropriate care prior to starting HBO_2 therapy (7 steps of wound management);
  - Evaluate blood flow → intervention when indicated,
  - Treat infection,
  - Debridement,
  - Glucose control,
  - Offloading,
  - Optimizing the host (e.g., nutrition, medications),
  - Moisture control & appropriate dressings.

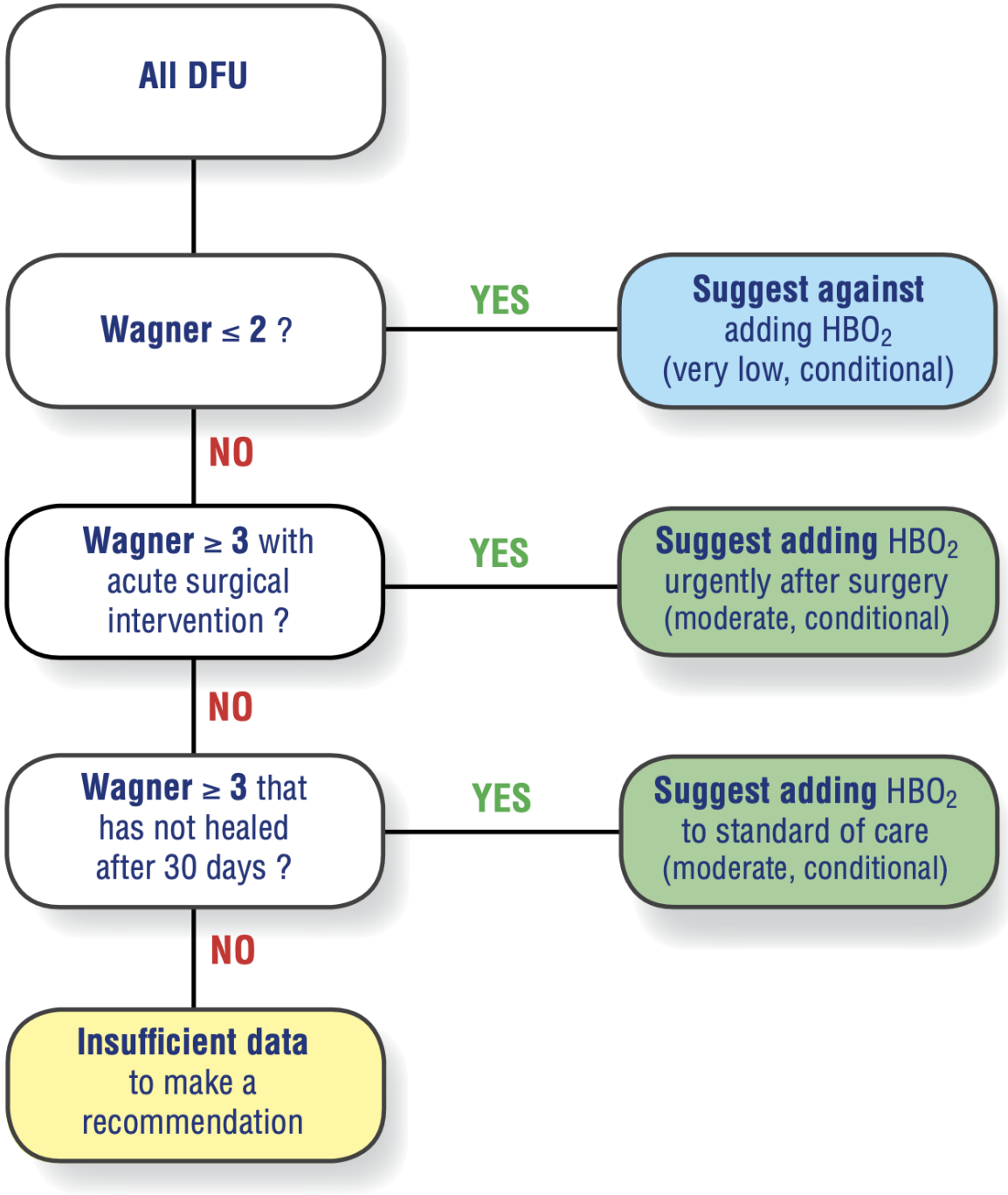
Rationale

- \+ Increased granulation
- \+ Enhanced neutrophil function
- \+ Reduced edema
- \+ Increased neovascularization
- \+ Increased collagen deposition
- \+ Increased epithelization
- \+ Reduced inflammation

Undersea Hyperbaric Medical Society. *Hyperbaric Oxygen Therapy Indications,* 15th ed. (E. Huang, Ed.) Best Pub; 2023.

ALGORITHM FOR THE USE OF HBO_2

- A clinical practice guideline for the use of HBO_2 therapy in the treatment of diabetic foot ulcers.[1]
- Class I AHA intervention for HBO_2 in osteomyelitis when Wagner Grade 3 or 4 diabetic ulcers are present.



1. Huang ET, Mansouri J, Murad MH, Joseph WS, Strauss MB, Tettelbach W, Worth ER; UHMS CPG Oversight Committee. A clinical practice guideline for the use of hyperbaric oxygen therapy in the treatment of diabetic foot ulcers. Undersea Hyperb Med. 2015 May-Jun;42(3):205-47. PMID: 26152105.

CLINICAL EXAMPLE

Diabetic foot ulcer complicated with chronic osteomyelitis

- 55 yr old male presented with multiple wounds/cellulitis to right foot that required TMA on 8/7; seen on 8/13 with hematoma to surgical wound.
- History: includes type 2 DM, HTN.
- ABI adequate, treated with Augmentin and surgical debridements (HgbA1c 7.7%).
- Prescribed HBO_2 therapy on 9/4/20 through 1/14/21.

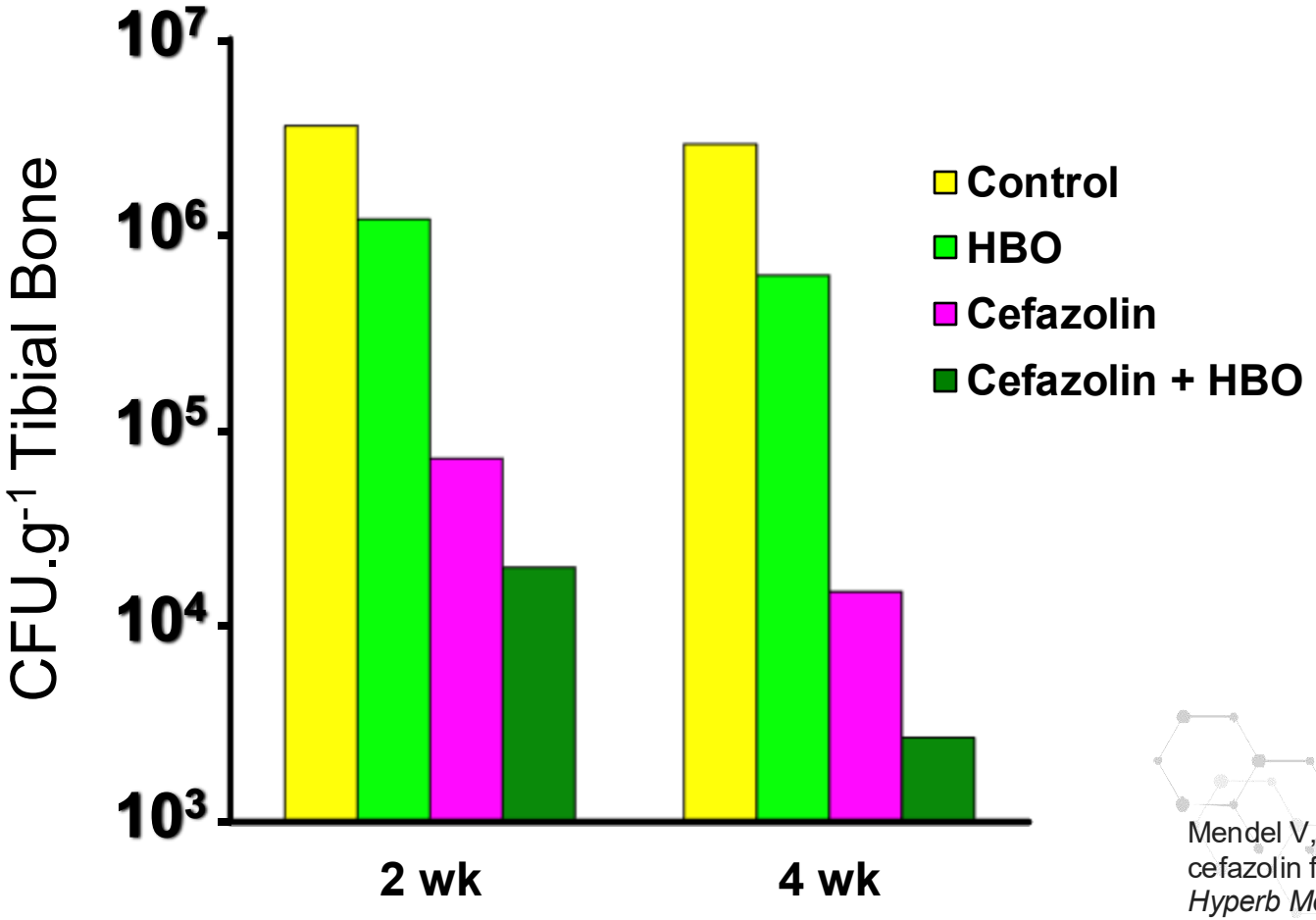
8.13.2020

9.3.2020

1.14.2021

CHRONIC REFRACTORY OSTEOMYELITIS

HBO_2 & Antibiotics with Osteomyelitis in Rats



Mendel V, Reichert B, Simanowski HJ, Scholz HC. Therapy with hyperbaric oxygen and cefazolin for experimental osteomyelitis due to Staphylococcus aureus in rats. *Undersea Hyperb Med*. 1999;26(3):169-174.

CHRONIC REFRACTORY OSTEOMYELITIS

- Studied treatment profile ranges: 2.0 to 3.0 ATA Q day or BID
  - RestorixHealth preferred profiles:
    - → 2 ATA with no air brakes, for a total treatment time of 90 minutes on 100% oxygen.
    - → 2.4 ATA includes 90 min of 100% oxygen with 5 min air brakes every 20 minutes for a total treatment time of 110 minutes.
- Where appropriate medical course entails aggressive debridement, removal of hardware, and adequate treatment of infection.
- Treatment range: 30 to 40, may require up to 60 treatments to achieve sustained therapeutic benefit.

William H. Tettelbach, MD; Bret B. Hart, MD. "Refractory Osteomyelitis." UHMS Hyperbaric Medicine Indications Manual 15th Edition, edited by Enoch T. Huang, MD, Best Publishing Company, 2023, 265-294

CHRONIC REFRACTORY OSTEOMYELITIS

Key points

- HBO_2 therapy is only indicated for chronic refractory osteomyelitis that has failed standard (and appropriate) therapy…
  - Was treated with appropriate antibiotics,
  - Any infected hardware has been removed,
  - Osteomyelitis has been diagnosed again, even after appropriate measures.

Rationale

- \+ Enhanced neutrophil function
- \+ Antibiotic potentiation
- \+ Increased osteogenesis
- \+ Increased neovascularization
- \+ Increased collagen deposition
- \+ Increased epithelization
- \+ Reduced edema
- \+ Reduced inflammation

Undersea Hyperbaric Medical Society. (2019). Hyperbaric Oxygen Therapy Indications. (R. Moon, Ed.) (14th ed.). Best Pub.

CHRONIC REFRACTORY OSTEOMYELITIS

Benefits of HBO_2 in Osteomyelitis:

- Tissue oxygen tension restored to > 30 mmHg
  - required by Neutrophils to destroy bacteria by oxidative killing mechanisms[1,2]
- Direct suppressive effect on anaerobic pathogens[3,4]
- Augments transport of certain antibiotics across bacterial cell walls
  - active transport of antibiotics (e.g. gentamicin, tobramycin, amikacin) across bacterial cell walls does not occur if tissue oxygen tensions are below 20 to 30 mmHg[5]
- Enhances osteogenesis[6]
- Reduces tissue edema[7]
- Promotes capillary angiogenesis[8]
- Prevents polymorphonuclear leukocytes from adhering to damaged blood vessel linings
  - decreases the degree of inflammation which may accompany the surgical treatment of refractory osteomyelitis
- Can reduce treatment costs of complicated refractory osteomyelitis by approximately 5x
  - 1987 estimated per case costs reduced from $115,000 to $20,000[9]

CHRONIC REFRACTORY OSTEOMYELITIS

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2. Kindwall EP. Uses of hyperbaric oxygen therapy in the 1990s. Cleve Clin J Med 1992;59: 517-28.
3. Slack WK, Thomas DA, Perrins D. Hyperbaric oxygenation in chronic osteomyelitis. Lancet. 1965;1:1093-1094.
4. Park MK, Myers RAM, Marzella L. Oxygen tensions and infections: Modulation of microbial growth, activity of antimicrobial agents, and immunologic responses. Clin Infect Dis 1992; 14: 720-740.
5. Verklin RM, Jr, Mandell GL. Alteration of effectiveness of antibiotics by anaerobiosis. J Lab Clin Med. 1977 Jan;89(1):65-71.
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CLINICAL EXAMPLE

Chronic refractory osteomyelitis

- 71 yr old male.
- History: type 1 DM, neuropathy, prostate CA, CVA.
- Fem-pop bypass of the left lower extremity, amputation of 5th toe secondary to osteomyelitis; worsening surgical wound.
- Completed 33 HBO_2 treatments, VAC therapy, offloading, compression, and medical honey dressing.

WHICH SERVICES TYPICALLY ENCOUNTER PATIENTS WHO MAY BENEFIT FROM HBO_2 SERVICES?

Traditional

- General Surgery
- Podiatry
- Plastic Surgery
- Vascular surgery
- Family & Internal Medicine
- Orthopedics

Unexpected

- Urology
- Gastroenterology
- Radiation Oncology
- Oral Surgery
- Dentistry
- Potentially any service!

INDICATIONS

1. Air Or Gas Embolism
2a. Carbon Monoxide Poisoning
2b. Carbon Monoxide Poisoning Complicated By Cyanide Poisoning
3. Clostridial Myositis And Myonecrosis (Gas Gangrene)
4. Crush Injury, Compartment Syndrome And Other Acute Traumatic Ischemia
5. Decompression Sickness
6a. Arterial Inefficiencies: Central Retinal Artery Occlusion
6b. Arterial Inefficiencies: 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 (Newest! Approved On October 8, 2011 By The UHMS Board Of Directors)

There are 16 scientifically recognized HBO indications, many of which are approved by CMS and other payors

Indications Seen More Recently

Soft Tissue Radionecrosis (STR)

Osteoradionecrosis (ORN)

SOFT TISSUE RADIONECROSIS

Key points

- HBO_2 therapy is indicated for any radiation wound when the symptoms are thought to be late effects of radiation and not expected short term effects which would otherwise heal spontaneously.
- Useful for radiation injury regardless of whether wound is inside or outside the body.
- Radiation injury can be encountered by many services:
  - Gastroenterology,
  - Dentistry,
  - Urology.

Rationale

+ Oxygenation
+ Increased neovascularization
+ Support marginal tissue

Undersea Hyperbaric Medical Society. *Hyperbaric Oxygen Therapy Indications,* 14th ed. (R. Moon, Ed.) Best Pub; 2019.

CLINICAL EXAMPLE

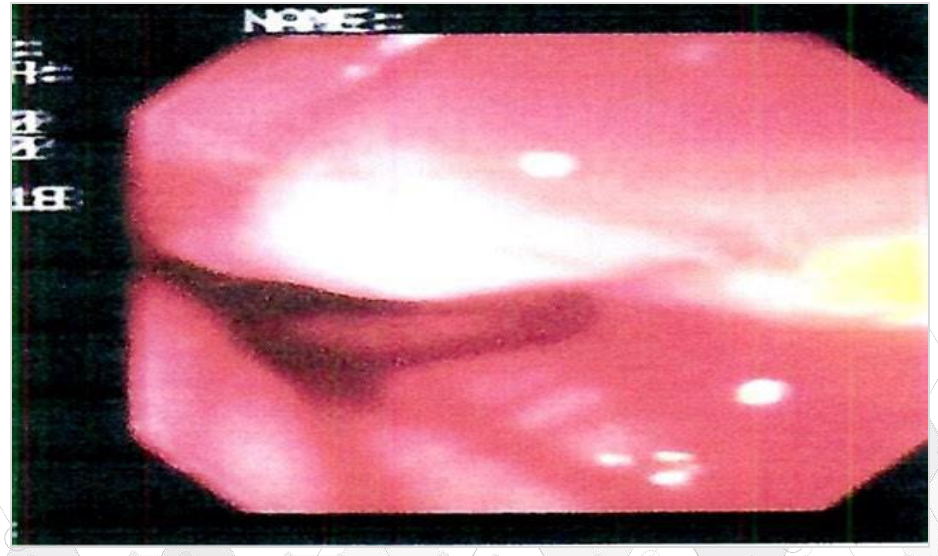
Soft tissue radionecrosis (external)

- 69 yr old female.
- History: breast CA 10 yrs ago.
- Treatment with mastectomy, radiation, chemo; presents to wound center with an open wound of chest wall.
- Recommended aggressive local care and HBO_2 therapy.

CLINICAL EXAMPLE

Soft tissue radionecrosis (internal)

- 70 yr old male.
- History: status post prostate CA; radiation treatment one year ago.
- Presents with persistent pain, bloody diarrhea, inability to sit for long periods.
- Recommended for HBO_2 therapy.



OSTEORADIONECROSIS (ORN)

Key points

- In a previously radiated site, ORN can occur spontaneously or as a result of surgical trauma.
- HBO_2 therapy may be used in combination with surgery.
- ORN symptoms can include…
  - Bony resorption,
  - Pathologic fracture of jawbone,
  - Exposed bone.

Rationale

- \+ Oxygenation
- \+ Support hypoxic tissue
- \+ Stimulate neovascularization

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CLINICAL EXAMPLE

Osteoradionecrosis

- CA of tonsils 5 yrs ago; Tx with 60 radiation treatments.
- Bony reabsorption with fixation of mandible.
- Presents to wound center with open wound and exposed screws.
- HBO_2 therapy recommended by oral surgeon in conjunction with antibiotics in preparation for reconstructive surgery

TOP 5 REFERRAL INDICATIONS

1. Diabetic foot ulcers (Wagner 3 and above).
2. Preservation/preparation flaps and grafts.
3. Chronic refractory osteomyelitis.
4. Soft tissue radionecrosis.
5. Osteoradionecrosis.

There are 16 scientifically recognized HBO indications, many of which are approved by CMS and other payors

THANK YOU