SPOTLIGHTS ON HYPERBARIC OXYGEN THERAPY

- Basic mechanisms
- Approved International Indications
- Applications

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President of Naval Hyperbaric Medical Institute
"Life without Music would be a mistake"

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Hyperbaric oxygen therapy

Hyperbaric oxygen is a mode of therapy in which the patient breaths 100% oxygen at pressures greater than normal atmospheric pressure for therapeutic purposes.
1 atmospheric pressure = pressure exerted on 1 cubic cm by the weight of the air column from the sea level up to the end of atmosphere = 760mmHg = 10 meters sea water

We are now at 10 meter under sea water surface.

+ 1 atmospheric pressure

2ATA
Physics of HBOT

HBO therapy is based on two physical factors from the ideal gas laws:

- Mechanical compression of bubbles (Boyle's law)
- High dose oxygen (Henry's law)
Boyle's law

At a constant temperature, a given volume of gas is inversely proportional to its pressure. Therefore, if the pressure is doubled, the volume of the gas is halved.
Boyle's law
Henry's law

The amount of gas that will dissolve in a given volume of solvent at a given temperature is directly proportional to the pressure of the gas with which the solvent is in equilibrium.
Increased pressure

Henry's law
Breathing 100% Oxygen at 3 ATA

Increases the physical solubility of the gas of the breathing medium (O₂) in the plasma:

from 0.3 ml/100 ml plasma
to 6.8 ml/100 ml plasma

Leading to a state of HYPEROXIA
HBOT hypersaturates the plasma
Physiological Effects of HYPEROXIA
HYPEROXIA

It leads to an increase in the diffusing distance of oxygen from functioning capillaries, providing immediate support to poorly perfused tissue in areas of compromised blood flow.
Theoretical Diffusion Radius

- **Air, 1 ATA**: PO$_2$ 100, RADIUS 64 MICRONS
- **O$_2$, 3 ATA**: PO$_2$ 2000, RADIUS 247 MICRONS
FACTORS AFFECTING OXYGEN DELIVERY

NORMAL

AIR AT 1 ATA

Normal Diffusion Distances

O₂

O₂

O₂

Normal Permeability

Typical Tissue Oxygen Tension (40 mm Hg)

Wound/Infection

AIR AT 1 ATA

Disrupted Circulation, Edema

O₂

Decreased Permeability

Hypoxia

Wound/Infection

OXYGEN AT 3 ATA

22 Times the Number of Oxygen Molecules per Unit Volume as Air at 1 ATA

O₂

O₂

O₂

O₂

Disrupted Circulation, Edema

Decreased Permeability

Optimal Tissue Oxygen Tension For Healing (Where Known) 80 mm Hg
Hyperoxia enhanced ANTIMICROBIAL ACTIVITY

- Hyperoxia enhances **phagocytosis** and white cell oxidative killing.
- Hyperoxia has a **synergistic** effect with antibiotics especially those needing oxygen for their cell membrane transport as aminoglycosids.
- Hyperoxia is **lethal** to anaerobic and microaerophilic organisms.
Hyperoxia - induced VASOCONSTRICTION

- It is a selective process occurring in normal, non hypoxic tissues in response to Hyperoxia.
- It leads to increase perfusion to hypoxic tissues (Robin Hood effect).
- It occurs without hypoxia.
- It reduces interstitial edema in inflamed and edematous tissue.
REDUCTION OF EDEMA

**HBO:**

**HBO:**
Reduced blood flow reduces hydrostatic pressure in capillaries. This reverses transcapillary pressure gradient. Fluid is removed from tissue.
It represents an indirect and delayed response to repeated hyperoxygenation. Therapeutic effects include:

- enhanced fibroblast migration and mitosis,
- neoformation of collagen, and
- selective capillary angiogenesis in hypoxic areas characterized by sluggish circulation high lactate level.
Approved International Indications
7th EUROPEAN CONSENSUS CONFERENCE ON HYPERBARIC MEDICINE

LILLE, DECEMBER 3rd – 4th 2004

RECOMMENDATIONS OF THE 2nd JURY
Consensus Jury

1. F. WATTEL, (France), Président
2. N. BITTERMAN (Israel, EUBS)
3. L. DITRI (Italy)
4. M. HAMILTON-FARELL (United Kingdom)
5. A. KEMMER (Germany)
6. F. LIND (Sweden)
7. JM. MÉLIET (France)
8. T. MESSIMERIS (Greece)
9. J. NIINIKOSKI (Finland)
10. F. ROQUE (Portugal)
11. Z. SICKO (Poland)
12. A. VAN DER KLEIJ (The Netherlands)
ECHM Recommendations

The Jury issues its recommendations using a 3 grade scale according to the strength each recommendation has been evaluated.

Type 1: Strongly Recommended.

The Jury considers the implementation of HBOT is of critical importance for final outcome of the patient.

Type 2: Recommended.

The Jury considers the implementation of HBOT is positively affecting the final outcome of the patient.

Type 3: Optional.

The Jury considers the implementation of HBOT is an option.
ECHM Recommendations

- The Jury will also report the level of evidence which supports, in its view, the recommendation.
  
  **Level A:** Recommendation supported by level 1 evidence.
  **Level B:** Recommendation supported by level 2 evidence
  **Level C:** Recommendation supported only by level 3 evidence.

- In using such a methodology, every physician reading the jury conclusions will be immediately able to assess the strength of evidence supporting each statement and how it has to be applied in clinical practice.
Type I

1. CO poisoning
2. Crush syndrome
3. Prevention of osteoradionecrosis after dental extraction
4. Osteoradionecrosis (mandible)
5. Soft tissue radionecrosis (cystitis)
6. Decompression accident
7. Gas embolism
8. Anaerobic or mixed bacterial anaerobic infections
Type II

1. Diabetic foot lesion
2. Compromised skin graft and musculocutaneous flap
3. Osteoradionecrosis (other bones)
4. Radio-induced proctitis / enteritis
5. Radio-induced lesions of soft tissues
6. Surgery and implant in irradiated tissue (preventive action)
7. Sudden deafness
8. Ischemic ulcer
9. Refractory chronic osteomyelitis
10. Neuroblastoma Stage IV
Type III

1. Post anoxic encephalopathy
2. Larynx radionecrosis
3. Radio-induced CNS lesion
4. Post-vascular procedure reperfusion syndrome
5. Limb replantation
6. Burns >20 % of surface area and 2nd degree
7. Acute ischemic ophthalmological disorders
8. Selected non healing wounds secondary to inflammatory processes
UNDERSEA & HYPERBARIC MEDICAL SOCIETY
Indications for Hyperbaric Oxygen Therapy

Approved Indications:
The following indications are approved uses of hyperbaric oxygen therapy as defined by the Hyperbaric Oxygen Therapy Committee.
1 Air or Gas Embolism
2 Carbon Monoxide Poisoning
   - Carbon Monoxide Poisoning Complicated by Cyanide Poisoning
3 Clostridal Myositis and Myonecrosis (Gas Gangrene)
4 Crush Injury, Compartment Syndrome, and other Acute Traumatic Ischemias
5 Decompression Sickness
6 Enhancement of Healing in Selected Problem Wounds
7 Exceptional Blood Loss (Anemia)
8 Intracranial Abscess
9 Necrotizing Soft Tissue Infections
10 Osteomyelitis (Refractory)
11 Delayed Radiation Injury (Soft Tissue and Bony Necrosis)
12 Skin Grafts & Flaps (Compromised)
13 Thermal Burns
Hyperbaric Oxygen Therapy is a modality in which the entire body is exposed to oxygen under increased atmospheric pressure. Effective April 1, 2003, a National Coverage Decision expanded the use of HBO therapy to include coverage for the treatment of diabetic wounds of the lower extremities. For specific coverage criteria for HBO Therapy, refer to the National Coverage Determinations Manual, Chapter 1, Section 20.29
Clinical cases
Chronic Circumferential Leg Ulcer
After 20 HBO sessions
After S.S.G. and HBO sessions
Unhealed Stumb
After 30 sessions
Diabetic foot gangrene
Chronic venous ulcer

Before & After 30 HBO Sessions
Monoplace Chamber
Monoplace Chamber

Photograph courtesy of:
Chronic Wound Treatment and Hyperbaric Center,
Mount Vernon Hospital, Mount Vernon, New York.
Monoplace Chambers
Monoplace Chamber
Control Unit Of Hyperbaric Chamber
Monoplace Chambers for Kids
Multiplace Chamber
Multiplace Chamber
Inside Multiplace Chamber
Multiplace Chamber
Multiplace Chamber
PORTABLE CHAMBER FOR DOMESTIC USE
Hyperbaric Chambers

Experimental Chamber
MOBLIE HYPERBARIC CHAMBER
World Distribution of Hyperbaric Chambers
2004

- China: 37%
- Russia: 26%
- South Korea: 8%
- Other: 2%
- USA: 7%
- Europe: 10%
- Japan: 10%
- China: 37%
Distribution of Hyperbaric Chambers in Europe 2004

- Italy: 33%
- UK: 3%
- Germany: 24%
- Benelux: 8%
- Spain: 5%
- France: 17%
- Eastern Europe: 6%
- Switzerland: 2%
- Scandinavia: 2%
- Eastern Europe: 6%
- Switzerland: 2%
- Benelux: 8%
- Spain: 5%
- France: 17%
- Germany: 24%
- UK: 3%
- Italy: 33%
HBOT in Egypt
The Egyptian Navy was the first to introduce this Medical Specialty in Egypt & Middle East, in 1967.
Naval Hyperbaric Medical Institute (1997)
HBOT in Egypt

HBOT Centers in Egypt

- Alexandria
- Cairo
- Red Sea
- Sinai
HBOT in Egypt
Alexandria
Naval Hyperbaric Medical Institute
(2004)
HBOT in Egypt
Alexandria

Alexandria Scan Center (Alex Scan)

(1997)
HBOT in Egypt
Cairo
Nasser Institute for Research and Treatment
HBOT in Egypt
Red Sea - Sinai
HBOT in Egypt
Red Sea - Hurghada
Naval Diving and Emergency Centre
(0000)
HBOT in Egypt
Red Sea - Hurghada
El Gouna - DECO International
(1998)
HBOT in Egypt
Red Sea – Safaga
HBOT in Egypt
Red Sea – Marsa Alam
HBOT in Egypt
Red Sea – Dahab

HBOT in Egypt
Red Sea – Sharm El Sheikh
Hyperbaric Medical Center
(1993)
Contraindications of HBO

- Pneumothorax
- Upper Respiratory Infections
- Emphysema
- C.O.P.D.
- Congestive heart failure
Side effects of HBOT

- Oxygen toxicity
- Clostrophobia
- Barotraumas of middle ear & nasal sinuses

You will never be safe