



Extivita

Hyperbaric Oxygen Therapy
“HBOT”

www.extivita.org

919-354-3775



Overview

- HBOT – Definition
- HBOT- How it works
- HBOT- in Stroke and TBI
- HBOT- Precautions, Contraindications, Side effects



What is Hyperbaric Oxygen Therapy?

- Literally Translated, Hyperbaric means “High Pressure”
- More specifically, HBOT involves breathing 100% medical grade oxygen in a high pressure environment, like a hyperbaric chamber for a certain duration
- HBOT is a therapeutic treatment that involves intermittently inhaling oxygen at higher than normal pressure.



History of Hyperbaric Oxygen Therapy

- HBOT / compressed air, has been advocated and used as medical therapy for centuries.
- First use of hyperbaric chamber for medical therapy was in the 1800's
- HBOT treatments first used for decompression illness in the early 1900's
- HBOT in the 1900's was used for hypoxia, infections, surgeries to name a few.
- HBOT research has been growing since mid 1900's to help with a variety of illnesses and conditions
- HBOT is now considered as either primary or adjunctive therapy for a spectrum of diseases



Background

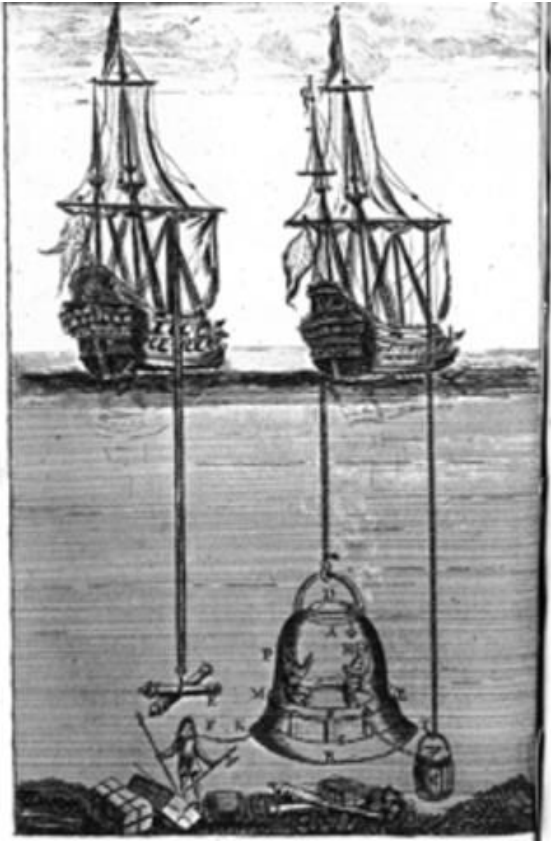
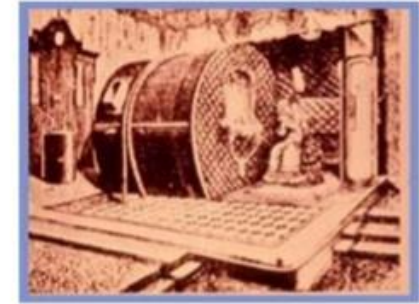


Image From Cambridge Univ Press



Image From slideShare



Henshaw, British clergyman built a sealed chamber called a Domicilium (O₂ discovered 1775).

HENSHAW'S DOMICILIUM

➤ Henshaw IN, Simpson A. Compressed Air as a Therapeutic Agent in the Treatment of Consumption, Asthma, Chronic Bronchitis and Other Diseases. 1857.



Background



Source: Rose L. Hamm: Text and Atlas of Wound Diagnosis and Treatment, 2e
Copyright © McGraw-Hill Education. All rights reserved.

Image From Ucsfcmc.com

Cunningham Sanitarium

- Dr. Orval J. Cunningham, Kansas City
- Steel ball hospital built in 1928
- Five-story, sixty-five foot, 900-ton sphere
- Able to accommodate forty patients
- Could pressurize to 3 ATA
- Cost 300 for 1 month stay!



HBOT has Two Components

OXYGEN

- HBOT involves the patient breathing medical grade oxygen via mask or hood.
- Oxygen is considered a drug by the FDA, thus requires prescription from a provider for these therapeutic treatments.

PRESSURE

- Normal atmospheric pressure (at sea level) is 1 atmosphere (1 atm). Patients receive HBOT in a pressurized chamber.
- During treatment, the chamber pressure gradually increases to about 2 – 2.5 x normal atmospheric pressure (2 – 2.5 ATA).



HBOT Treatment Benefits

Primary Effects:

- Involves both increased pressure and hyperoxia

Secondary Effects:

- As a result of controlled oxidative stress
 - Wound healing
 - Anti-microbial
 - Lessens reperfusion injury



Types of Chambers - Soft

- Portable
- Much less pressure and oxygen
- Usually used for altitude sickness
- Role not yet scientifically determined



Image From The Rimland Center



Types of Chambers - Monoplace

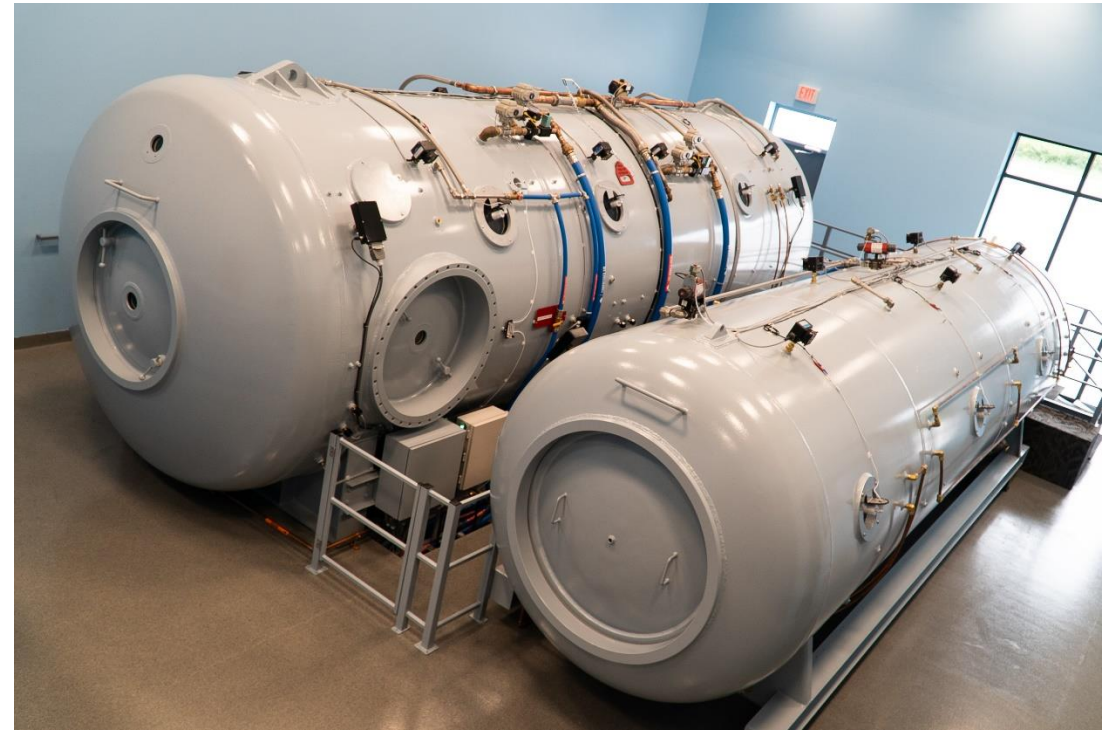
- Holds one person at a time
- Pressurized with oxygen
- Patients do not need equipment
- Cant dive as deep as Multiplace
- Takes up less place, less costly
- Less opportunity for patient interaction while in chamber





Types of Chambers - Multiplace

- Holds multiple patients at a time
- Allows for medical personnel inside with patients
- Pressurized with air
- Patients wear equipment which delivers 100% O₂
- Can go to very deep pressures



Physiological & Pharmacological Effects of HBOT

How it works





Hyperbaric Oxygen Therapy Heals Wounds

- Reverses Hypoxia
- Decreases Inflammation
- Significantly Increases Stem Cell Release
- Fights Infection



Wound Healing



Image From Uhms.org





Increases Oxygen In the Body: Oxygen Carrying Capacity

- Usually carried by hemoglobin (RBC)
- Significantly Increases oxygen in circulation
- Oxygen rich plasma transported to hypoxic tissues

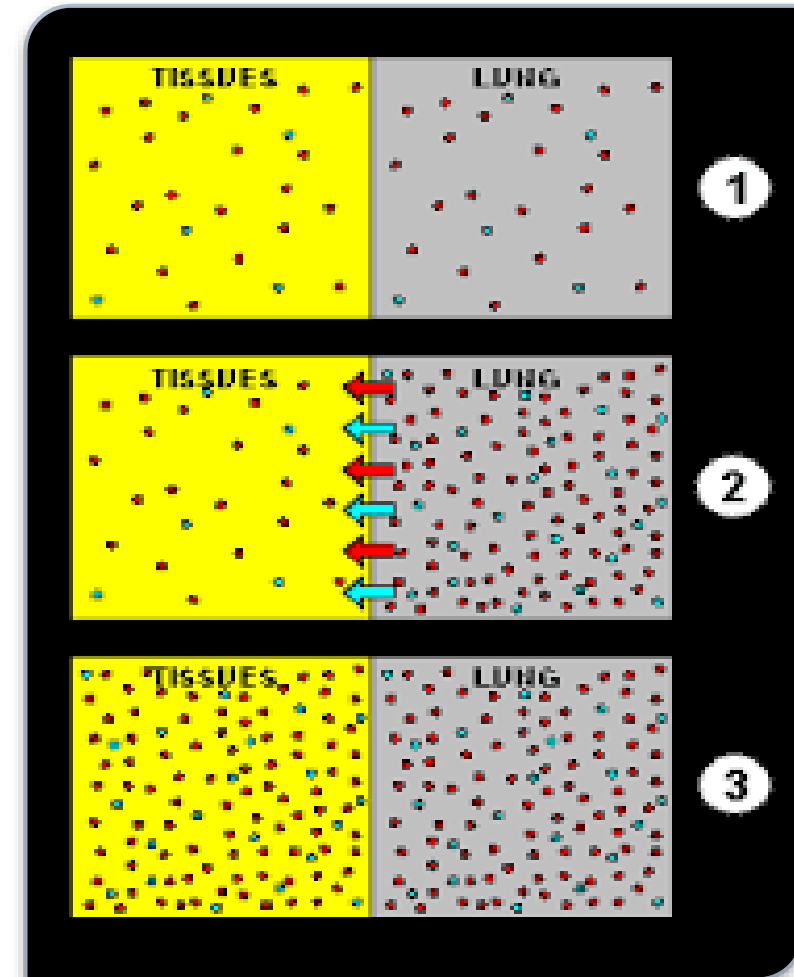


Image From Flightbridgeed.com



Brain Facts

- 2% of your body weight
- Uses up 15% of cardiac output
- Consumes 20% of overall oxygen in the blood
- Consumes 20% of body's energy
 - This energy management is provided by blood flow



Image From Piedmont.org



HBOT Effects in the BODY and the Brain

- Used by the body to form energy for all types of the cells to function
- In the brain, HBOT increases oxygen availability which starts the healing process
 - Decrease swelling
 - Cellular repair and healing
 - Stem cell mobilization for neuronal cell
 - Reduce cell necrosis and death



Is there a difference?

Brain Injury

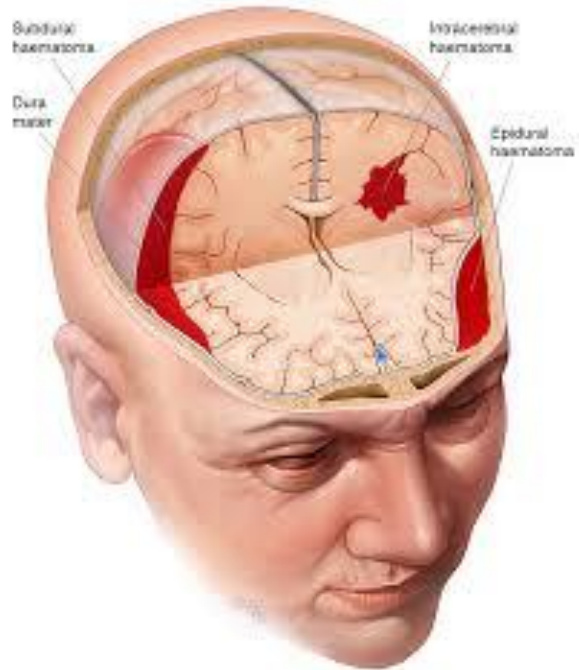


Image From Queensland brain institute

Wounds on the body



Image From Woundcareadvisor.com



The Injured Brain: Stroke & TBI

Differences:

- Causes
- Prognosis
- Outcomes

Similarities

- Broad spectrum of disabilities
- Have acute and chronic phases
- Type of degree of disability affected by time



Stroke

Results in Injury to Parts of the Brain

- Compromised oxygen supply
 - Occlusion
 - Bleeding
- Cell death and reduced cell function attributed to lack of oxygen
 - Excitotoxicity
 - Oxidative stress
 - Inflammation
 - Apoptosis
- Ongoing impairment of motor, sensory, or processing pathways
- Acute or Chronic

Current Medical Management

- Thrombolytics- given within 3 hours of event, only 1-3% receive
- Clot extraction
- Anticoagulants/antiplatelets
- Vasodilators



Penumbra



Image from Radiology Assistant.nl



ACUTE STROKE – 24 Hours to 7 Days

HBOT:

- Most effective when applied early
- Can reverse tissue oxygenation deprivation
 - Downregulates inflammatory response
 - Improves mitochondrial function
 - Leading to enhanced cerebral metabolism
 - Cell survival
 - Maintains BBB integrity
 - Reduces brain swelling
 - Decreases blood viscosity, improves circulation
- Very low risk

Clinically:

- Can reduce neurological deficits
- Can improve outcome
- Enhance post stroke recovery
- Reduce frequency of recurrent strokes



Chronic Stroke- Greater than 3 weeks

Reactivates Dormant Neurons in Penumbra Zone:

- Angiogenesis
- Promotes cellular repair
- Regenerate nerve cells
- Promotes vascular repair
- Inhibit Nogo-A pathways

Clinically:

- Recent research found significant benefits during chronic phase of stroke recovery
- These include
 - Improvements in neurologic functions
 - ADL's
 - Motor function
 - Brain metabolism
 - Quality of Life
 - Healing of damaged brain areas per brain scans



Stroke: HBOT Study 1

The Effect of Hyperbaric Oxygen Therapy on Functional Impairments Caused by Ischemic Stroke.

Neurology research international, 2018, 3172679. <https://doi.org/10.1155/2018/3172679> Rosario, E. R., Kaplan, S. E., Khonsari, S., Vazquez, G., Solanki, N., Lane, M., Brownell, H., & Rosenberg, S. S. (2018).

Summary:

- 7 participants
- between 18 and 80 years
- suffered a stroke at least 12-month prior
 - participants 50% were 1 year after stroke when they enrolled in the study and the other 50% were 2 years after stroke
- Exhibited some functional impairments

Protocol:

- 20 treatments of 100% O₂ at 2.0 ATA for 60 minutes each day Monday through Friday for a total of 4 weeks
- 4 week break
- Followed by a second round of 20 treatments



Stroke: HBOT Study 1 - Results

Results:

- Significant improvements in
 - Cognition
 - gait velocity
 - upper extremity mobility
 - sleep
 - overall recovery
 - inflammatory biomarkers suggesting sustained functional change

Conclusion:

- Authors report treatment effects maintained when examined at 3 month follow up (except for UEFM)



Stroke: HBOT Study 2

Improvement of memory impairments in poststroke patients by hyperbaric oxygen therapy.

Boussi-Gross R, Golan H, Volkov O, et al. *Neuropsychology*. 2015;29(4):610-621. doi:10.1037/neu0000149

Summary:

- Retrospective analysis on data of 91 stroke patients
- Age >18 (mean age 60)
- 3-180 months before HBOT therapy

Protocol:

- 40-60 daily sessions
- 5 days a week
- 90 minutes
- 100% O₂ at 2 ATA



Stroke: HBOT Study 2 - Results

Results:

- Statistically significant improvements ($p < .0005$, effect sizes medium to large) in all memory measures after HBO₂ treatments.
- Clinical improvements were well correlated with improvement in brain metabolism, mainly in temporal areas.

Conclusion:

- HBOT has the potential for improving memory impairments in post stroke patients



Stroke: HBOT Study 3

Hyperbaric oxygen induces late neuroplasticity in post stroke patients--randomized, prospective trial.

Efrati S, et al PLoS One. 2013

Summary:

- Randomized prospective trial
- 74 patients
- Suffered stroke 6-36 months before HBOT
- Had at least 1 motor dysfunction

Protocol:

- Randomly assigned
- SPECT imaging, neurofunctional tests
- 40 sessions 5 days a week 90 min each 100% O₂ at 2 ATA



Stroke: HBOT Study 3 - Results

Results:

- Significant improvement in neurological functions and quality of life
- SPECT Imaging correlated with clinical improvement

Conclusion:

- HBOT can lead to significant neurological improvements in post stroke patients
- Activation of Neuroplasticity implicated by clinical improvements



Traumatic Brain Injury

- Caused by external physical force
 - Mild, moderate or severe
 - Blast related
- Rapid Acceleration/Deceleration of the head with shearing, stretching, compressing and tearing of white matter
- Primarily causes cell death in the outer part of the brain called the cortex
- Secondary cell death
 - Inflammatory cascade, increased ICP
- Leads to cognitive impairment, motor dysfunction, seizures



How Does HBOT Help In TBI?

- Delivers increased partial pressure of oxygen to the brain
 - Hyper-oxygenates tissues
 - Reduces inflammation and swelling
 - Reduces neuronal cell damage/death
 - Repairs and enhances cellular function
 - Neurogenesis/angiogenesis
 - Improvement in brain blood flow per SPECT
 - Upregulates and downregulates over 8,000 genes



TBI HBOT Study 1

Glasgow Coma Scale, brain electric activity mapping and Glasgow Outcome Scale after hyperbaric oxygen treatment of severe brain injury.

Ren H, et al. 2001

Summary

- 55 patients - Treatment and control group
- Observe alteration in clinic GCS
- Brain electrical activity
- Prognosis and GOS

Results

- Significant improvement
- GCS, BEAM and GOS were improved in the treatment group.
- There was a statistic significant difference between the two groups ($P < 0.01$)

Clinical Trials (and case reports) of Mild to Moderate TBI (With or Without PTSD) Using HBOT

Clinical Trials	Authors	Year	Improvement		Statistical Significance		Type of Design	# of Arms	Air Tx Group Pressure	HBOT Pressure 100% O ₂	HBOT Dives	Time At Depth (Min)	Total Time (Min)	Brain Imaging	# of Subjects (Total)	Time Since Injury	Level of Evidence (1-4)
			Symptoms	Neurocog Tests	Pre/Post HBOT	Between Groups											
1	Hardy et al.	2007	Yes	Yes	Yes	N/A	Pre to Post	1	N/A	2.0 ATA	20/60	60	1200 to 3600	SPECT	1	12 months	3
2	Lin et al.	2008	^{soc} No/Yes	N/A	^{soc} No/Yes	Yes	RCT w/ SoC group	2	N/A	2.0 ATA	20	120	2400	N/A	22/22 (44)	> 3 monhts	1
3	Wright et al.	2009	Yes	Yes	N/A	N/A	Pre to Post	1	N/A	1.5 ATA	40	60	2400	N/A	2	8 months	3
4	Eovaldi et al.	2010	Yes	N/A	N/A	N/A	Pre to Post	1	N/A	2.4 ATA	7	90	630	N/A	1	4 days	3
5	Stoller et al.	2011	Yes	Yes	N/A	N/A	Pre to Post	1	N/A	1.5 ATA	40	60	2400	SPECT	2	3 months-20 years	3
6	Harch et al.	2012	Yes	Yes	Yes	N/A	Pre to Post	1	N/A	1.5 ATA	40	60	2400	SPECT	16	1.25-4.75 years	3
7	Wolf et al.	2012	Yes	Yes	Yes	No	RCT	2	1.3 ATA	2.4 ATA	30	90	2700	N/A	50	3-71 months	1
8	Boussi-Gross et al.	2013	Yes	Yes	Yes	Yes // No	RCT - Cross-over	2	N/A	1.5 ATA	40	60	2400	SPECT	32 / 24 // 24 (56)	~34.6 months / ~31.7 months	1
9	Cifu et al.	2014	Yes	N/A	Yes	No	RCT	3	10.5% / 75%	2.0 ATA	40	60	2400	N/A	21 / 18 / 21 (60)	3-39 months	1
10	Miller et al. (HOPPS)	2014	^{soc} No/Yes	Yes	Yes	^{soc} Yes/No	RCT w/ SoC group	3	1.3 ATA	1.5 ATA	40	60	2400	N/A	23 / 24 / 25 (72)	17.2 / 24.9 / 26.3 months	1
11	Harch et al.	2017	Yes	Yes	Yes	N/A	Pre to Post	1	N/A	1.5 ATA	40	60	2400	SPECT	29	1.25-5.83 years	3
12	Tal et al.	2017	Yes	Yes	Yes	N/A	Pre to Post	1	N/A	1.5 ATA	60	90	5400	MRI / DCI	15	6 months - 27 years	3
13	Weaver et al. (BIMA)	2018	Yes	Yes	Yes	Yes	RCT	2	1.3 ATA	1.5 ATA	40	60	2400	N/A	71	25.6 +/- 16.2 months	1
14	Hadanny et al.	2018	N/A	Yes	Yes	N/A	Retro	1	N/A	1.5 - 2.0 ATA	40-70	60-90	2400 to 6300	SPECT	154	4.6 +/- 5.8 years	3
15	Mozayeni et al. (NBIRR)	2019	N/A	Yes	Yes	N/A	Pre to Post	1	N/A	1.5 ATA	40-82	60	2400 to 4920	N/A	32	9.5 +/- 12.7 years	3
16	Shytle et al.	2019	Yes	Yes	N/A	N/A	Pre to Post	1	N/A	1.5 - 1.75 ATA	20-35	60	1200 to 2100	N/A	3	> 1 year	3
17	Harch et al	TBA	Yes	Yes	Yes	No	RCT - Cross-over	2	N/A	1.5 ATA	???	???	???	SPECT	23/27 (50)	???	1



Jon and Laura G.





Potential Side Effects of HBOT

- Barotrauma:
 - Middle ear-most common
 - Sinus
 - Dental
- Pulmonary barotrauma
- Oxygen Toxicity
- Ocular side effects



Contraindications with HBOT

- Pneumothorax is absolute no-no
- Certain chemotherapy drugs
- Relative Contraindications examples
 - COPD
 - Seizure disorders
 - Recent thoracic surgery
 - Pregnancy



What is it like to do HBOT?

- Ears feel the pressure just like when you fly
- Usually about 60 to 90 minutes long
- Can watch movies on the TV inside the chamber or read or sleep
- Ambient temp changes





Resources

- Boussi-Gross R, Golan H, Volkov O, et al. Improvement of memory impairments in poststroke patients by hyperbaric oxygen therapy. *Neuropsychology*. 2015;29(4):610-621. doi:10.1037/neu0000149
- Efrati S, et al. Hyperbaric oxygen induces late neuroplasticity in post stroke patients--randomized, prospective trial. *PLoS One*. 2013;8(1):e53716. doi:10.1371/journal.pone.0053716
- Kidd PM. Integrated brain restoration after ischemic stroke--medical management, risk factors, nutrients, and other interventions for managing inflammation and enhancing brain plasticity. *Altern Med Rev*. 2009;14(1):14-35.
- Rosario ER, Kaplan SE, Khonsari S, et al. The Effect of Hyperbaric Oxygen Therapy on Functional Impairments Caused by Ischemic Stroke. *Neurol Res Int*. 2018;2018:3172679. Published 2018 Oct 9. doi:10.1155/2018/3172679
- Ren H, Wang W, Ge Z. Glasgow Coma Scale, brain electric activity mapping and Glasgow Outcome Scale after hyperbaric oxygen treatment of severe brain injury. *Chinese Journal of Traumatology = Zhonghua Chuang Shang za zhi*. 2001 Nov;4(4):239-241.
- Singhal AB. A review of oxygen therapy in ischemic stroke. *Neurol Res*. 2007;29(2):173-183. doi:10.1179/016164107X181815



Resources

- Xavier Figueroa, Ph.D. Why The <bleep> Are We Still Having this Debate for TBI Treatment?
9/29/2019 HMI: HBOT 2019
- UHMS
- Wikipedia



Extivita

Thank You!

www.Extivita.org

