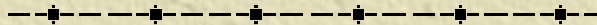


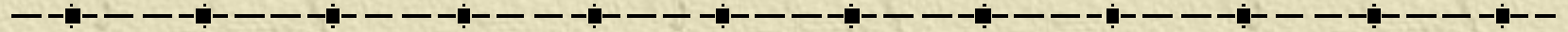
Introduction to Hyperbaric Oxygen Therapy: Applications in ASD



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HBOT



✦ H – hyper

✦ B – baric

✦ O – oxygen

✦ T - therapy

History of HBOT

-
- ✦ Extends back 350 years
 - ✦ Dr. Henshaw – English physician 1600s
 - ✦ Change in climate due to barometric pressure
 - ✦ First HBOT chamber ... “sealed room”

History of HBOT cont.

- Dr. Corning – Neurologist, 1880's
- Chamber 6 foot in diameter
- Powered air compressor
- Hudson River tunnel construction site – paralytic decompression sickness
- “Compressed air therapy”... used for wide range of conditions.

Early Uses for HBOT

- ✦ Dr. Almeida – Brazil, 1934
- ✦ Use of HBOT for cancer treatments
- ✦ Oxygen became the focus
- ✦ Hypothesis: malignant cells more sensitive to high oxygen levels

Early Uses of HBOT cont.

- ✦ Diving medicine – 1937
- ✦ Radiation “sensitizer” – 1950’s
- ✦ Cardiac surgery – 1950’s
- ✦ Dr. Boerema – hypothesized that large volumes of O₂ could be transported in absence of Hgb.

Physics of HBOT - Pressure

- ✦ The amount of force applied over a unit of area
- ✦ Atm = atmospheres
- ✦ ATA = atmospheres absolute
- ✦ Psi = pounds per square inch

Physics of HBOT - Gases

✦ Atmospheric air:

- ✦ 79% - Nitrogen
- ✦ 21% - Oxygen
- ✦ Trace – Carbon dioxide

✦ Oxygen:

- ✦ Colorless, tasteless, odorless
- ✦ Soluble in fluids and tissues

Oxygen Defined

- ✦ Basic chemical elements
- ✦ Colorless gas found in air
- ✦ One of the life sustaining elements on Earth
- ✦ **NEEDED BY ALL ANIMALS!**

O₂ and Respiration

✦ Human respiratory system: designed to supply O₂ to tissues

✦ Oxygen travels:

- ◆ Lungs

- ◆ Blood

- ◆ Circulation

✦ Delivery of O₂ >>> Tissues

Oxygen and Energy

- ✦ Respiratory system – series of compartments linked by circulation
- ✦ O₂ transferred from gas >>> cells
- ✦ In cell O₂ consumed by mitochondria
- ✦ “Powerhouse” of the cell – makes energy!
- ✦ Energy = work!!!

Oxygen Transport

- ✦ O₂ travels from lung >>> vessel
- ✦ RBC carries O₂ via hemoglobin (Hgb)
- ✦ Blood has large “carrying capacity”
- ✦ Good circulation + adequate Hgb = good oxygenation

Oxygen Transport cont...

✦ Blood transports O₂ via

- ◆ Hgb

- ◆ Plasma

✦ Hgb saturated...

✦ How do we increase O₂ content???

Oxygen and Plasma

- ✦ Increase O₂ content via increasing O₂ dissolved in PLASMA!!!
- ✦ Amount of O₂ in plasma ~ O₂ partial pressure
- ✦ Increase pressure = increased O₂ in the tissues

Oxygen Partial Pressures

1.0 ATM	1.3 ATM	1.3 ATM	1.5 ATM
21% oxygen	24% oxygen	100% oxygen	100% oxygen
160 mm Hg O ₂	237 mm Hg O ₂	988 mm Hg O ₂	1143 mm Hg O ₂
Arterial = 100 Mm Hg	Arterial = 149 Mm Hg	Arterial = 632 Mm Hg	Arterial = 1036 Mm Hg

O₂ Transport and HBOT

- At atmospheric pressure oxygen transport limited by oxygen binding capacity of hemoglobin (hgb is already saturated)
- Plasma carries oxygen... to areas that RBCs can not reach!!!

HBOT and the Brain

- ✦ Increases cerebral glucose levels
- ✦ Improves neuron function
- ✦ “Recovers” neurons injured by:
 - ◆ Ischemia
 - ◆ Hypoxia

Altered Perfusion in ASD

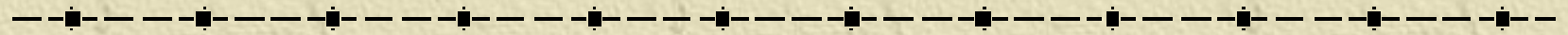
✦ Communication/social defects

- ◆ Medial prefrontal cortex
- ◆ Anterior cingulate gyrus

✦ Desire for “sameness”

- ◆ Medial temporal lobe

Perfusion Patterns



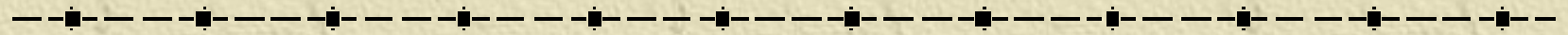
Location of abnormalities of brain function...

Underlie the abnormal behavior patterns in
ASD!

Mitochondria and ASD

-
- ✦ “Powerhouse” of the cell
 - ✦ Produces nrg in the form of ATP via ETC
 - ✦ Mitochondria have separate DNA
 - ✦ Mitochondrial DNA prone to mutations

Mitochondrial Hormesis



Short periods of stress on the body...

Causes body to adapt and improve function!

Dysfunction vs. Disease

✦ Mitochondrial disease – very rare

- ◆ Genetic defects
- ◆ Affects mitochondria profoundly

✦ Mitochondrial dysfunction

- ◆ Refers to impaired function of the mitochondria
- ◆ Very common in ASD

Signs of Mitochondrial Dysfunction

- ✦ Hypotonia
- ✦ Cognition slow
- ✦ Seizures
- ✦ Oxidative stress markers elevated

Causes of Mitochondrial Dysfunction

-
- ✦ Heavy metal toxicity
 - ✦ Pesticides
 - ✦ Hypoxia
 - ✦ Oxidative Stress

Oxidative Stress

- ✦ Electrons passed along ETC to create nrg
- ✦ Electrons “leak” >>> free radicals (Reactive O₂ species – ROS)
- ✦ Free radicals can lead to damage of:
 - ◆ Lipids
 - ◆ Proteins
 - ◆ Mito DNA

Oxidative Stress cont...

-
- ✦ Occurs when ROS can't be “quenched”
 - ✦ Increased in most chronic diseases
 - ✦ Oxidative stress leads to ... mitochondrial dysfunction

Autism and Oxidative Stress

- ✦ James, et al 2004 Am J Clinical Nutrition 80(6): 1611-7.
- ✦ Comparing ASD to neurotypical children
- ✦ Total Glutathione: 46% lower
- ✦ Oxidized Glutathione: 72% higher

Oxidative Stress and HBOT

✦ HBOT decreased oxidative stress (below 2.0 Atm)

✦ HBOT increasing anti-oxidant enzyme levels:

- ✦ Superoxide dismutase
- ✦ Glutathione peroxidase
- ✦ Catalase

Increased Oxidative Stress: Mitochondrial Dysfunction

✦ ASD

✦ Amyotrophic Lateral Sclerosis (ALS)

✦ Alzheimer's disease

✦ Parkinson's disease

✦ Huntington's disease

Effects of HBOT on Mitochondria

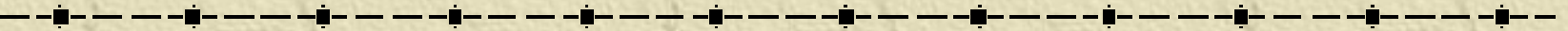
✦ Increase function of normal mitochondria

✦ Mitochondria:

- Weaker – apoptosis

- Stronger – multiply

✦ Aging – result of accumulated mitochondrial damage from ROS



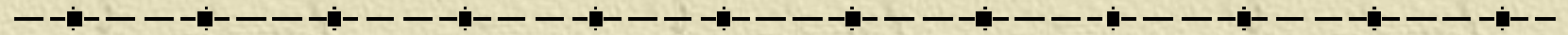
Is it the infection causing the illness...

OR

Simply an opportunistic infection affecting
people that are susceptible

Proposed Mechanisms in ASD

1. O₂ causing angiogenesis
2. Increased blood flow independent of new blood vessel formation
3. Decrease in inflammatory markers
4. Up-regulation of key antioxidant enzymes
5. Increasing O₂ to mitochondria
6. Increase production of new mitochondria



7. Improvements in immune system function
8. Decreasing bacterial load in the GI system
9. Decreasing yeast load in the GI system
10. Decreasing viral load in the GI system
11. Increased production of stem cells

HBOT and ASD

Problem	Autism Finding	HBOT Effect
Cerebral perfusion	Reduced	Increased
Inflammation	Increased	Reduced
Immune function	Reduced	Increased
Oxidative stress	Increased	Reduced
Mitochondrial function	Reduced	Increased
Neurotransmitter abnormalities	Increased	Reduced
Dysbiosis	Increased	Reduced

HBOT Indications

- ✦ Air or gas embolism
- ✦ Carbon Monoxide
- ✦ Gas gangrene
- ✦ Compartment syndrome
- ✦ Decompression sickness
- ✦ Wound healing
- ✦ Severe anemia
- ✦ Intracranial abcess
- ✦ Osteomyelitis
- ✦ Skin grafts
- ✦ Delayed radiation injury
- ✦ Thermal burns

Chinese Indications

- ✦ Coronary artery disease
- ✦ Myocardial infarction
- ✦ Myocarditis
- ✦ CABG operation
- ✦ Arrhythmia
- ✦ CHF

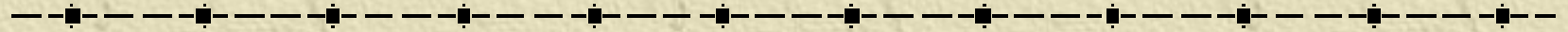
Russian Indications

-
- ✦ Heart arrhythmias
 - ✦ Cardiac insufficiency
 - ✦ Irregular heartbeats
 - ✦ Cardio-pulmonary insufficiency

“Off label” uses of HBOT

- ✦ Traumatic brain injury
- ✦ Inflammatory bowel disease
- ✦ Cerebral Palsy
- ✦ Ischemic stroke
- ✦ Myocardial infarction
- ✦ Autism
- ✦ Parkinson’s Disease
- ✦ Multiple Sclerosis
- ✦ Osteoarthritis
- ✦ Cancer
- ✦ Lyme Disease
- ✦ Dementia
- ✦ CFS/Fibromyalgia

HBOT Contraindications - Absolute



- ✦ Pneumothorax
- ✦ Severe Bronchospasm
- ✦ Specific rx meds

HBOT Contraindications - Relative

-
- ✦ Upper airway infection
 - ✦ Chronic sinusitis/otitis
 - ✦ COPD
 - ✦ H/O pneumothorax
 - ✦ H/O thoracic surgery
 - ✦ H/O ENT surgery
 - ✦ Seizures
 - ✦ Uncontrolled HTN
 - ✦ Heart failure
 - ✦ Claustrophobia

HBOT Delivery

✦ Multiplace

✦ Monoplace

✦ Hard Chamber

✦ Soft Chamber – “mild hbot”

Adverse Effects of HBOT

✦ Incidence: 5-50 per 1000 dives

✦ Injuries occur due to:

- ◆ Change in pressure
- ◆ High pressure O₂ breathing
- ◆ Environment of chamber

✦ Patient related issues

HBOT Hazards: Therapy

1. Barotrauma

- ❖ Can affect any cavity: ears, sinus, gut, etc
- ❖ Middle Ear most common - .1%-.5%

2. High Pressure Breathing: O₂ toxicity

- ❖ Seizures
- ❖ Pulmonary
- ❖ Ocular

3. Chamber Injuries

HBOT Hazards: “Patient Issues”

1. Infants/children – O₂ toxicity
2. Pregnant women - ? Effect on fetus
3. History of cancer – angiogenesis
4. Diabetes – hypoglycemia
5. Implanted medical devices
6. Rx meds: Bleomycin, Doxorubicin
7. Anxiety/claustrophobia – 5% in monoplace

Contraindications: Absolute

- ✦ Pneumothorax
- ✦ Acute severe bronchospasm
- ✦ Specific prescription medications

Contraindications: Relative

- ✦ URI
- ✦ Chronic sinusitis
- ✦ Chronic otitis
- ✦ COPD
- ✦ h/o pneumothorax
- ✦ h/o cardiac surgery
- ✦ Seizure d.o.
- ✦ Uncontrolled htn
- ✦ Heart failure
- ✦ Optic neuritis
- ✦ Claustrophobia

HBOT Factors

1. Facility

- Training
- Experience

2. HBOT Systems

- Hard chamber
- Soft chamber

3. Protocols

4. Prescription

Preparing for HBOT

- ✦ Take away what harms...
- ✦ Increase supplements: Vitamin C, GSH
- ✦ Increase mitochondrial support
 - ◆ B vitamins
 - ◆ Co Q 10
 - ◆ Carnitine

HBOT Protocols

-
- ✦ Condition specific protocols
 - ✦ Pressure
 - ✦ Oxygen level
 - ✦ Duration of dives
 - ✦ # of dives
 - ✦ Other factors