Hyperbaric Medicine, Serotonin, and Its Effect On Neuropsychological Conditions

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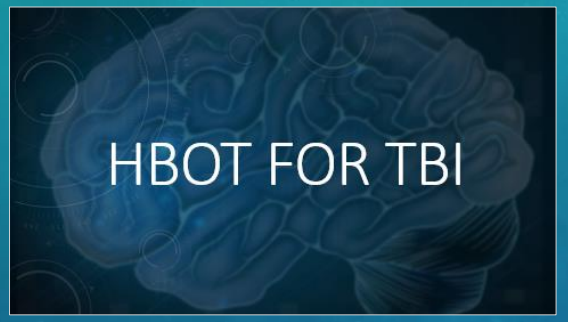
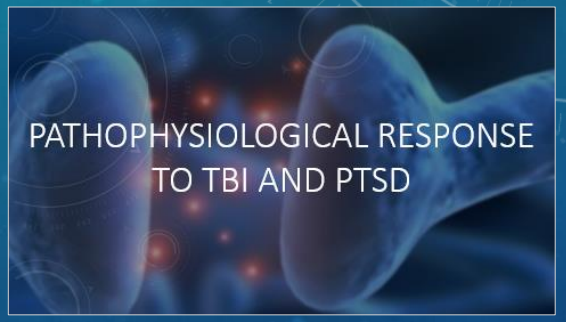
OMED - Baltimore, MD - October 26, 2019

OVERVIEW


HBOT BASIC
PHYSIOLOGICAL EFFECTS


HBOT FOR TBI


HBOT FOR PTSD


PATHOPHYSIOLOGICAL RESPONSE
TO TBI AND PTSD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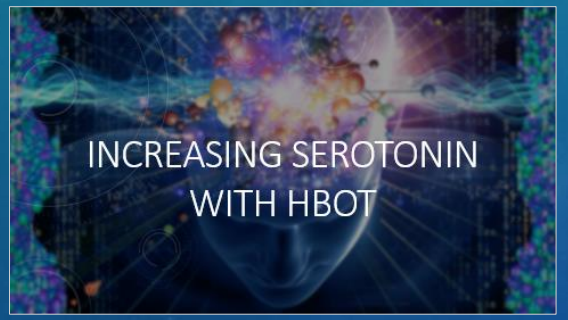
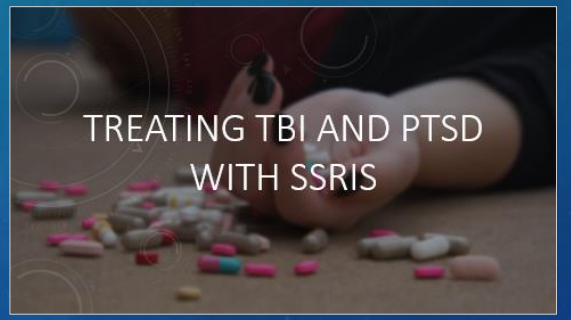
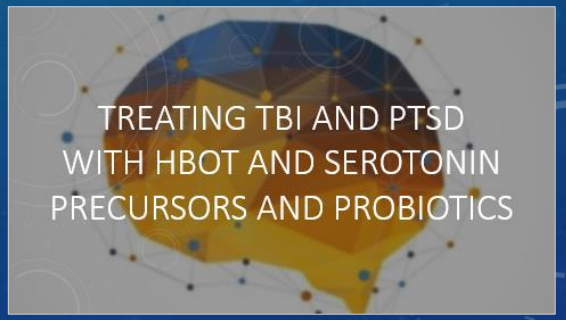
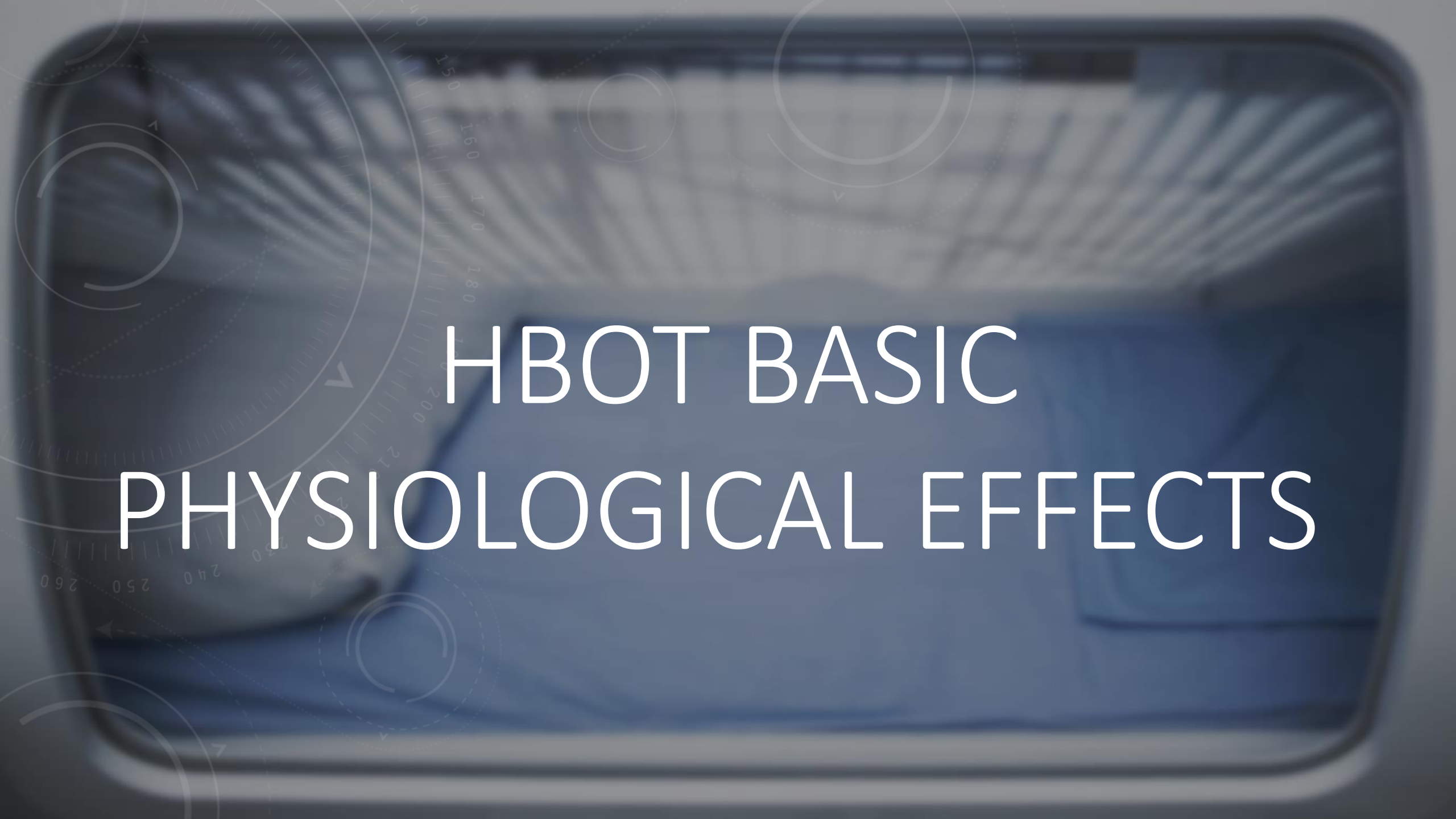
SEROTONIN AND
TBI/PTSD/DEPRESSION


INCREASING SEROTONIN
WITH HBOT


TREATING TBI AND PTSD
WITH SSRIS


TREATING TBI AND PTSD
WITH HBOT AND SEROTONIN
PRECURSORS AND PROBIOTICS

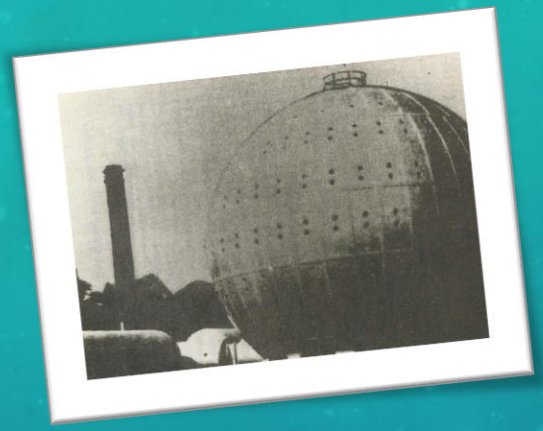


HBOT BASIC PHYSIOLOGICAL EFFECTS

HYPERBARIC MEDICINE (HBOT)
Basic Science and Standard Uses

A medical treatment in which a patient breathes 100% oxygen under increased atmospheric pressure.

- “Hyper” – more
- “Baric” – atmospheric pressure
- Hyperoxygenation – “high dose”



History

1928

Largest hyperbaric chamber constructed for various maladies

1938

Used for treatment of leprosy in Brazil

1950

Used by UK to enhance tumor radio-sensitivity

100% O2 first used in hyperbarics for decompression sickness

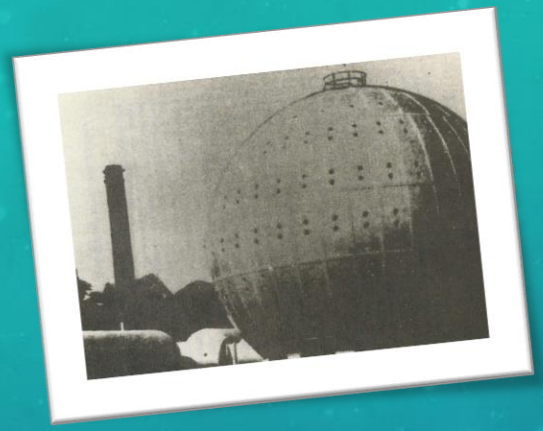
1937

Used in USA to treat experimental CO poisoning in animals

1938

Boerema proved life can be sustained in absence of blood flow

1959



History

1960s

Effectiveness shown for stoke, MS, MLS, brain ischemia, CO poisoning, gas gangrene, etc

1970s

Majority of US hyperbaric chambers were military

1980

Hyperbaric community began to develop with various organizations and certifications

1991

The National Board of Diving and Hyperbaric Medical Technology (NBDHMT) formed

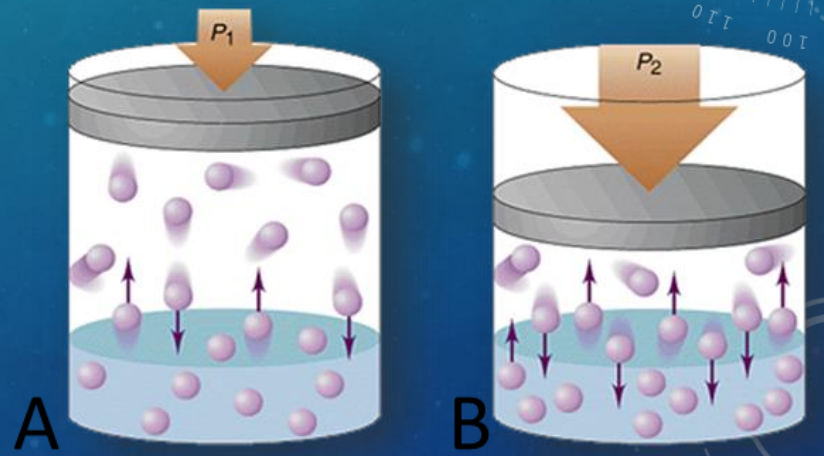
2002

International Hyperbaric Medical Association (IHMA) formed

Physics

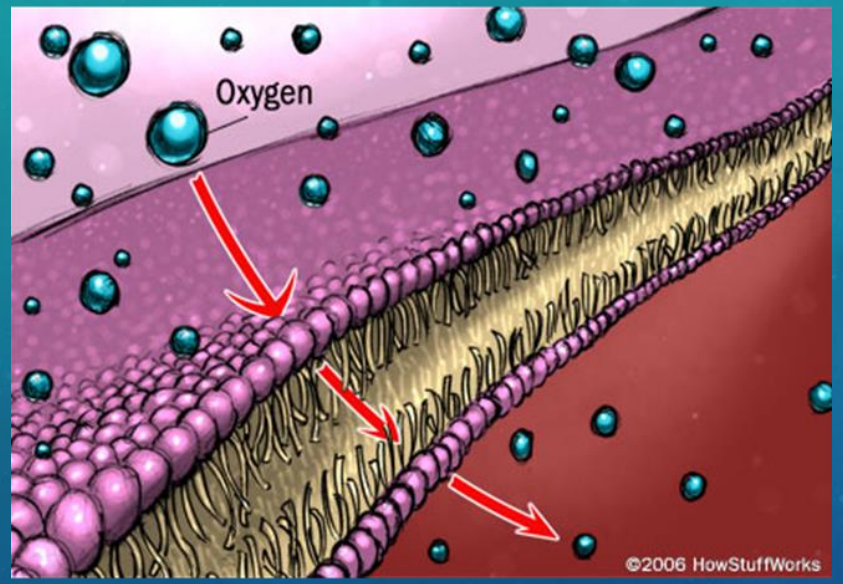
Henry's Law of Gas Solubility

- Solubility of gas in liquid is directly proportional to partial pressure of gas above the liquid
- Increasing atmospheric pressure increases amount of gas dissolved into a fluid
- Oxygen → Blood Plasma



Physiology

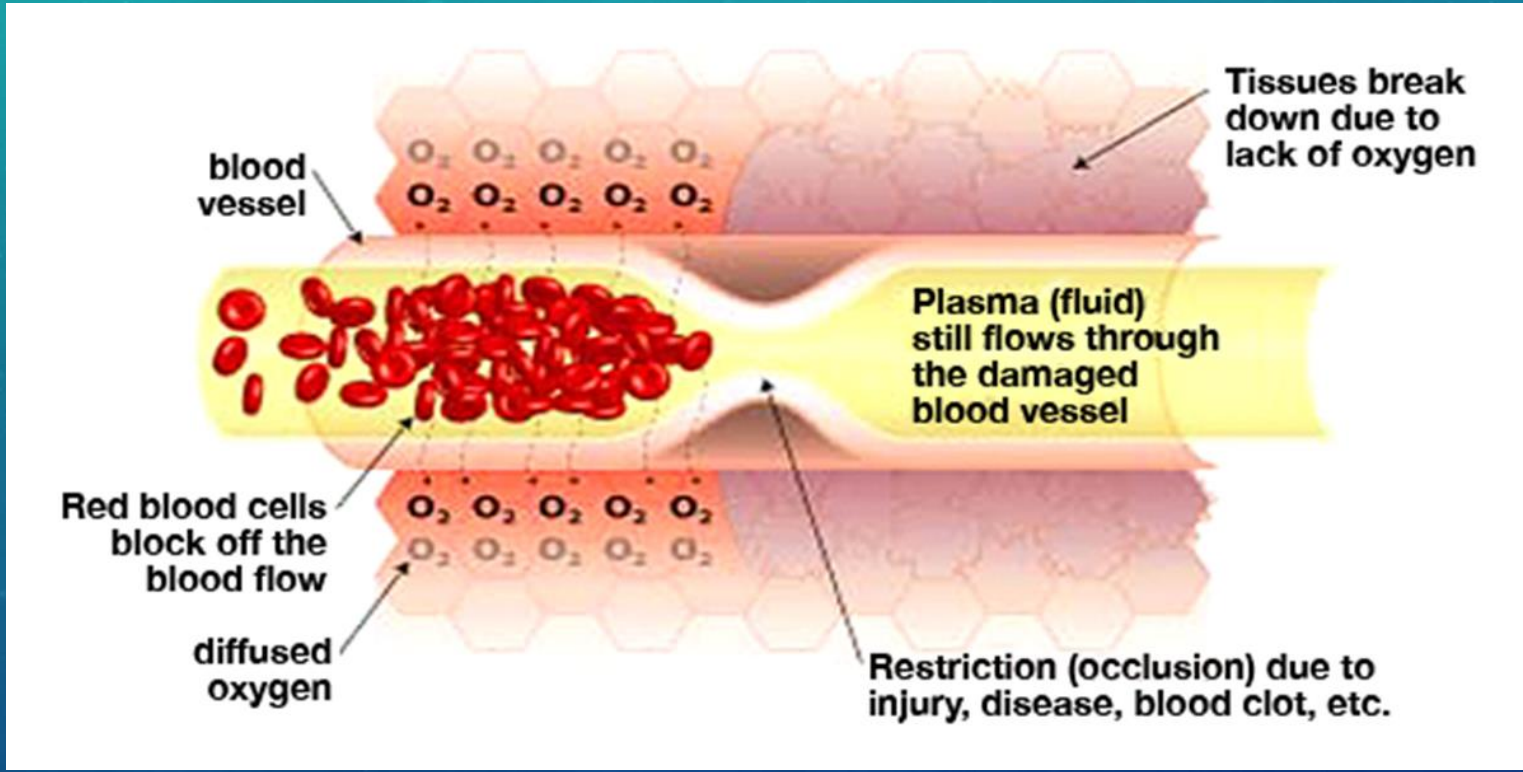
What Gets Hyper-Oxygenated?



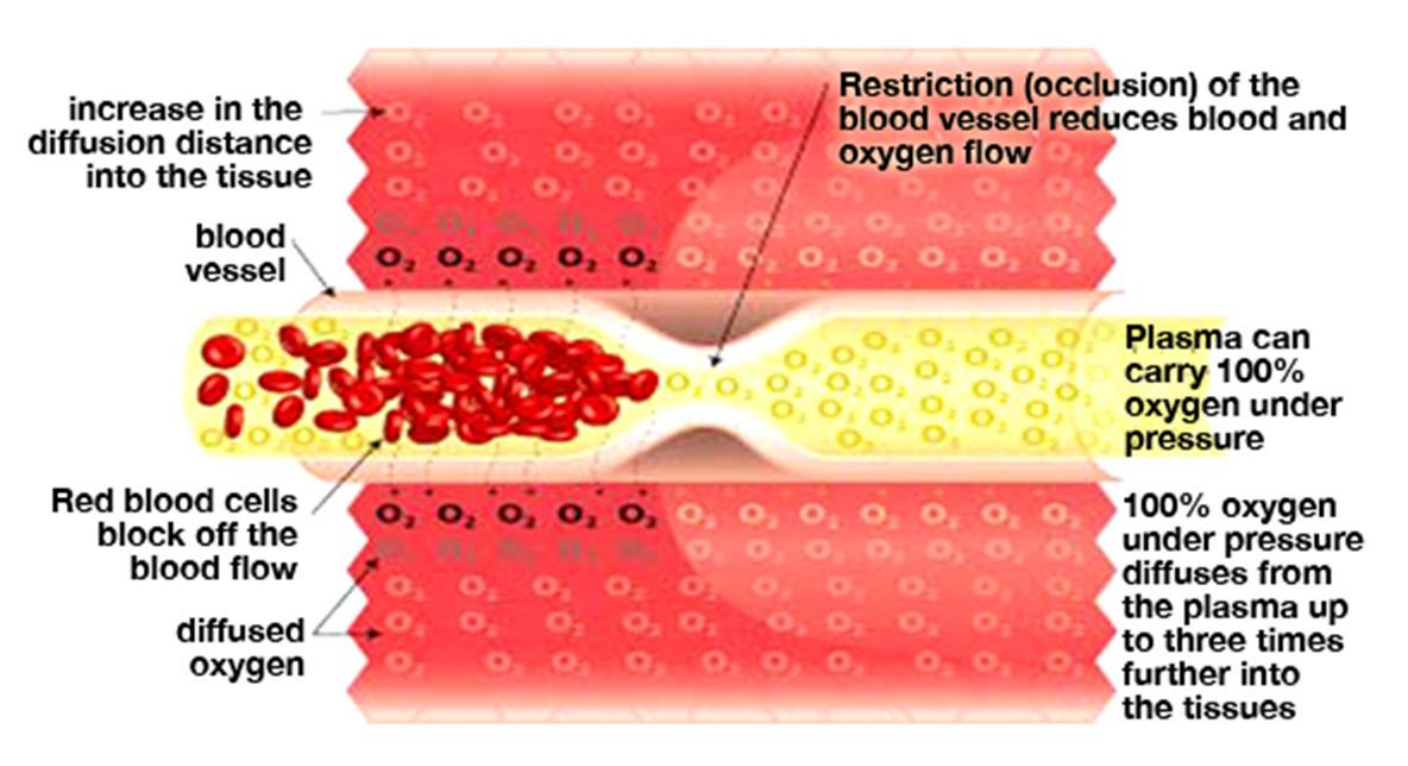
- Blood Plasma
- Cerebrospinal Fluid
- Lymph Fluid
- Clinical Hyperbaric Pressures = 7 – 22 psi
- 10–15x normal amount of O2 at 2ATA

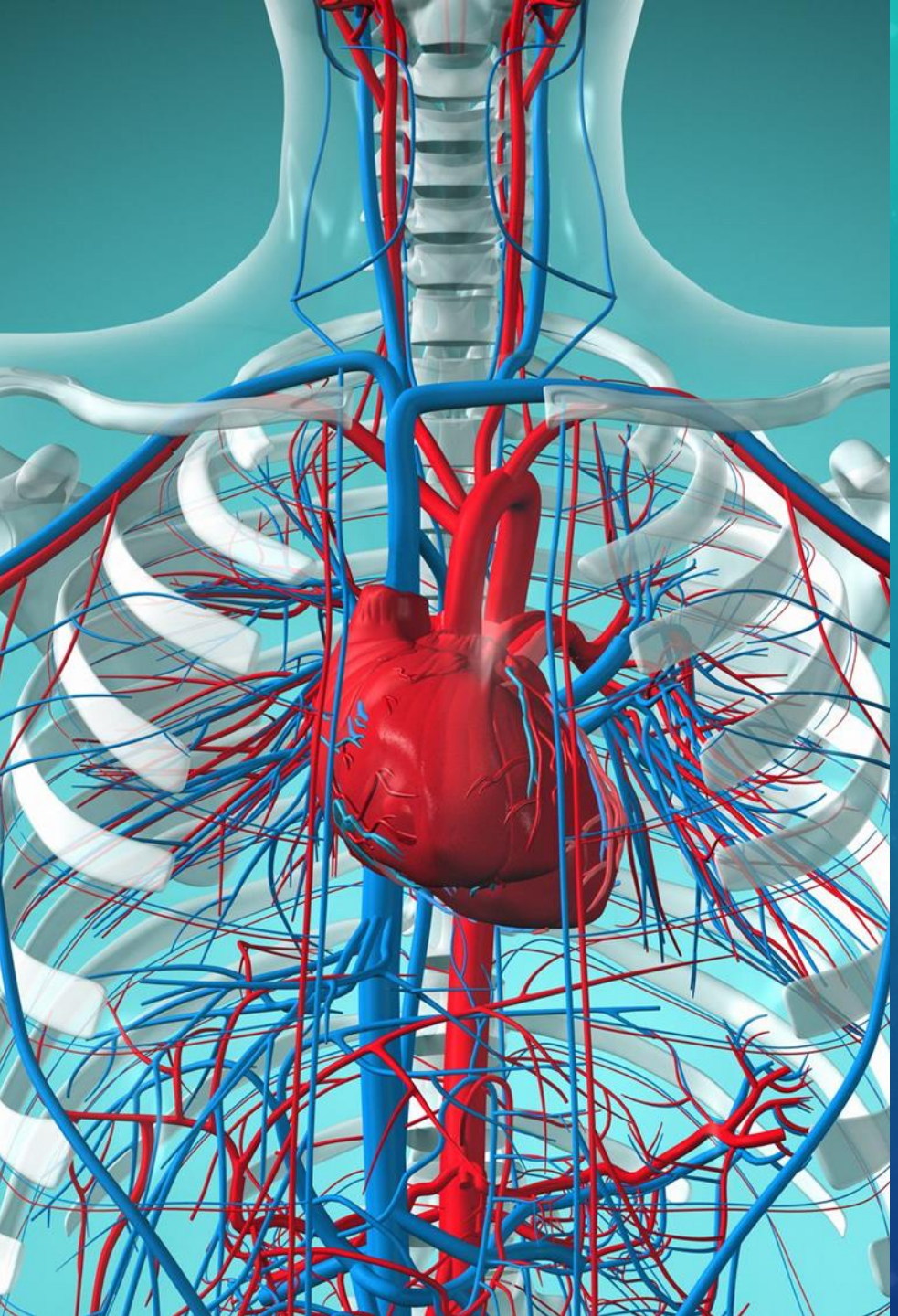
Bypasses body’s normal system of transporting oxygen

POOR BLOOD FLOW = POOR OXYGENATION = TISSUE DAMAGE



HYPERBARIC CONDITIONS





HBOT Mechanism of Action

Increases:

- Collagen synthesis (fibroblast stimulation)
- Oxygen dependent killing of bacteria (antimicrobial)
- Mitochondrial ATP production (aerobic respiration)

Decreases:

- Lactate production and tissue acidosis
- Ischemia, cell death, and inflammation
- Leukocyte adhesion and degranulation (immune modulation)

HBOT FDA-Approved

Drug that affects non-specific biological repair

Oxygen can never be a placebo

Only non-hormonal FDA-approved treatment known to repair and regenerate human tissue

High Dose Oxygen RX

FDA approved drug for specific diseases or injuries causing low oxygen levels/poor perfusion in the tissues

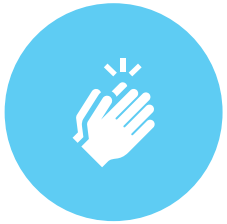
Results: Enhances and speeds up body's natural healing process

FDA-Approved Uses

Diabetic Wounds*	Osteomyelitis*	Delayed Radiation Injuries(Soft tissue/bone)*	Compromised skin grafts/flaps*	Decompression sickness
Carbon monoxide poisoning	Intracranial abscess	Acute Arterial insufficiency	Thermal burns	Crush injuries, acute trauma
	Necrotizing soft tissue infections	Exceptional blood loss anemia	Gas gangrene	

*Represent 95% of all hospital treatments

HBOT: Barriers to Access

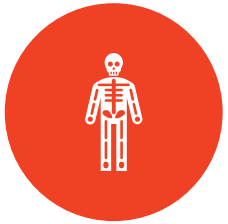


Limited number of FDA approved, insurance covered applications

HBOT is non-patentable

Research funded by nonprofits only

No patent, no development or marketing

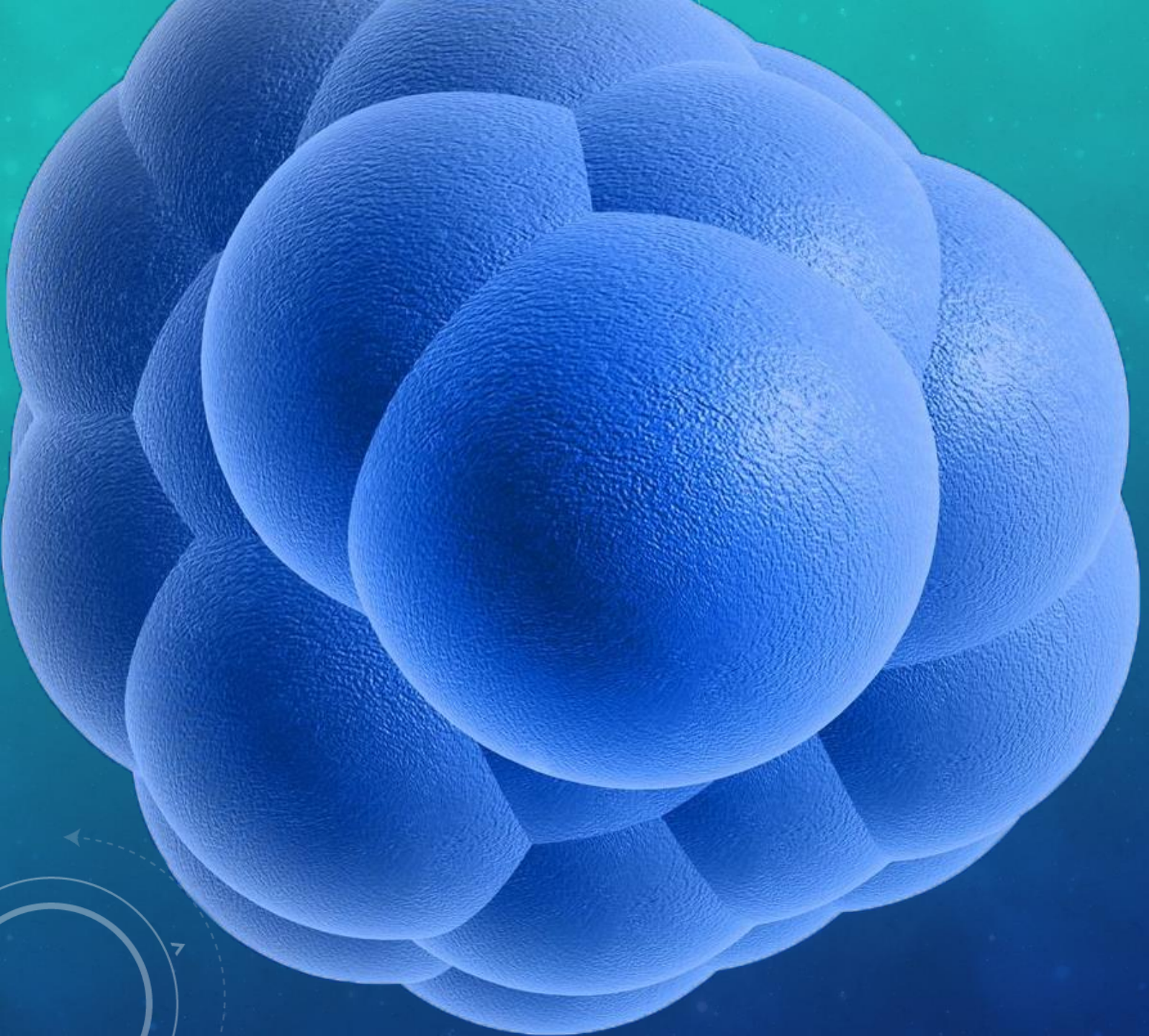


Caregivers cannot take advantage of potentially effective treatments (aka HBOT for TBI)

HBOT FOR TBI

HBOT for TBI- Mechanisms

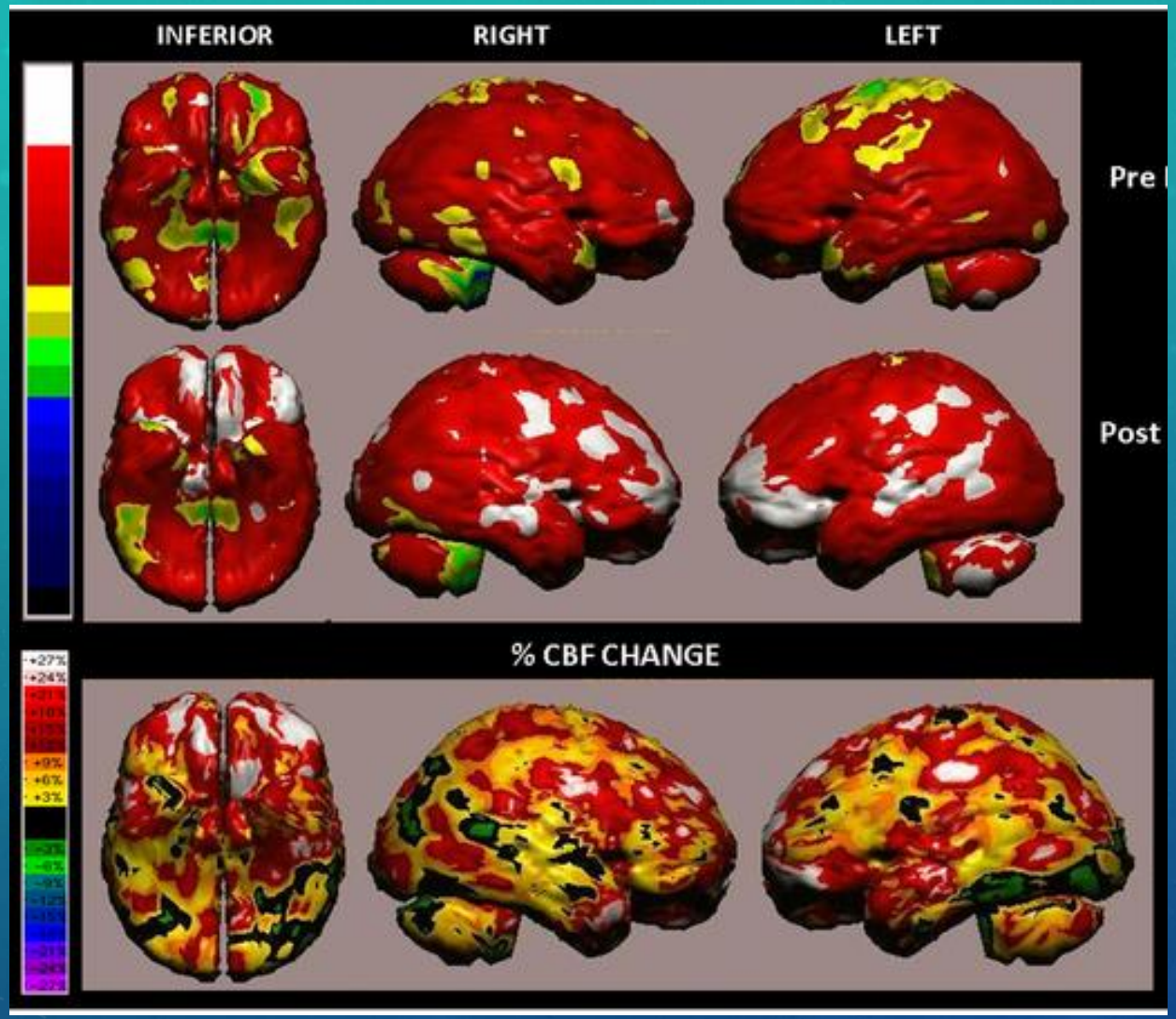
- Induces neuroplasticity
- Increases tissue oxygenation
- Generates new capillary networks
- Restores blood supply
- Increases stem cells in the blood



HBOT and Stem Cells

- 2 hours of HBOT triples the patients own circulating stem cells at 2 ATA
- 20 sessions of HBOT increases circulating stem cells to 8-fold (800%)

Thom et al., 2006



Volume Rendered Brain SPECT Perfusion Map

- 51-year-old woman
- mTBI occurred 2 years prior

Boussi-Gross et al., 2013

Acute Rat Model of Moderate TBI

- Edema decreased in hippocampus 2wks post-HBOT; measured by DWI
- Spatial learning and memory improved
- Cognitive functioning improved significantly
- **Take home: Reducing brain inflammation with HBOT improves TBI patient post-concussive symptoms**

Liu et al., 2015

HBOT FOR PTSD

PTSD: Post Traumatic Stress Disorder

Anxiety disorder triggered by exposure to a stressful event

= exaggerated response to normal and trauma-related stimuli

Concentration problems

Anxiety

Perturbed fear conditioning

Disrupted sleep

Lack of extinction of traumatic memories

Hyperarousal

Suicide ideation

Are PTSD and TBI Related?

- Symptoms of PTSD and TBI overlap
- Pathophysiological symptoms are similar:
  - Hippocampal damage is observed in both
- TBI predisposes individual to PTSD
  - PTSD can occur after TBI even if there is little or no recollection of injury

McMillan et al., 2003

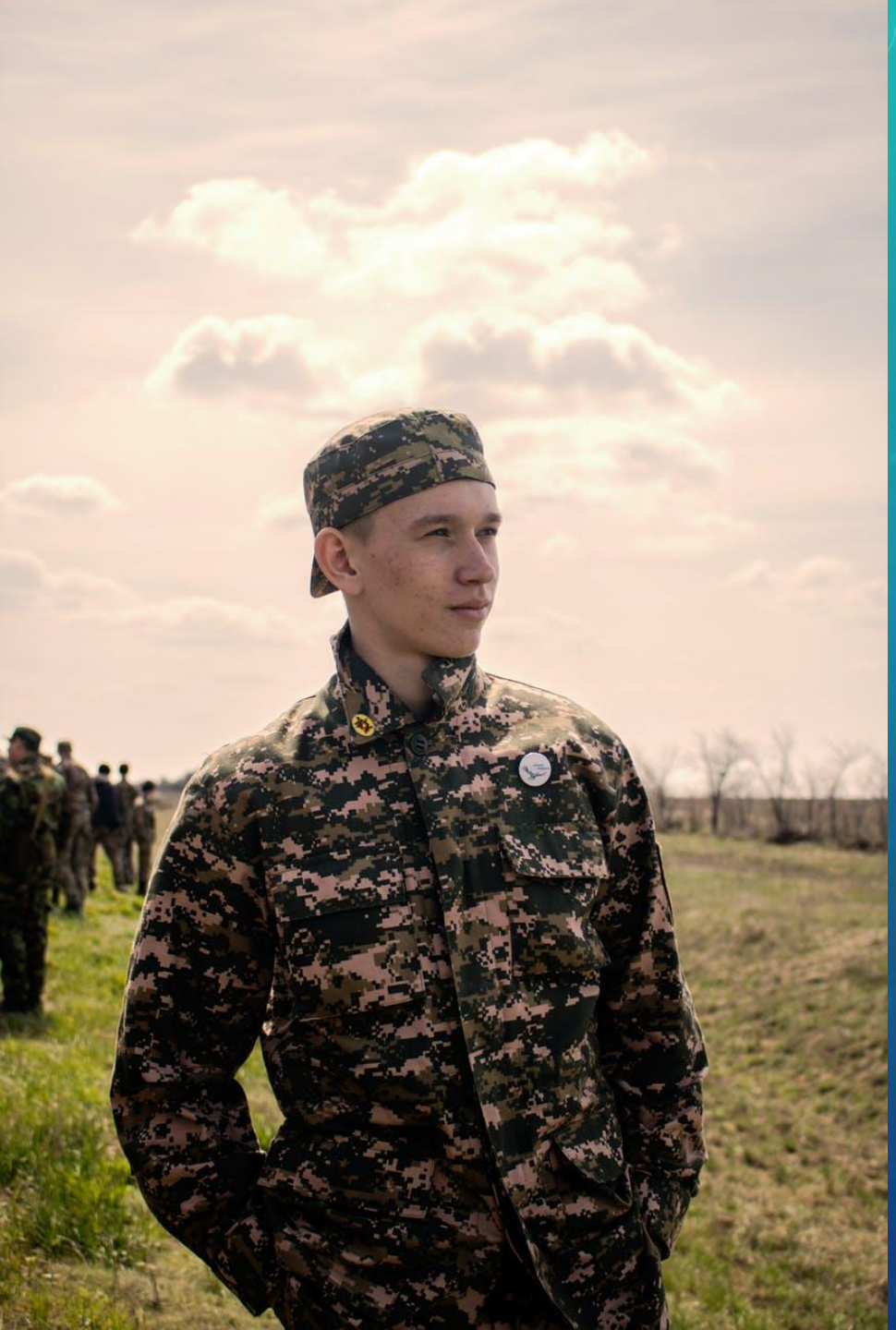
HBOT for PTSD and TBI—Treatment Mechanisms

- HBOT reduces apoptosis and inhibits inflammatory cytokines
- HBOT upregulates growth factors and antioxidant levels

Take Home:

- Similar mechanisms behind treatment benefits of HBOT for TBI and PTSD
- TBI and PTSD symptoms and treatments are synonymous

Eve et al., 2016



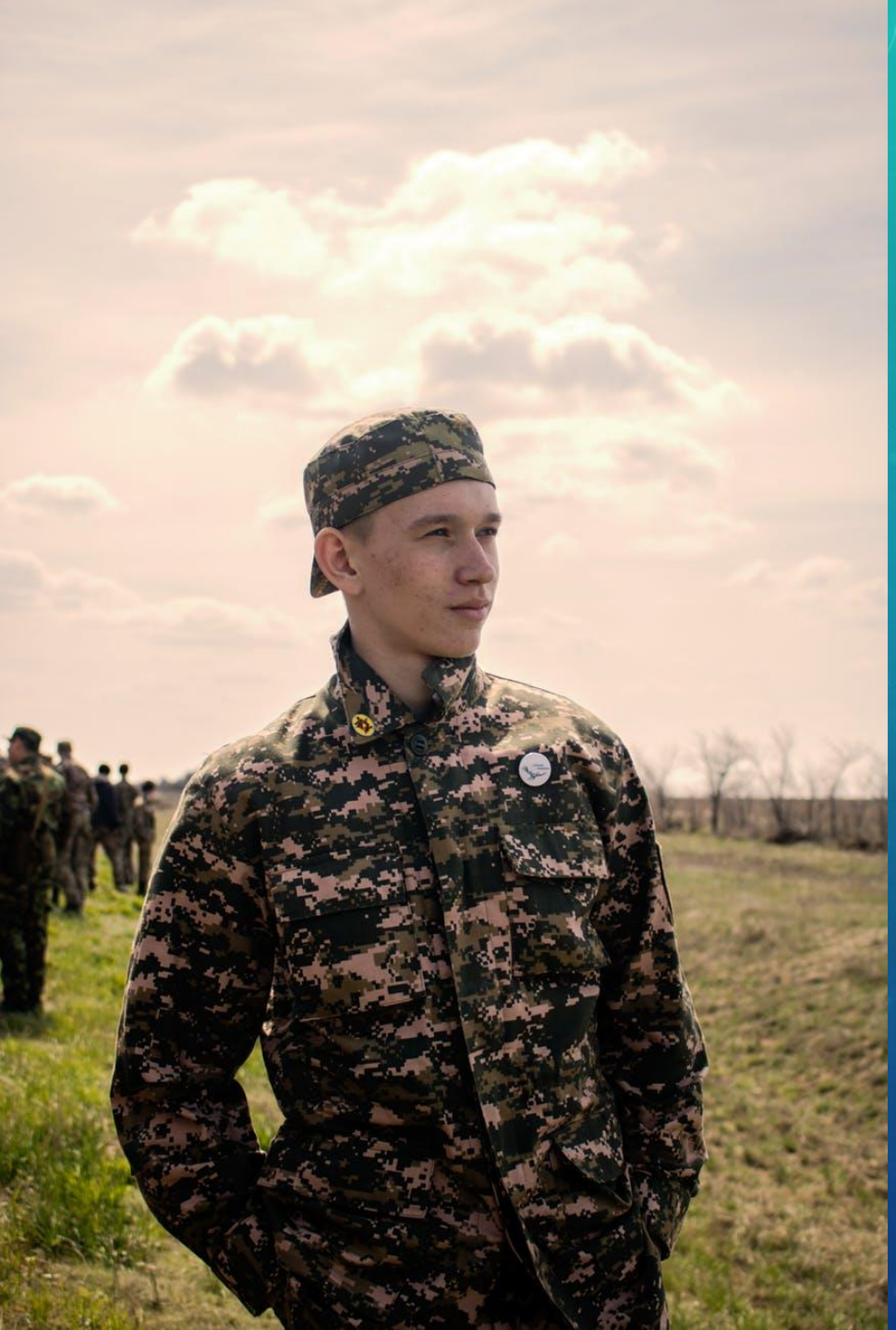
HBOT for PTSD Case Report

Participant: 25yr old male vet w/ PCS and PTSD

Diagnosis: TBI – 3yrs after LOC of several minutes from an explosion in combat

Treatment: Completed 39 HBOT treatments at 1.5 ATA

Harch et al., 2009



HBOT for PTSD Case Report

Results

Permanent marked improvement in the following:

- Post-concussive symptoms
- Physical exam findings
- Brain blood flow
- Complete resolution of PSTD symptoms

Patient returned to work with no issues

Harch et al., 2009

HBOT for PTSD and Suicidality

Participants: 30 active-duty or retired military service

Diagnosis: **Moderate/Severe TBI -** Blast TBIs with LOC

Treatments: 40 HBOT sessions 2x/day, 5x/week

Harch et al., 2017

HBOT for PTSD and Suicidality

Results

Significant improvements in the following:

- Neurological exam
- Hand motor speed/dexterity
- Quality of life
- PCS symptoms including IQ, memory, and attention
- Moods including general anxiety, PTSD, and depression
- Reduction in suicide ideation (10 of 12 patients with previous SI)

Conclusion: HBOT produces a significant drop in PTSD symptoms and suicidal ideation

Harch et al., 2017

HBOT for Blast-Induced PCS and PTSD

Participants: 16 military subjects, male ages 21–45

Diagnosis: 2.8 years post-TBI, LOC of 2 min+, PCS and PTSD

Treatments: 40 - 1.5 ATA/60 min HBOT sessions in 30 days

Harch et al., 2012

HBOT for Blast-Induced PCS and PTSD

Results

The subjects reported:

- Significant drop in depression and anxiety
- Increase in perceived quality of life
- Suicidal ideation component improved

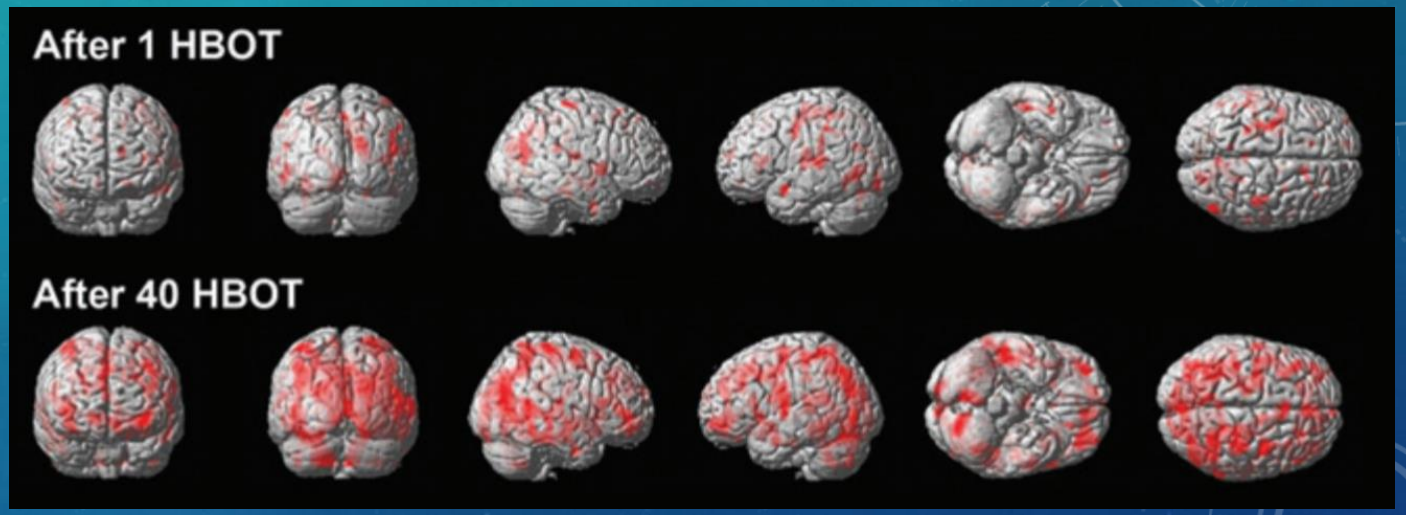
On physical exam 15 subjects:

- Significant improvements: symptoms, neurological exam, full-scale IQ, cognitive testing, PCS and PTSD symptoms
- 64% on medication decreased or discontinued their medication

Bottom Line: HBOT may be better than any medication for post-concussive mood changes in TBI/PTSD patients

Harch et al., 2012

HBOT for Blast-Induced PCS and PTSD



Harch et al., 2012

HBOT Accepted By VA

Congressman Andy Biggs and Senator Kevin Cramer Introduce the TBI and PTSD Treatment Act

- Freedom to use healthcare benefits for HBOT

Several states laws require vets with PTSD be treated with HBOT

- So far there has been no money allocated to these treatments

Cost of Treatment

- 2yr taxpayer costs w/in first 2yrs service member returns home
  - PTSD: $5,904 to $10,298
  - PTSD and major depression: $12,427 to $16,884
- 1yr taxpayer costs for TBI patients:
  - mTBI: $27,259 to $32,759
  - Moderate to severe: $268,902 to $408,519
- The above costs are not for curative therapies but simple symptom management. Patients accrue other costs in the forms disability payments, inability to work, etc.
- HBOT **cost** for 80 treatments **averages $16,000**

- **Bottom line: HBOT is a cost-effective, superior treatment to current VA SOC for TBI and PTSD vets**

From National Guardsman, Rusty Ouart…

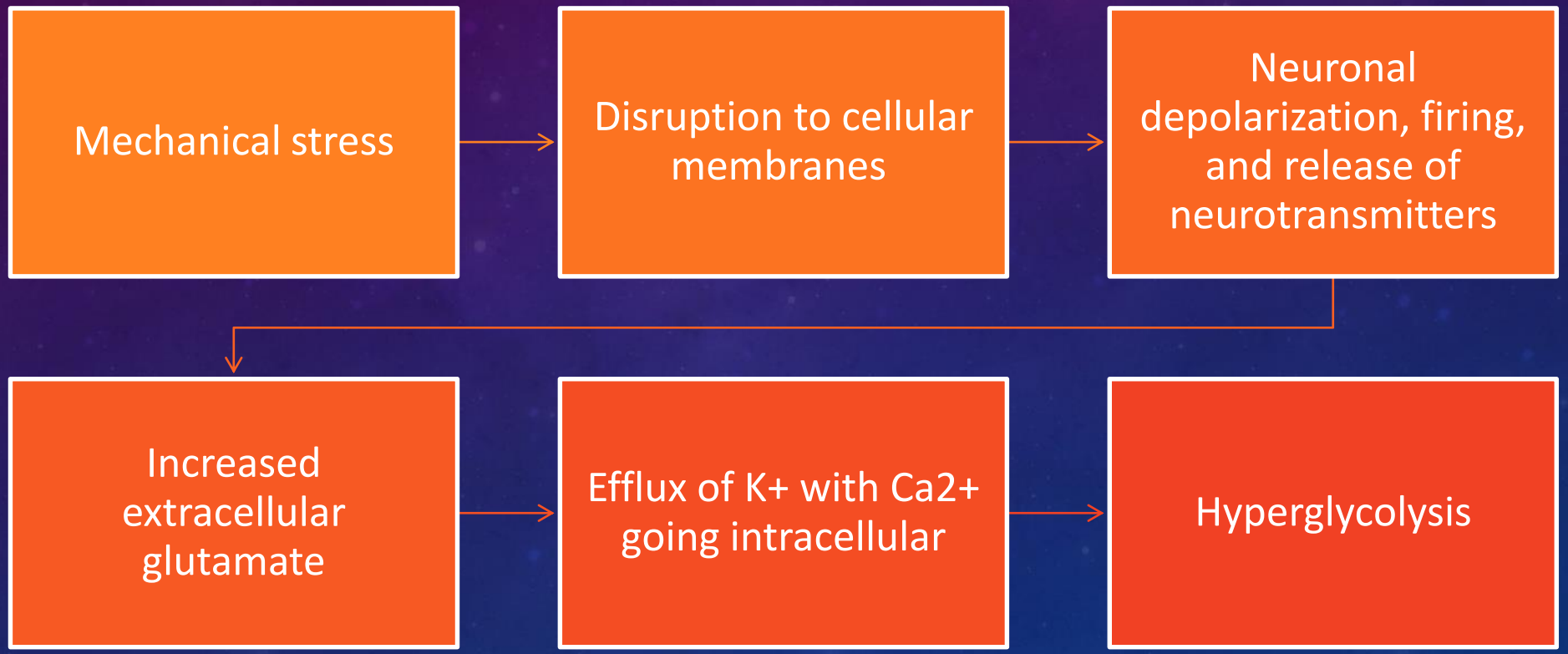
“As a TBI veteran, I received HBOT that has given me the quality of life back to enjoy time with family. My symptoms all were helped tremendously.

I have the blood flow back in my brain. The SPECT scan imaging of my brain showed that half my brain was not getting blood supply and the MRIs were all read as normal.

After HBOT, I have color in my world, and I feel like I have my life back!”

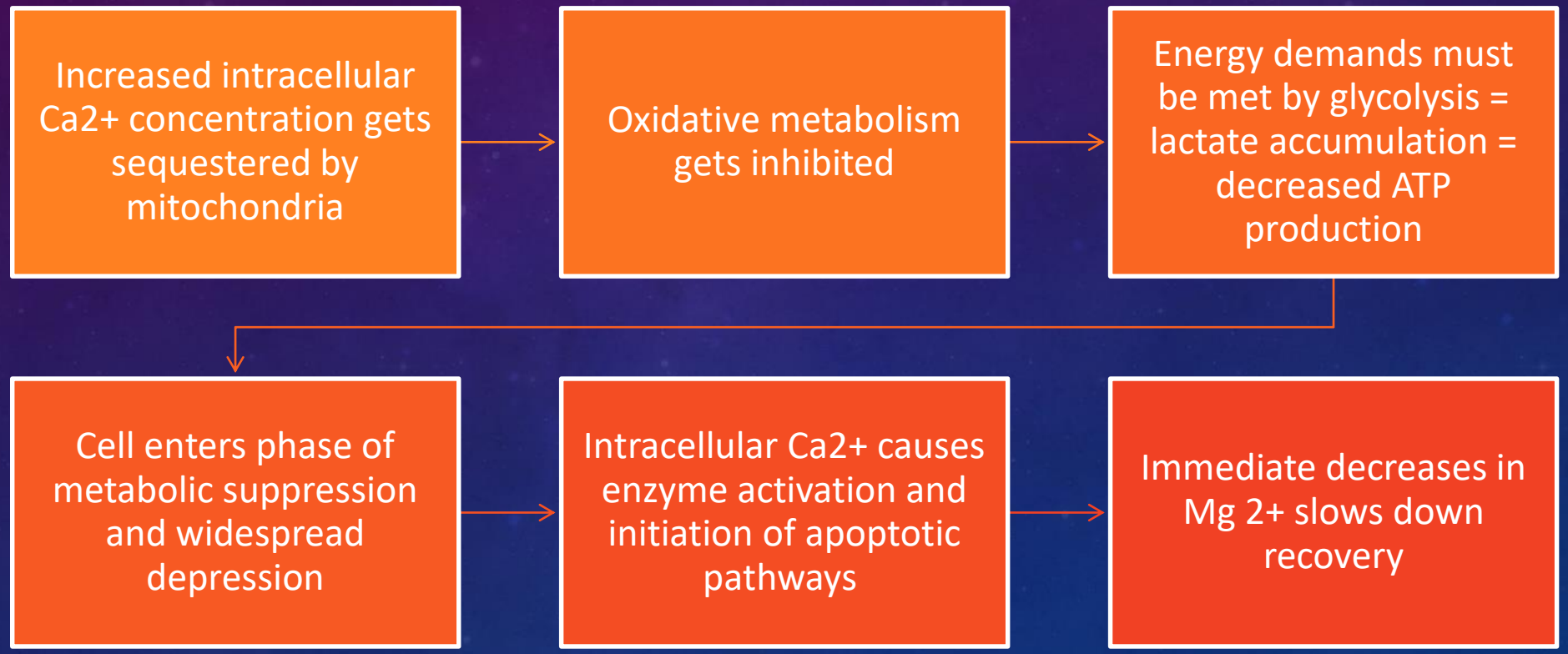
PATHOPHYSIOLOGICAL RESPONSE TO TBI AND PTSD

Neurobiochemical Cascade in TBI



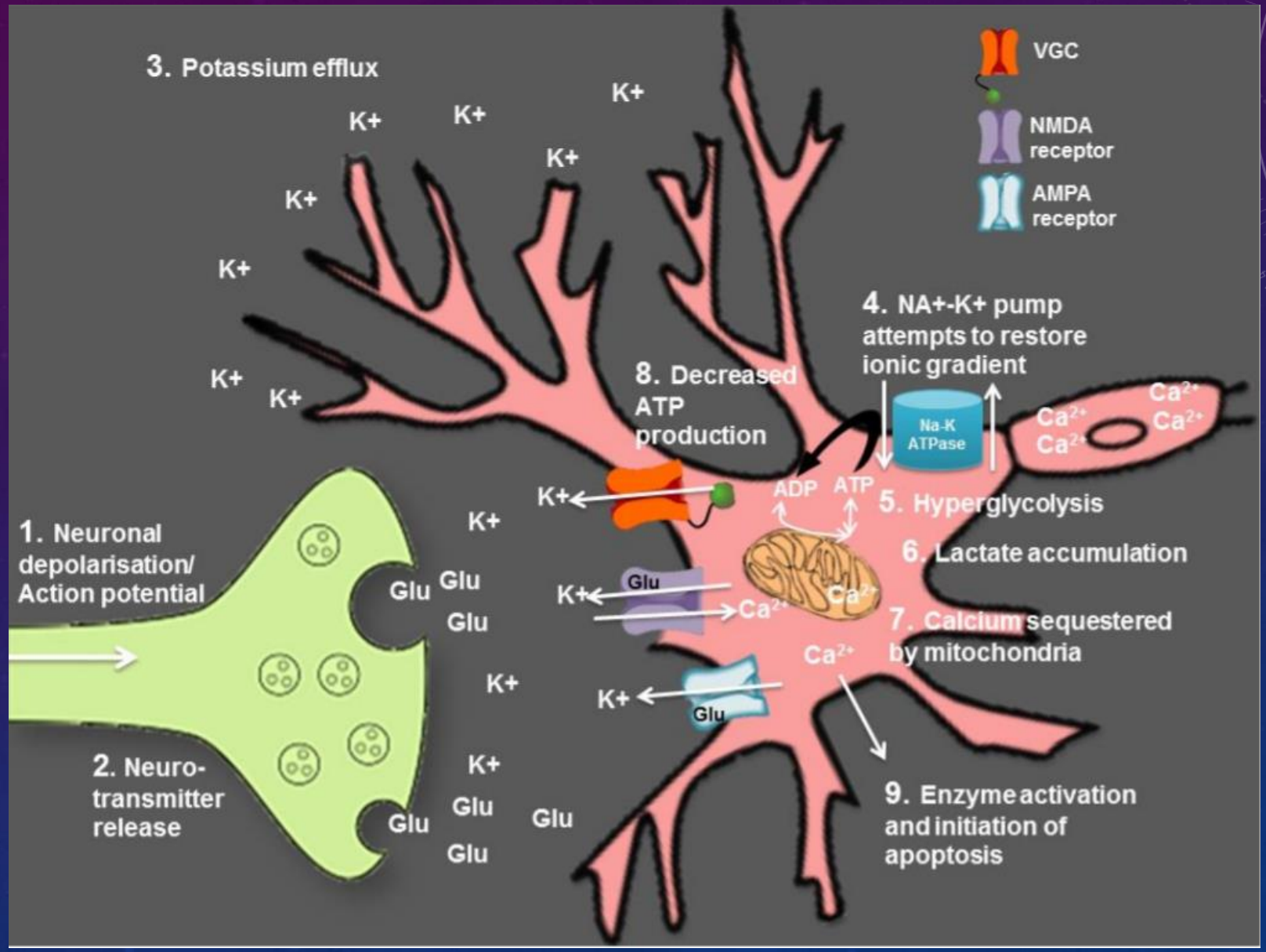
Kawa, 2017

Neurobiochemical Cascade in TBI



Kawa, 2017

Neurobiochemical Response to TBI



Kawa, 2017

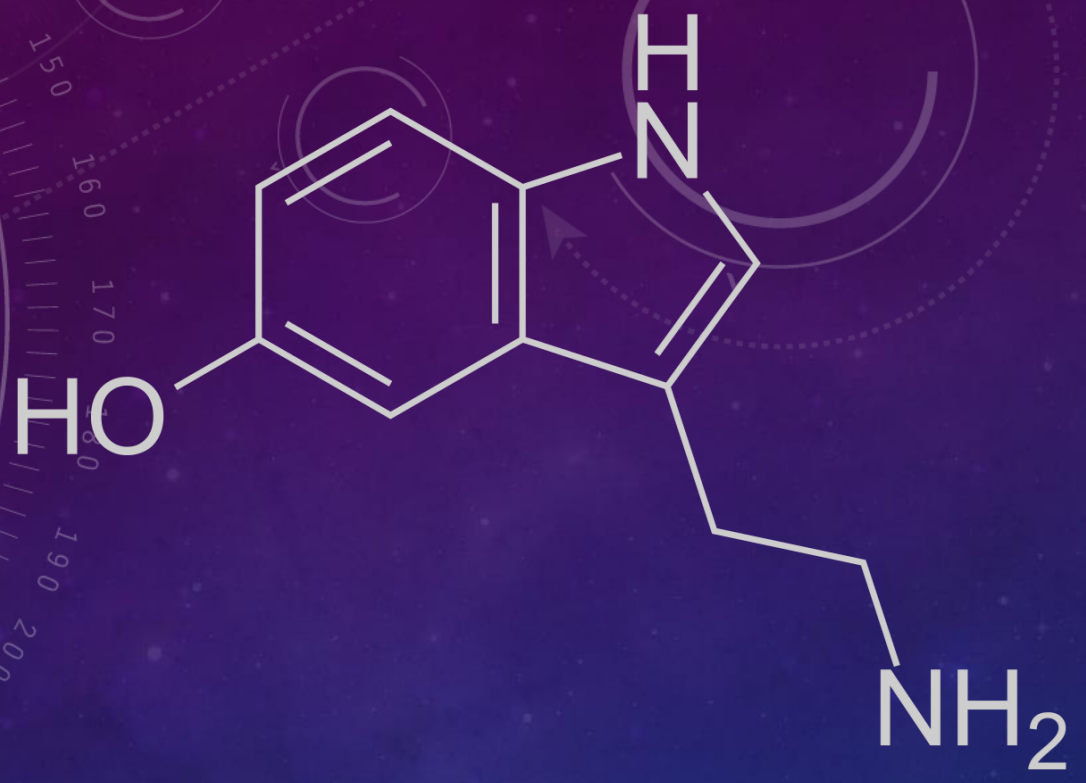
Neurobiochemical Cascade in TBI: Take Home

Disruptions in the neurobioochemical cascade of TBI lead directly to the patient's persistent emotional, cognitive, and somatic symptoms

Further support for this conclusion:

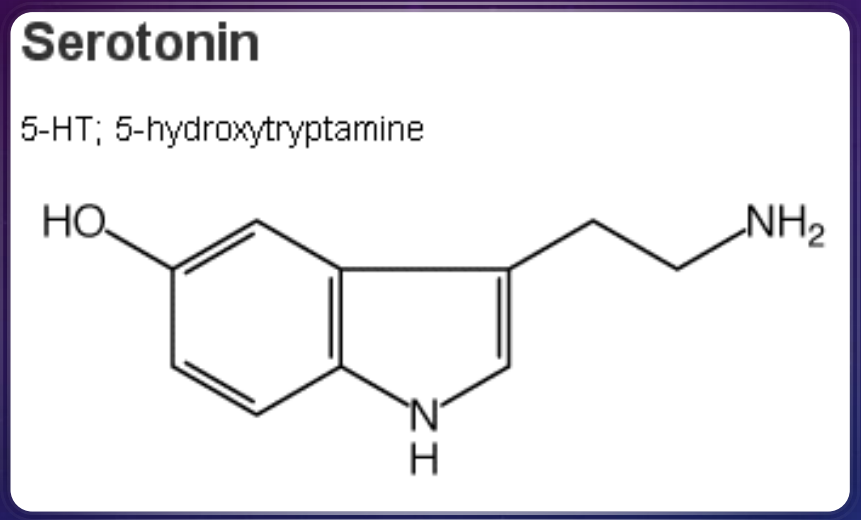
Pre-treatment of animals with magnesium results in improved post-traumatic outcomes

Kawa, 2017



SEROTONIN AND TBI/PTSD/DEPRESSION

Serotonin Transporter Protein (SERT) Levels Decreased in TBI



- Decreased SERT immunoreactivity in neuronal fibers
- Decreased SERT mRNA and protein expression
- Decreased SERT expression in the cerebral cortex
- Take Home: Decreased serotonin neurotransmission means increased depression with TBI patients

Abe et al., 2016

Serotonin (5HT) Origins and Functions

Origins and rate limiting steps:

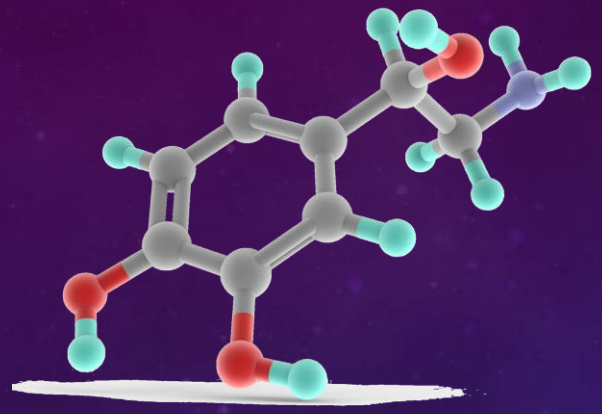
- The raphe nuclei neuron cell groups, B1-B9 are the principal neurons that give rise to spinal and extensive serotonergic forebrain projections
- These nuclei in the brain express the rate-limiting enzyme **tryptophan hydroxylase 2** for 5-HT synthesis

Functions: 5-HT regulates sleep, appetite, pain and mood.

5-HT levels are reduced in following conditions:

- Chronic stress: reduces 5-HT is found in the plasma and CSF (Gao et al., 2008)
- Depression: Decreased 5-HT transporter binding in post-mortem brains of depressed patients (Maes et al., 1995)
- "5-HT plays a role in stress and PTSD—possibly modulating the “fight-or-flight” response." (McAllister, 2011)

Abe et al., 2016; Gao et al., 2008; Maes et al., 1995; McAllister, 2011



Neurotransmitter Systems Post-TBI

- TBI increases noradrenaline levels (and other catecholamines)
  - Increasing inflammation in the forebrain
  - Increasing anxiety-like behavior
- TBI decreases the serotonin metabolite 5-HIAA in pre-frontal cortex

Bottom Line:

- ↑ catecholamines + ↓ 5HT metabolism = PTSD (internal anxiety with poor ability for patient to manage)

Kawa et al., 2015

Neurotransmitters Going Awry Post-TBI

Cholinergic excess:

- Amplifies destructive effects of excitatory amino acid excesses

Cerebral monoaminergic excesses:

- Initially induced elevations of certain cerebral monoamines
- Leads to decreased cerebral glucose use
- Results in a metabolic crisis that characterizes TBI

McAllister, 2011

Neurotransmitters Going Awry Lead to Metabolic Crisis

"The brain is in a **metabolic crisis** with concussion… potassium ion from inside the cell going extracellularly, calcium ions going intracellularly, neurotransmitters widely released in a **chaotic manner.**

It takes **energy** to pump that potassium back, put the neurotransmitters back on so the cell can function."

Dr Robert Cantu, MD, 2013

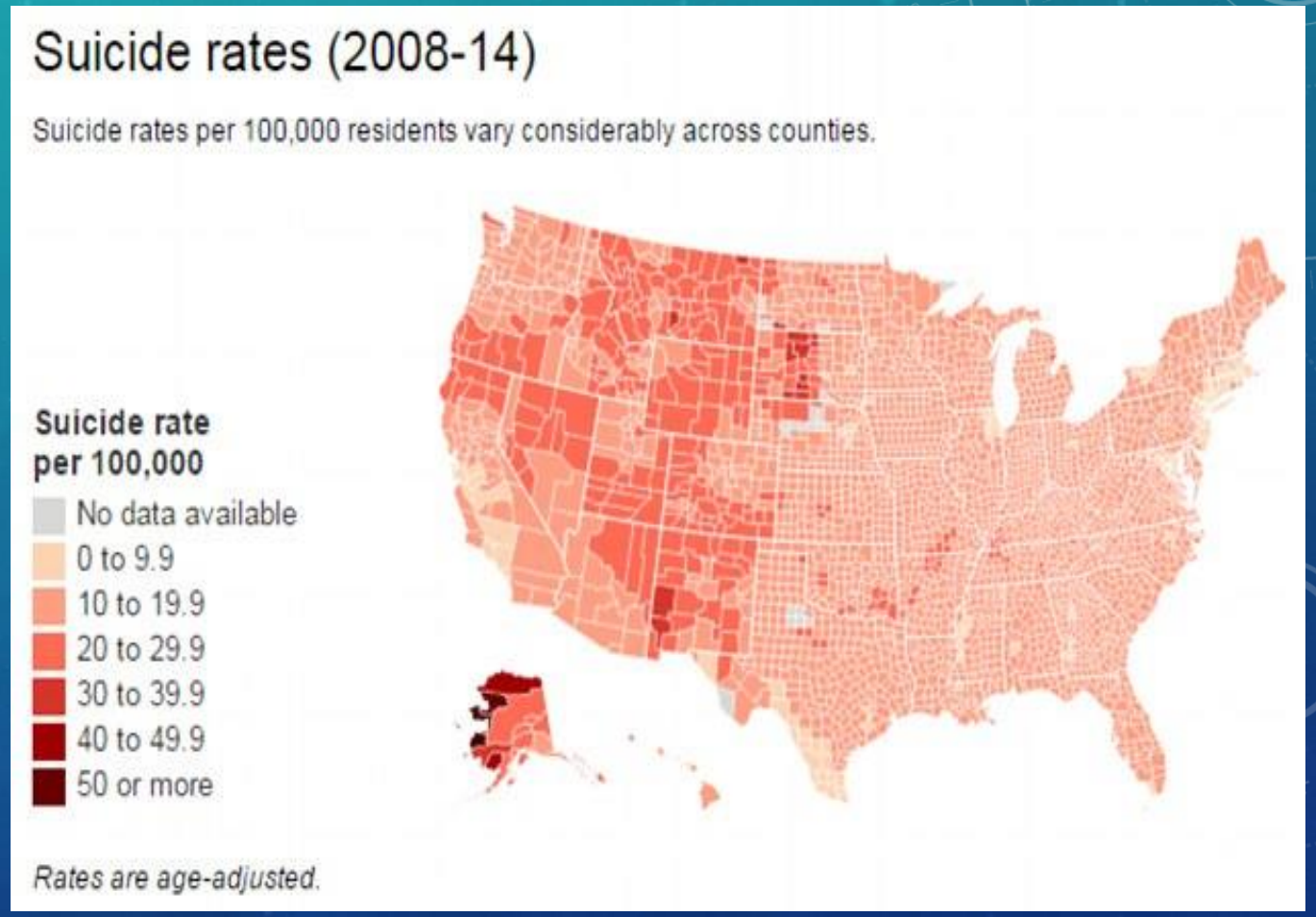

INCREASING SEROTONIN
WITH HBOT

What Raises Excitatory Neurotransmitters and Lowers Serotonin?

- **ALTITUDE**
- Low oxygen = low serotonin
- High altitude = high dopamine

- 25% of variation in rates of suicide could be uniquely attributed to altitude
- “With lower oxygen, the brain doesn’t make as much serotonin.”

  Perry Renshaw, Phd.



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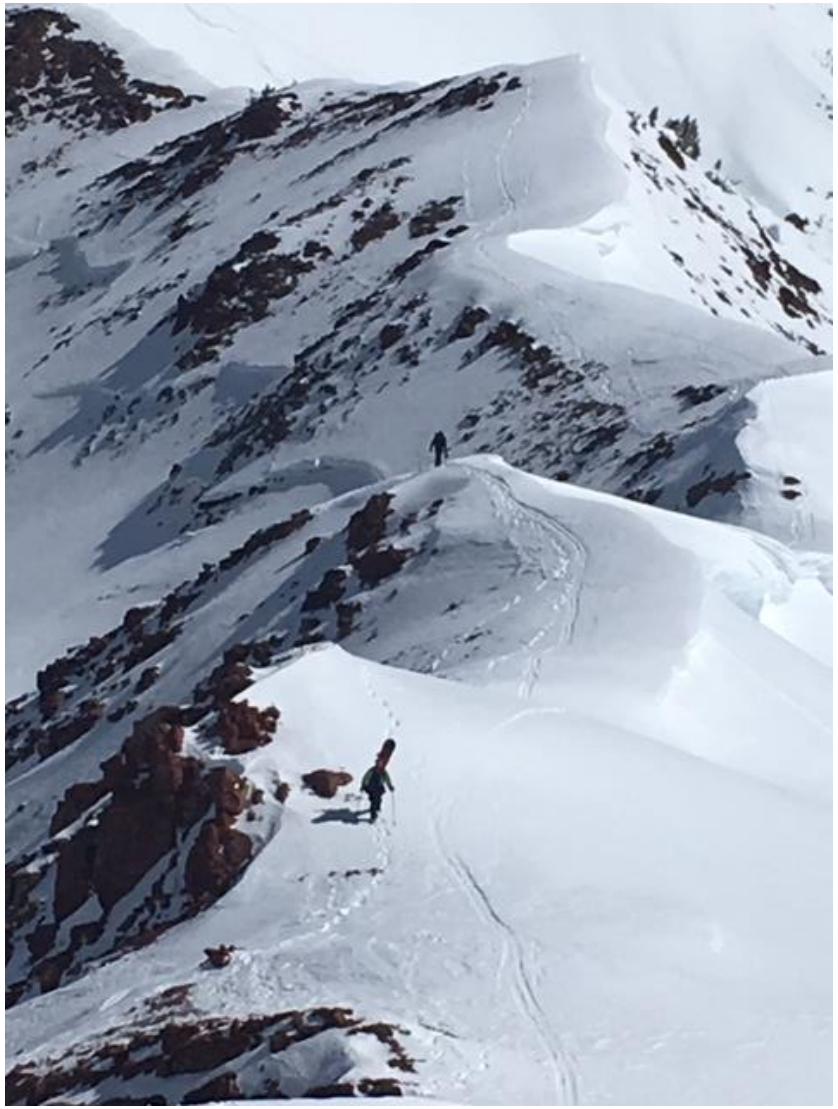
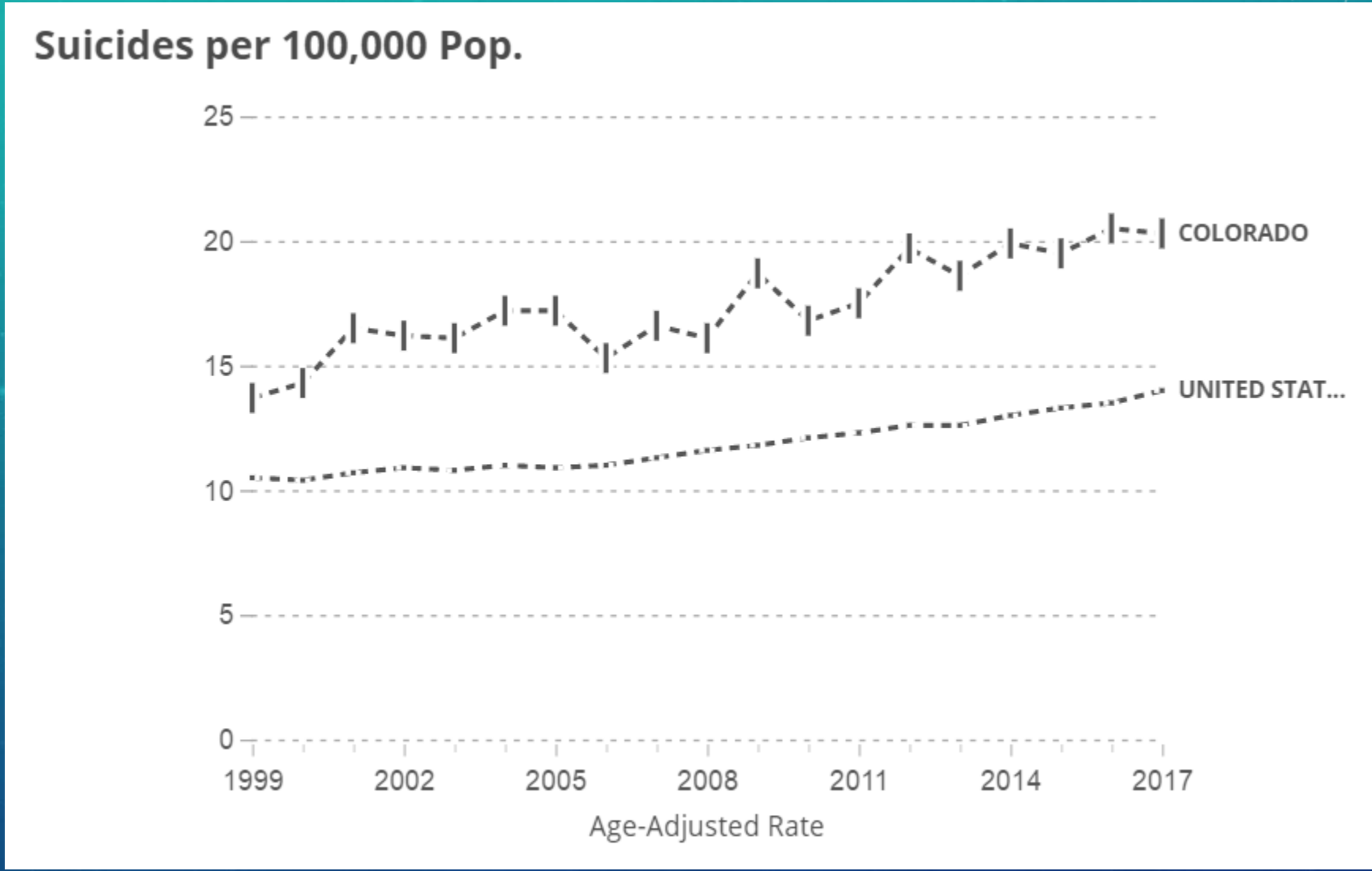
Kious et al., 2019



Suicide and Altitude



https://www.livestories.com/statistics/colorado/pitkin-county-suicide-deaths-mortality

Inhaled Oxygen Increases Serotonin

Participants: Six healthy participants (3 male, 3 female) breathed a 15% or 60% oxygen mixture 15 min before injection of tracer and during acquisition period

Observations: Two sets of PET images were acquired

- Before and after each of the oxygen mixtures and after reconstruction
- All images were converted into brain functional images illustrating the brain trapping constant K(*) (microL/g/min).

Results: Highly significant increases (50% on average) in brain serotonin synthesis (K(*) values) at high (mean value of 223+/-41 mmHg) relative to low (mean value 77.1+/-7.7 mmHg) blood oxygen levels

Nishikawa et al., 2005

Serotonin Increased by Oxygen: Conclusions

- Increasing blood oxygen increases 5-HT synthesis in brain
- Tryptophan hydroxylase 2 is not saturated with oxygen in brain
- Take Home: Inhaled oxygen (60%) over a short period of time rapidly increases serotonin levels in comparison to 15% inhaled oxygen
- Other studies: Support that hyperbaric medicine increases serotonin (Silliphant, 2017)

Nishikawa et al., 2005; Silliphant, 2017

PTSD and Serotonin: New Directions for Research and Treatment

Serotonin dysfunction linked to pathophysiology of symptoms of PTSD

Higher CSF **serotonin** metabolites inversely correlate with **impulsive behavior and severe aggression**

Fluoxetine has the most published data and has been used for PTSD **symptoms**

Are SSRI's safe for TBI/PTSD?

Davis et al., 1997

TREATING TBI AND PTSD WITH SSRIS

SSRIs for TBI and PTSD: Danger

- Only modestly effective in reducing symptoms of severe depression
- Increase brain's susceptibility to mood disorders after discontinuation
- Causes mature neurons to revert to an immature state and neuronal apoptosis
- **Take Home: SSRI's deplete both catecholamines and serotonin leading to neuronal degeneration and death—DO NOT USE SSRIs FOR TBI/PTSD**

Delgado et al, 2002; Wilson and Hamm, 2002

SSRI Warnings for TBI/PTSD Patients

- “The epidemic of suicides amongst military veterans is most likely due to cocktail of antidepressants. None of which are approved for treating TBI.”

- “Antidepressants increase the risk of suicidal thinking in short-term studies of major depressive disorder (MDD) and other psychiatric disorders. Anyone considering the use of any antidepressant must balance this risk with the clinical need.” –FDA warning

- Bottom Line: For TBI/PTSD patients, SSRI's = SI (suicide ideation) and depression
  - **DO NOT USE SSRIs FOR TBI/PTSD**

Delgado et al, 2002; Wilson and Hamm, 2002

Effects Of Fluoxetine on the 5-HT1A Receptor

Objective

- View effects of chronic administration of fluoxetine on cognitive performance and 5-HT1A receptor immunoreactivity following TBI

Design

- Rats received a moderate severity of lateral fluid percussive injury or sham injury 24 h after surgical preparation.
- Fluoxetine or vehicle was administered chronically on postinjury days 1–15.

Wilson and Hamm, 2002

Effects Of Fluoxetine on the 5-HT1A Receptor

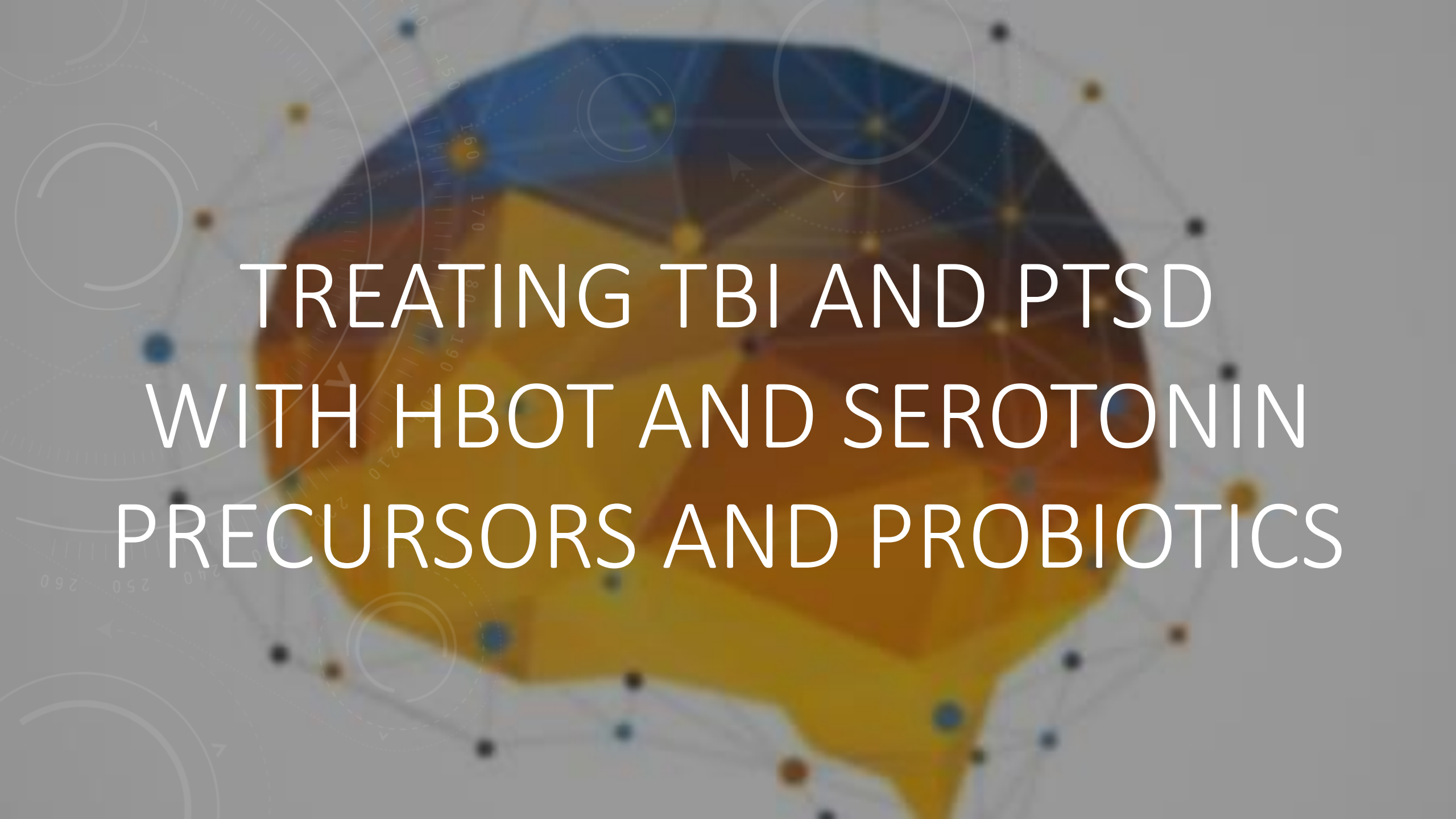
Results

- Chronic fluoxetine treatment did not affect motor or maze performance.
- Injured groups showed significantly higher 5-HT1A receptor immunoreactivity
- Fluoxetine treatment did not alter 5-HT1A receptor immunoreactivity

Conclusions

- Chronic postinjury fluoxetine administration did not influence recovery
- Injury-induced changes in the 5-HT1A receptor may contribute to TBI–induced cognitive deficit
- **Bottom Line: SSRIs such as fluoxetine do not increase serotonin levels long-term and have great risks for TBI/PTSD patients**

Wilson and Hamm, 2002



TREATING TBI AND PTSD WITH HBOT AND SEROTONIN PRECURSORS AND PROBIOTICS

Treating TBI and PTSD with Tryptophan Diet

- **Serotonin levels enhanced by carb ingestion**
  - Insulin release accelerates the serum removal of competing valine, leucine, and isoleucine
  - Increased protein in diet slows serotonin elevation so a strict Keto paleo diet is not the best
- **Tryptophan hydroxylase is the rate-limiting enzyme for serotonin production so serotonin levels are directly on bioavailable tryptophan**
  - Converts Trp to 5-HTP
  - Trp plentiful in chocolate, oats, bananas, dried dates, milk, cottage cheese, meat, fish, turkey, and peanuts.

Take Home: Along with turkey ingestion, a diet with some healthy carbs can improve oral tryptophan assimilation

Thorne Research. Retrieved October 12, 2019 http://www.altmedrev.com/archive/publications/11/1/52.pdf

Oral Ingestion of Tryptophan for TBI/PTSD

- Daily nutritional requirement for L-tryptophan (Trp) = 5 mg/kg
  - Most adults consume much more, up to 4–5g/d (60–70 mg/kg)
  - Ingesting L-Trp raises brain tryptophan levels and stimulates its conversion to serotonin in neurons
- Side effects at higher doses (70–200 mg/kg), include tremor, nausea, and dizziness, with a drug that enhances serotonin function (e.g., antidepressants)
- **Tryptophan can be taken as supplement (used for 50 years now)**
  - Risks: “serotonin syndrome” occurs - too much serotonin stimulation when Trp combined with serotonin drugs
  - Symptoms include delirium, myoclonus, hyperthermia, and coma
- **Tryptophan supplement dosing: Should be individualized for each patient**

Fernstrom, 2012

Oral Tryptophan (Trp) Can Increase Serotonin in Brain

- Variations in Trp concentrations in the brain found to modify the rate of 5HT synthesis in and release by neurons
- **5HT synthesis falls when brain Trp declines**
- Trp is a large neutral amino acids (LNAA) and competes with other LNAA for a shared, competitive transporter across the blood-brain barrier
- Raising plasma levels of the LNAA (other than Trp) reduces Trp transport into the brain and lowers brain (and CSF) Trp concentrations

Fernstrom, 2012

IV L-Tryptophan

- IV Trp infusion moderately increases in prolactin and GH concentration
- Subjects report feeling significantly more 'high', 'mellow', and 'drowsy' following IV Trp infusion

Charney et al., 1982

IV L-Tryptophan Study

- L-tryptophan at doses of 75 and 100 mg/kg were compared with normal saline
- **Results:** ECG showed a significant increase in slow-wave activity and a trend toward decreased fast-wave activity
- 100 mg/kg infusion produced a 40-fold increase in free tryptophan and an 8-fold increase in the bound form.
- Some impairment of a motor speed task was also noted.
- **Take Home: IV L-tryptophan can be used to improve moods and possible TBI/PTSD symptoms**

Greenwood et al., 1974

L-Tryptophan More Studies Needed

The dose of Trp required to raise brain 5-HT levels is controversial.

Brain 5-HT levels elevated after Trp administration in different intensities, dependent of the brain region evaluated and the time of administration.

Further studies needed to assess dose-response of Trp administration to brain 5-HT levels.

Carneiro et al., 2018

Serotonin in the Gut

- Microbes can also alter availability of tryptophan - amino acid building block required for serotonin production
- After synthesis in intestinal enterochromaffin cells, serotonin is stored in platelets and released upon stimulation
- Estimated that 90% of the body's serotonin is made in the digestive tract
- Beneficial microbes produce short-chain fatty acids like butyrate that influence production of serotonin in enterochromaffin cells
- Take Home: A healthy gut microbiome leads to increased serotonin levels

Banskota, Ghia, and Khan, 2019

Probiotics Help Depression

- Gut probiotics play a major role in the bidirectional communication between the gut and the brain.
- Probiotics may be essential to people with depression - a metabolic brain disorder.
- **Meta-analysis showed that probiotics significantly decreased depression and psychological stress**
- *Lactobacillus* increases expression of SERT

Huang, Wang, and Hu, 2016

Increased Mean Platelet Volume and Lower Levels of Generalized Anxiety Disorder

OBJECTIVE:

- Mean platelet volume (MPV), which is indicative of platelet size, is accepted as an indication of platelet activity.

METHOD:

- Compare complete blood count especially in terms of platelet count (PLT), platelet distribution width (PDW), plateletcrit (PCT) and MPV values
- 60 GAD patients with 60 healthy controls.

RESULTS:

- MPV found to be significantly higher (p = .008) and platelet count found to be significantly lower in the GAD group (p = .001)

DISCUSSION:

- Increased MPV levels in GAD = increased platelet activation due to sympathetic system activation
- Platelet levels were found to be significantly lower in GAD
- Non-linear inverse relation between platelet volume and platelet count

Almis and Aksoy, 2018

Increased Mean Platelet Volume and Lower Levels of Generalized Anxiety Disorder

		GAD	Control	*p*
Age (years)		38.35 ± 18.97	34.90 ± 14.62	.229
Gender	Women (n:81)	38 (%63.3)	43 (%71.6)	.330
	Men (n:39)	22 (%36.7)	17 (%28.4)	
WBC (10^3/uL)		8.04 ± 1.70	7.88 ± 1.84	.623
HGB (g/dL)		14.01 ± 1.42	13.64 ± 1.54	.177
HTC (%)		42.12 ± 3.98	41.74 ± 5.02	.644
RBC (10^6/uL)		4.86 ± 0.46	4.80 ± 0.55	.478
MCV (fL)		85.92 ± 4.93	85.84 ± 5.22	.936
PLT (10^3/uL)		258.83 ± 52.41	297.93 ± 57.85	.001*
PDW (fL)		19.44 ± 2.10	19.33 ± 1.25	.721
PCT (%)		0.21 ± 0.05	0.20 ± 0.04	.112
MPV (fL)		8.15 ± 1.41	7.50 ± 1.24	.008*

Almis and Aksoy, 2018

Increased Platelets Leads to Increased Serotonin

- After synthesis in intestinal enterochromaffin cells, serotonin is stored in platelets and released upon stimulation
- Hence, more platelets = more serotonin
- Foods to increase platelets: Lean meats, beans, garlic, kale, carrots, foods rich in B9
- Don't block platelets with Aspirin and other prescription medications (Penicillins, NSAIDS, anticonvulsants, sedatives)

Banskota, Ghia, and Khan 2019; Visentin and Liu, 2007

SUMMARY AND CONCLUSIONS

Hyperbaric oxygen Therapy (HBOT) is drug that can treat many low oxygen diseases or injuries

HBOT can effectively treat TBI and PTSD: Scientifically and cost-effectively

TBI can be the cause of or existent concurrently with PTSD. TBI and PTSD symptoms are almost identical; therefore treatments should be very similar.

The Neurobiochemical Cascade of TBI is directly related to the post-concussive symptoms experienced by the patient. Treatment of the TBI patient's neurobiology, including ATP deficiencies, electrolytes, and neurotransmitters is essential for recovery.

SUMMARY AND CONCLUSIONS

Serotonin levels in the brain decrease with TBI, PTSD, depression, and chronic stress. Restoring serotonin levels is a key component to treating TBI and PTSD.

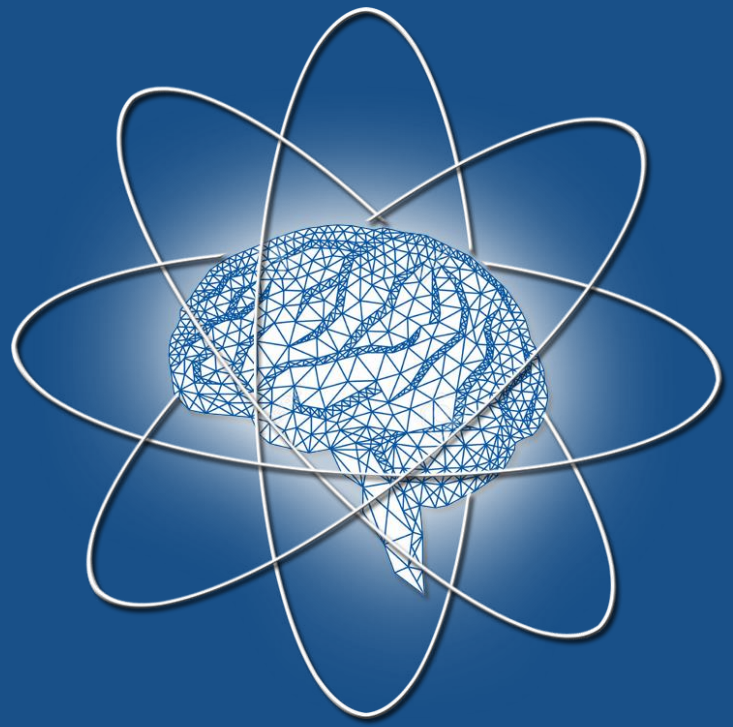
HBOT can increase serotonin levels in the brain. Inhaled oxygen can also increase serotonin.

Treatment of TBI and PTSD patients with SSRIs may result in further depression long-term or suicide. DO NOT USE SSRIs for TBI or PTSD.

Serotonin can be increased by oral tryptophan intake (turkey, carbohydrate foods or supplementation), IV tryptophan, improving the gut microbiome (with probiotics, as necessary), and improving platelet levels.

Treatment Protocols for TBI/PTSD Should Include the Following:

- HBOT and/or inhaled oxygen (home hyperbaric chambers and oxygen concentrators are options)
- Oral tryptophan (dosing varies: start with 500mg to 1000mg per day; take away from other proteins)
- Carbohydrate foods in diet and tryptophan rich foods (turkey)—modified keto diet with carbs at dinner
- IV tryptophan (made by compounder; dosing varies per patient: effects seen with 5mg/kg)
- Avoidance of platelet blocking medications such as aspirin or NSAIDs
- Avoidance of SSRIs
- IV and oral supplements foods that increase ATP, platelets, and balance electrolytes (eg. B-vitamins, minerals, especially Magnesium)
- Intranasal therapies (including platelet rich plasma) to enhance brain platelets (containing tryptophan), growth factors, and stem cells in the brain. These treatment bypass the BBB to get compounds to the brain (TBI Therapy's protocols at tbitherapy.com)
- Cranial osteopathy



TBI Therapy

Treats TBI patients by combining regenerative therapies: HBOT, stem cells, PRP, and nutritional therapies.

tbitherapy.com

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