Acute Concussion Diagnostics and Treatment: Case Study Results

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One Year Follow Up

• What we know about concussions
• Our data
• What we have learned
• FUTURE!
Full Disclosure

I got some images off of the internet without prior approval

Because these talks are boring...

without pictures
My Background:
General Surgery Training 1993-2000
Traumatic Brain Injury

Intra-cranial monitors

A pressure sensor is placed through the skull to monitor the pressure in the brain.

Wait and watch... Respond
Herniation

• By about age 2 the skull is closed

• Too much swelling of the brain can cause herniation

• Death
“Standard of care 2017”

PROACTIVE

part of the skull is removed to allow room for the brain to swell

Think compartment syndrome
FDA approved HBO
Wound Care and Hyperbaric Medicine
WARNING: Wounds
In January 2012, Chicago

Teenage girl
Left a party after drinking......

36 hours
after walking in the snow
87 year old with Pyoderma Gangrenosum
Less than 1 month—Lesions often open for months to years
HBOT 2014

HBO post-treatment improved SWI outcomes following rmTBI
Mechanisms of hyperbaric oxygen neuroprotection. Adapted from Zhang et al., 2005.
Scope of the Problem?
Google: Concussion

• More than 3 million/year

• “no specific cure”

• “rest...allow brain to recover”
STOP HIGH SCHOOL STUDENT CONCUSSIONS

STUDENTS ARE AT RISK FOR CONCUSSIONS

15% REPORTED AT LEAST ONE CONCUSSION IN PREVIOUS YEAR

6% REPORTED MORE THAN ONE CONCUSSION

SOME STUDENTS ARE AT HIGHER RISK

MALES

STUDENTS WHO PLAY ON SPORTS TEAMS

CREATE A CULTURE OF CONCUSSION SAFETY

LEARN ABOUT CONCUSSION SYMPTOMS

REPORT SUSPECTED CONCUSSIONS

SEE A HEALTHCARE PROVIDER

But then what?
So, if someone has a concussion, how is that treated?

June 21, 2018

- **Dr. Lara DePadilla**, Behavioral Scientist, Centers for Disease Control and Prevention

- “Well, as I’ve kind of alluded to, there is no one size fits all approach to treating concussion. Instead, healthcare providers can create a tailored return to activity plan that makes sense with a person’s individual symptoms. This could include short-term changes to a person’s daily activities, such as wearing sunglasses if they’re having light sensitivity, or maybe allowing for breaks at school if they’re feeling more slowed down than usual. But as they feel better, they can start to remove these changes and use their symptoms as a guide for how quickly to return to normal activities.”
About 20 percent of teens said they have been diagnosed with at least one concussion. And nearly 6 percent said they've been diagnosed with more than one, according to a research letter published Tuesday in the Journal of the American Medical Association.”
REPORT TO CONGRESS

The Management of Traumatic Brain Injury in Children: Opportunities for Action

2018
Recovery Time

mTBI

**Symptoms of mTBI**

- Headaches
- Dizziness
- Thinking and memory problems
- Mood and emotions
- Sleep difficulties

**Mild TBI**

Common symptoms of mTBI include headaches, dizziness, and problems with thinking/memory, changes in moods/emotions, and sleep difficulties (Table 1). Symptom onset usually occurs immediately, but they can also develop over a few days after injury. Longitudinal studies suggest that most children with mTBI recover from the initial symptoms within 6 weeks after injury, with 30-60% having persistent symptoms at one month post-injury, 10% at three months post-injury, and less than 5% at one year post-injury. Although children can recover quickly from the initial symptoms, little information is available about the long-term outcomes of single or multiple mTBIs in children, particularly among those who experience an mTBI at a young age. In addition to changes in thinking and memory, children can also experience changes in their motor systems, such as balance and postural instability, and these can affect the motor performance that is critical for a return to physical activities.

**30-60% of children with mTBI have persistent symptoms one month post-injury.**
Consequences

• “...social isolation.....harmful effects on their well-being.”
640,000 ER visits, 85% mTBI

544,000
School outcomes
A child's daily life is centered on school, social participation, and extracurricular activities. A TBI of any severity can negatively affect a child's future ability to learn and perform in school. Children with a moderate-to-severe TBI earn worse grades, show higher rates of grade retention, and receive more special education services than their uninjured peers. Students with a mild injury typically recover within a few weeks, and most of them return to their pre-injury classrooms. However, in a large study following children younger than 18 years of age, 14% of children who experienced an mTBI needed educational support services at school twelve months later. Furthermore, educational needs can emerge over time as school demands increase, especially among children injured at a young age. In a cross-sectional study, children with complicated mild and moderate TBI needed more school supports 6 years post-injury than they did 2 years post-injury. Recent studies examining adults with a history of mTBI also report an increased risk for lower educational attainment, particularly among those who sustain multiple mTBIs.
BREAKING NOW
LANDFALL EXPECTED SOON ON TX COAST
Harvey now a Cat 4 storm with winds of 130 mph.
TREAT a Concussion

Currently, no “TREATment.”

We have concussion “management.”

2018

In 2017, “REST” Is the best we’ve got?
Jill Barker: Exercise or rest after a concussion?

Hyperbaric Oxygen just makes sense

When it comes to concussions, rest is often recommended as the first line of treatment. But in the last couple of years, staying sedentary while waiting for a concussion to heal is no longer a given. Instead, physical activity is now considered a viable part of an overall treatment plan — especially in those crucial first few days post concussion.

It turns out that the science behind rest after receiving a blow to the head isn’t as strong as previously thought. There’s even discussion suggesting it may be more harmful than helpful, leading to increased risk of lethargy, anxiety and depression, especially among the active set for whom exercise is a vital part of their lifestyle.

The support behind the idea that exercise can help heal concussions is the result of a growing number of studies posting positive results when exercise is introduced sooner rather than later during post-concussion care. One of the most recent studies, performed by a team out of the Children’s Hospital of Eastern Ontario Research Institute, reported that “resumption of physical activity within seven days post concussion was associated with a lower risk of Persistent Post Concussion Syndrome as compared to no physical activity.”

“Preliminary studies in concussed adolescents found that participants engaging in moderate levels of activity reported lower symptom levels and superior neurocognitive performance compared to those with physical rest,” stated the researchers.

No one is ready to go on record to explain why exercise is so beneficial, though there has been plenty of suggestion that the boost in oxygen flow associated with exercise allows the brain to heal quicker as compared to the more sluggish cerebral blood flow associated with sedentary behavior.
Concussions

Wound of the brain

TREAT with HBO
Our Experience

Since last year’s conference

- August 1, 2017 until June 1, 2018
- **TREAT** a Concussion
- Still word of mouth

Any patient suspected of a concussion
Protocol Definitions

• Acute---14 days or less

• Subacute  everything in between

• Chronic 3-6 months with persistent symptoms

Acute on Chronic:  acute concussion but patient was still symptomatic from previous concussion
Rough data

I have not been back through each chart to confirm
Last Year

- 54 patients
  - 8 adults --- excluded
  - 47 patients age 6 - 23
- 52 concussions
  - 5 patients had a 2\textsuperscript{nd} concussion

- Gender
  - 17 females
  - 30 males

- All but 1 patient completely resolved his/her symptoms in our office after hyperbaric oxygen treatment.
103 concussions (adults removed)

- 99 patients
- 4 patients had 2 concussions tx

Gender

- 40 females
- 59 males
## Previous Concussions
### 103 Concussions

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<tr>
<th>First</th>
<th>One prior</th>
<th>Two prior</th>
<th>Three prior</th>
<th>Four prior</th>
<th>Five prior</th>
<th>Six+ prior</th>
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<td>5</td>
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<td>11</td>
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<td>49.5%</td>
<td>20%</td>
<td>10.7%</td>
<td>4.9%</td>
<td>0</td>
<td>2%</td>
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Mostly first concussion
Number of Treatments Needed

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<th></th>
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<th>3</th>
<th>4</th>
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<td>3</td>
<td>2</td>
<td>1</td>
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Average 2.95
Photophobia

• Has been shown to be a risk factor for increased duration of symptoms

• 75 of the 103 concussions (no data on 5)

• Average number of treatments 3.1 verses 2.5 if not photophobic
What we have learned in 3 years?

Fall 2015 started
1. We can TREAT concussions

Now over 150 acute concussions TREATED
High School Senior Football Player

- September 2017
- Taken off the field on stretcher + LOC
- Diagnosed in ER with a concussion
- Pediatrician recommended HBO
- 2:00 Saturday (less 24 hours) Tx

Wow, I was messed up!

“Are you better than what you thought you needed to be?”
2. Concussed athletes do not appreciate full extent of their injury

The damaged brain just doesn’t self-report very well

Danger of returning too early
Father emailed me
“(Patient) resumed playing after sitting for (2) games and did not have any impairment from the original concussion. School and social activities were back on par after a week. Currently, he is enrolled at (university) as a student-athlete. He is likely to red shirt this season to get his body prepared for the rigors of playing in the Big Ten.”

[He did not miss a single day of school.]
What if we start treatment before full progression of concussion?

3. Can we stop full extent of concussion?
Retrograde amnesia
Risk factor for prolonged recovery

- 12 year old male could not remember events 1 hour prior to fall

- HBO less 3 hours after injury

- 5 treatments

- Back in school 1 week after (Monday)
- No issues now 3 months out
Retrograde amnesia

• 12 year old male hockey player, boarded
• Appeared to have shoulder injury---off ice, dazed

• Coach sent him to locker room
• Father got him out of his uniform, drove home

• 45 minutes later, took ice pack off his head
  “What happened?”
Concussion mitigated?

- 1st HBO five hours after injury
- Was back in school by Tuesday, 3 days post-injury
- Total of 6 treatments
- Worth noting, he had a previous concussion year prior
Prevent Concussion Progression

30 patients began treatment 1 day or less from injury
4. Can we decrease risk of subsequent concussions?

We have had 4 recurrent concussions in the same playing season.

"1 in 15 players with a concussion may have additional concussions in the same playing season."

JAMA November 19, 2003
Subsequent Concussions

*Time will tell*

- One of our “recurrent concussion” patients

  16 year old, straight A student, couldn’t read
  Post-concussive syndrome until 15 HBO July 2016

  Started playing lacrosse May 2017
  Returned twice less 24 hours after injury
  fear of another concussion

  Recent ACT > 30
Celebrate Success?

• Concussion experts say:
  “Normal recovery”
  “Just relaxation”

  My favorite:
  “What Dr. Denham is doing is not okay.”
Why is this so hard?
“But I can still go, right Mom?”

Told by “concussion doctor” that ‘HBO was not helping him and he didn’t need to return’
Fargo, North Dakota
Thank you Gary Tharaldson!

- Met January 14, 2018
- Less 6 months
  - Found and built out incredible space
  - 4 chambers
  - Room to grow
Visual Symptoms
69-82% of concussed patients

• Dr. David Biberdorf will test patients prior to treatment and immediately after HBO.

We will have OBJECTIVE EVIDENCE
Future:

- Protocol perfection
  - MRI pre-season
  - Eye studies

- Can we change the attitude of reporting a concussion

- Longer term follow up
  - Academic performance
  - Social/emotional
  - Subsequent concussions

- Cost-effective
Can we afford not to treat?
Limbic System

- Wikipedia: system supports a variety of functions including **emotion**, **behavior**, **motivation**, **longterm memory**, and **olfaction**. Emotional life is largely housed in the limbic system, and it has a great deal to do with the formation of memories.
Vulnerable Areas of the brain with swelling

Figure AB-17: Limbic System
(Cross-Coronal Section)
Black Friday Crowds

people at the doors get crushed
Traumatic brain injury results in acute rarefaction of the vascular network

Andre Obenauf1*1, Michelle Ng1, Amanda M. Grant1, Eli Kinney-Lang1, Faisal Rashid1, Mary Hamer1, Richard A. DeFazio1, Jiping Tang1, John H. Zhang1,4,5 & William J. Pearce1,6

The role of the cerebrovascular network and its acute response to TBI is poorly defined and emerging evidence suggests that cerebrovascular reactivity is altered. We explored how cortical vessels are physically altered following TBI using a newly developed technique, vessel painting. We tested our hypothesis that a focal moderate TBI results in global decrements to structural aspects of the vasculature. Rats (n=6, sham-operated, TBI) underwent a moderate confined cortical impact. Animals underwent vessel painting perfusion to label the entire cortex at 1 day post TBI followed by whole brain coronal and coronal images using a wide-field fluorescence microscope. Cortical vessel network characteristics were analyzed for classical angiographic features (junctions, length) and we observed significant global (both hemispheres) reductions in vessel junctions and vessel lengths of 33% and 22%, respectively. Biological complexity can be quantified using fractal geometric features where we observed that fractal measures were also reduced significantly by 33%, 59% and 13% for kurtosis, peak value frequency and skewness, respectively. Acutely after TBI there is a reduction in vascular network and vascular complexity that are accentuated at the lesion site and provide structural evidence for the bilateral hemodynamic alterations that have been reported in patients after TBI.
We Can **TREAT** a Concussion

- Acute
- Subacute
- Acute on Chronic
- Chronic

**Oxygen + Pressure**
- Oxygenate tissue—heal
- Decrease swelling
- Turn off the inflammation