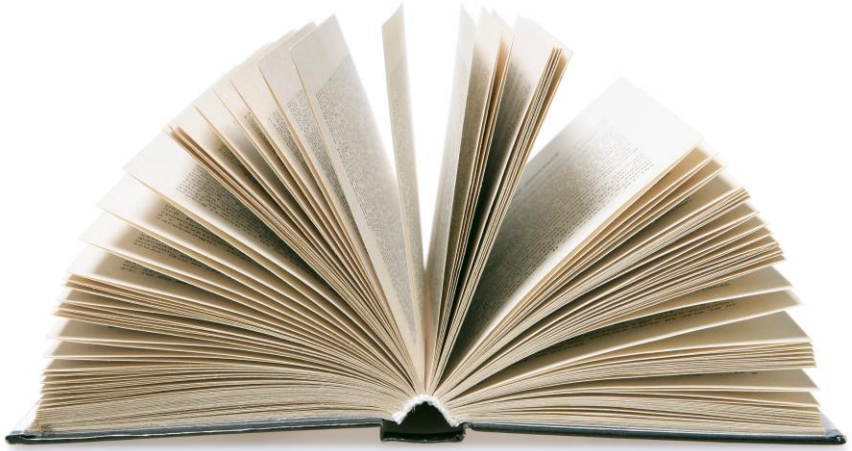
Acute Concussion Diagnostics and Treatment: Case Study Results

Daphne W Denham, MD FACS FACCWS

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

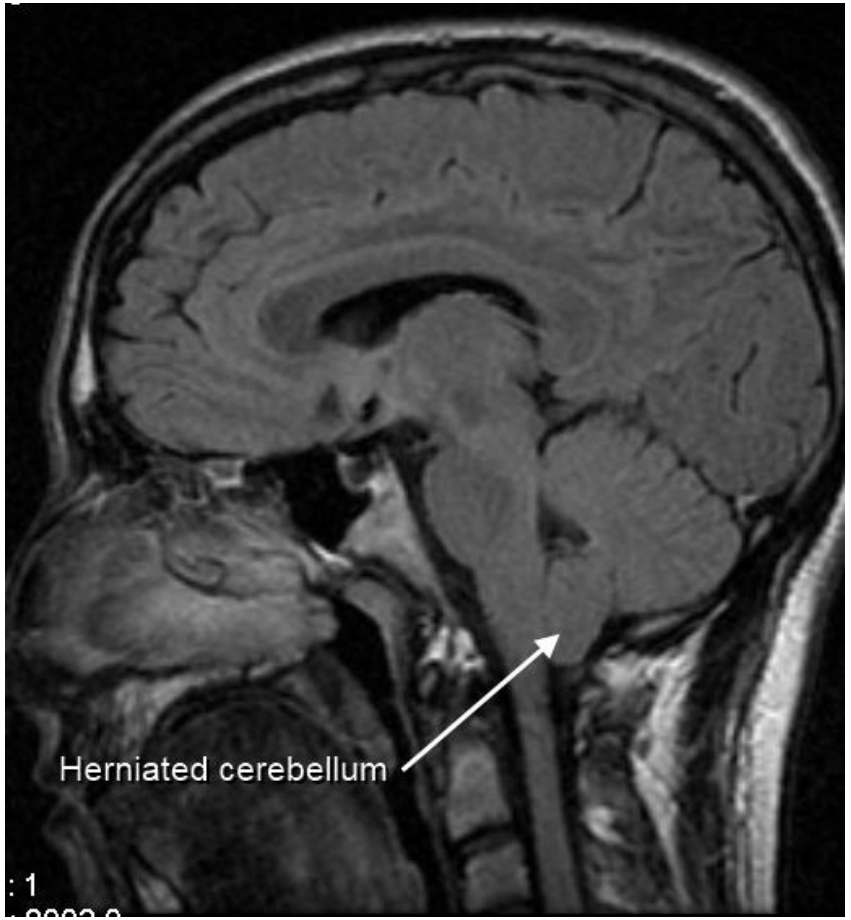
Intra-cranial monitors

A pressure sensor is place
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

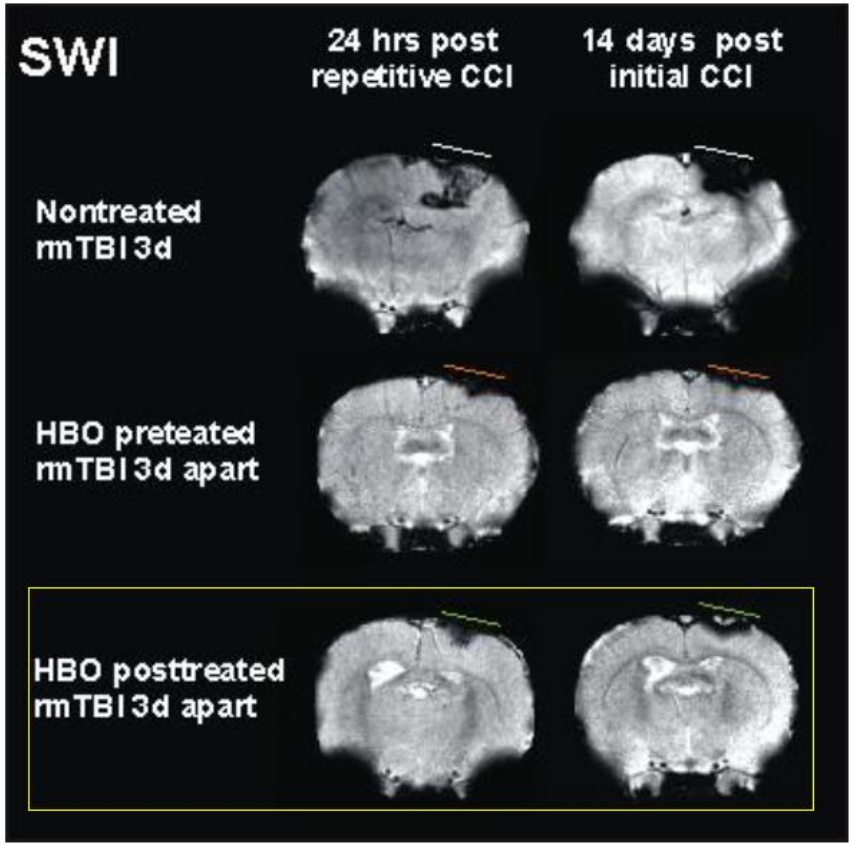

Location

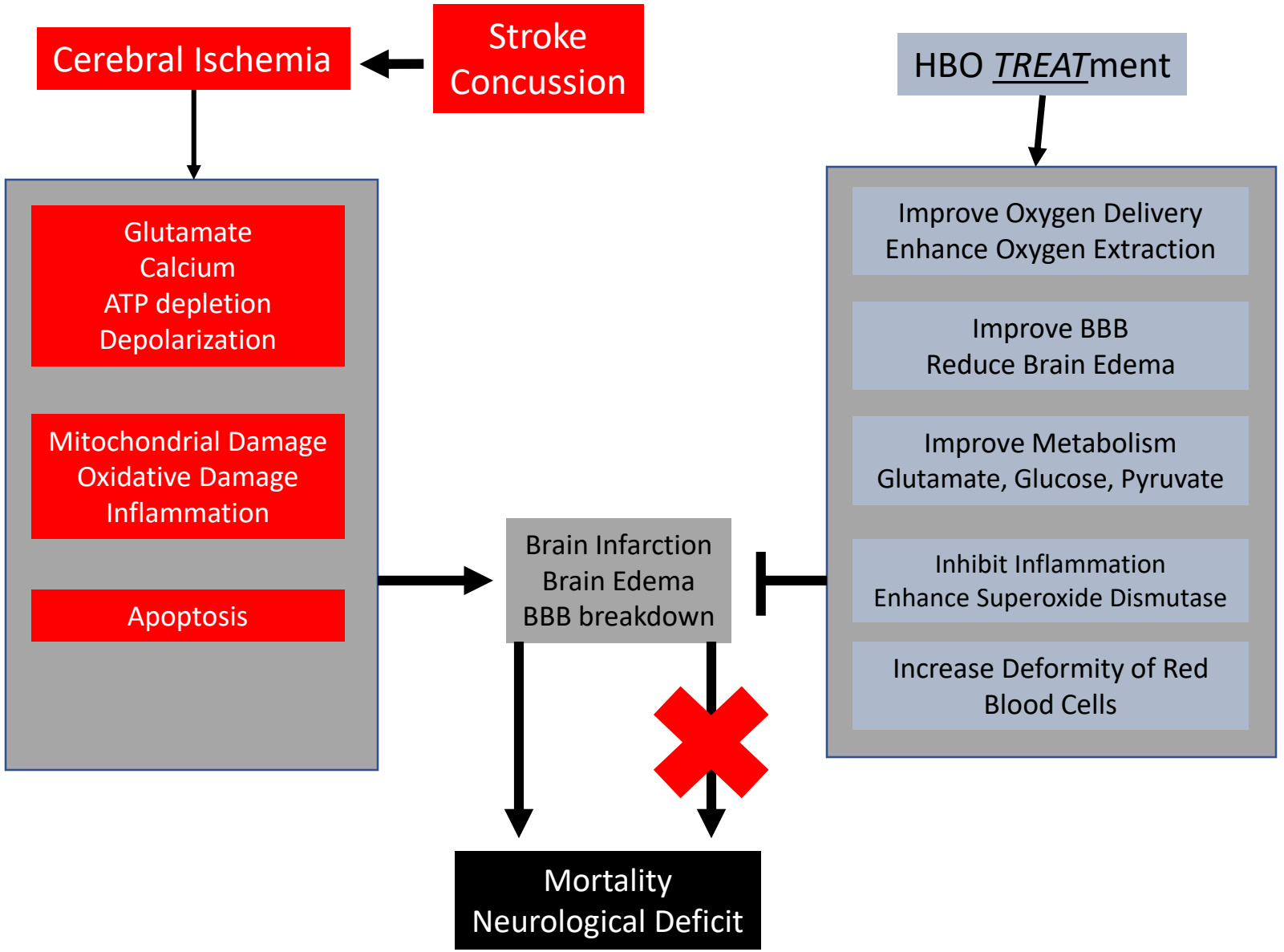
87 year old with Pyoderma Gangrenosum

Less than 1 month--*Lesions often open for months to years*

HBOT 2014

HBO post-treatment improved SWI outcomes following rmTBI





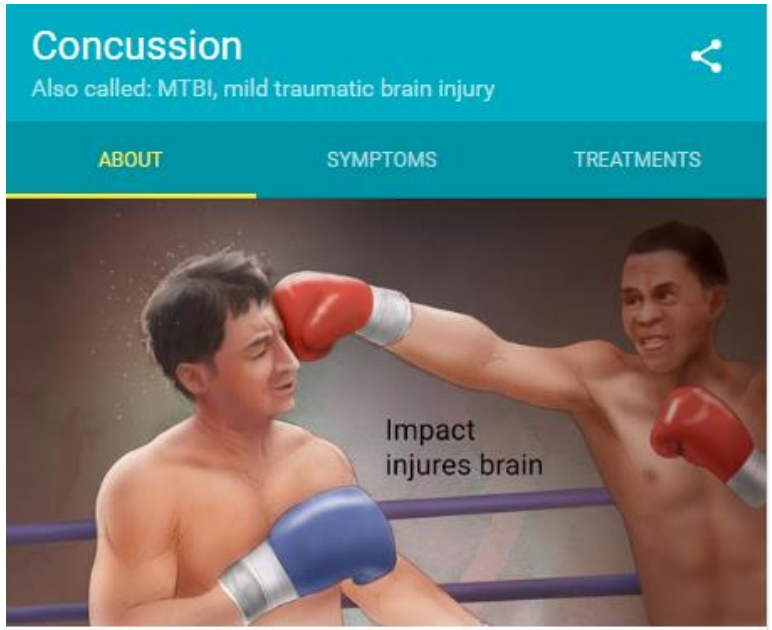
Mechanisms of hyperbaric oxygen neuroprotection. Adapted from Zhang et al., 2005.

Scope of the Problem?

Google: Concussion

- More than 3 million/year

- “no specific cure”
- “rest…allow brain to recover”



But then what?

Weekly / June 22, 2018 / 67(24);682–685

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."

1 in 5 Teens Reports a Concussion

shots HEALTH NEWS FROM NPR

PUBLIC HEALTH

1 In 5 Teens Reports A Concussion Diagnosis

September 26, 2017 · 11:42 AM ET

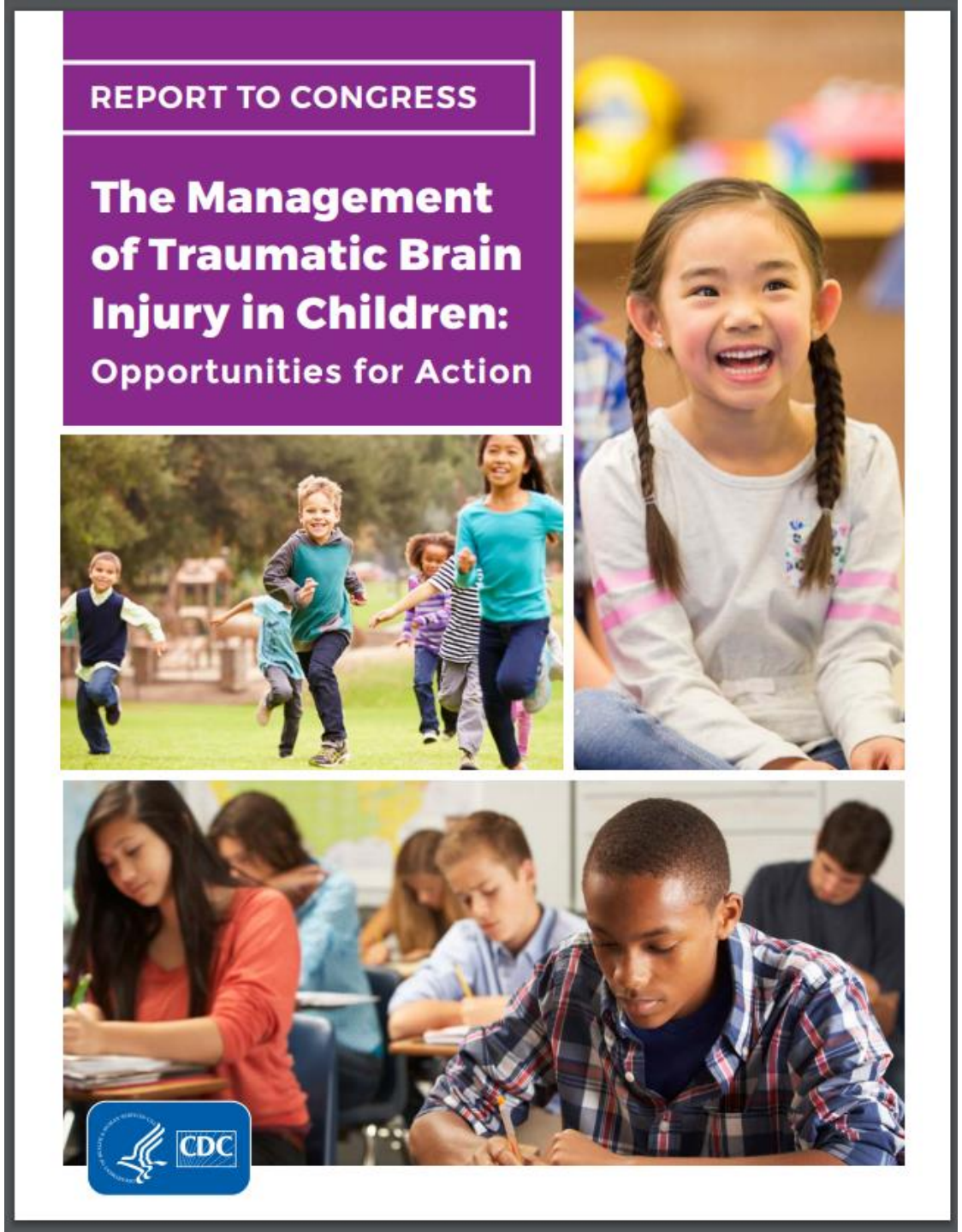
GRETA JOCHEM

Teens involved in contact sports were more likely to report concussions.

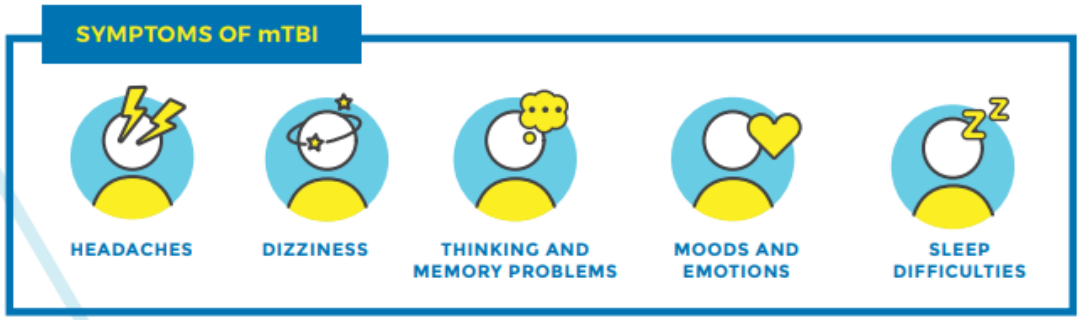
Krista Lona/Getty Images

"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."

2018


REPORT TO CONGRESS
The Management of Traumatic Brain Injury in Children:
Opportunities for Action
CDC

Recovery Time mTBI



Mild TBI

Common symptoms of mTBI include headaches, dizziness, and problems with thinking/memory, changes in moods/emotions, and sleep difficulties (Table 1).[12-20] Symptoms usually develop 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.[13,14,21-23] 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[143] and postural instability,[144] and these can affect the motor performance that is critical for a return to physical activities.[145]

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

Consequences

- “….social isolation…..harmful effects on their well-being.”

Return to activity

Although return-to-play guidelines for sports have been devised for mTBI, similar consensus guidelines have not been developed for return to other recreational and physical activities outside of organized sports.

While there may be awareness of these risks among those who care for children, there is a lack of guidance as to how to minimize these risks. Additionally, neither consensus nor evidence-based guidelines for return to activities after moderate and severe TBI exist.

> Following TBI, children are at risk for increased social isolation and reduced participation in activities outside of the school setting, and this can have harmful effects on their well-being.

Transition to adulthood for children with TBI

As children reach adulthood, the transition from pediatric to adult medical care providers is a particular area of clinical concern.[81] Research has demonstrated that access to (and use of) healthcare services declines significantly as adolescents transition to adult care, resulting in worse health outcomes in adolescents with identified health conditions.[81-84] In the public school system, only children enrolled in special education when they enter high school

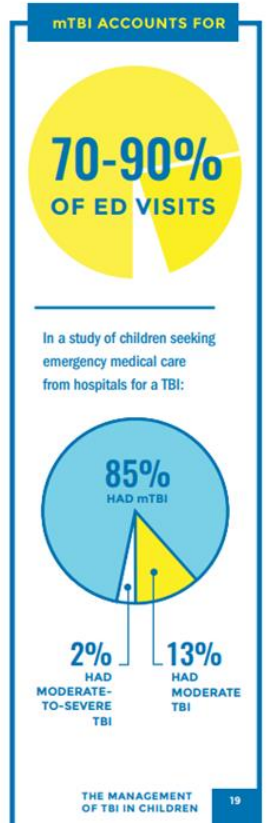
INCIDENCE

Traumatic brain injury in children represents a significant public health burden in the United States.

> A traumatic brain injury disrupts the normal function of the brain, and can be caused by a bump, blow, or jolt to the head, or a penetrating head injury.[3]

In 2013, there were approximately 640,000 TBI-related emergency department (ED) visits, 18,000 TBI-related hospitalizations, and 1,500 TBI-related deaths among children 14 years of age and younger.[1] The leading cause of TBI-related ED visits, hospitalizations, and deaths for years of age the leading causes were motor vehicle crashes and falls.[1] Sports and recreation-related TBIs are a leading cause of TBI-related ED visits among children and teens with an estimated 325,000 occurring in 2012.[4]

Children with TBI can present to a number of clinical locations: the ED, urgent care clinics, primary care, concussion/sports medicine clinics, or other specialty clinics. In addition, some do not seek or receive medical care.[101] Recent research examining the point of entry in a large healthcare network found that among pediatric patients with mild TBI (mTBI), 82% initially visited primary care, 5% visited specialty care, and 12% visited an ED.[102] This information suggests that incidence estimates of pediatric TBI based solely on ED visit data are significant undercounts, likely missing those with mTBIs seen at lower levels of care, in addition to those with mTBIs who don't seek care at all.[101] Because of these gaps in TBI surveillance, researchers have



640,000 ER visits, 85% mTBI

544,000

Economic Impact

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.[29] 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.[30-33] 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.[7] 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.[111] 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.[242]

14%

of children who experienced an mTBI needed educational support services at school twelve months later.[7]


LIVE
CORPUS CHRISTI, TX 76°
WAY
00:04
BREAKING NOW
TRACKING HARVEY
LANDFALL EXPECTED SOON ON TX COAST
Harvey now a Cat 4 storm with winds of 130 mph
DU SCREEN RECORDER

TREAT a Concussion

2018

In ~~2017~~, "REST"
Is the best
we've got?

Currently, no "***TREAT***ment."

We have concussion
"***management***."

Hyperbaric Oxygen just makes sense

Jill Barker: Exercise or rest after a concussion?

JILL BARKER, SPECIAL TO MONTREAL GAZETTE

More from Jill Barker, Special to Montreal Gazette

Published on: April 2, 2017 | Last Updated: April 2, 2017 11:00 AM EDT

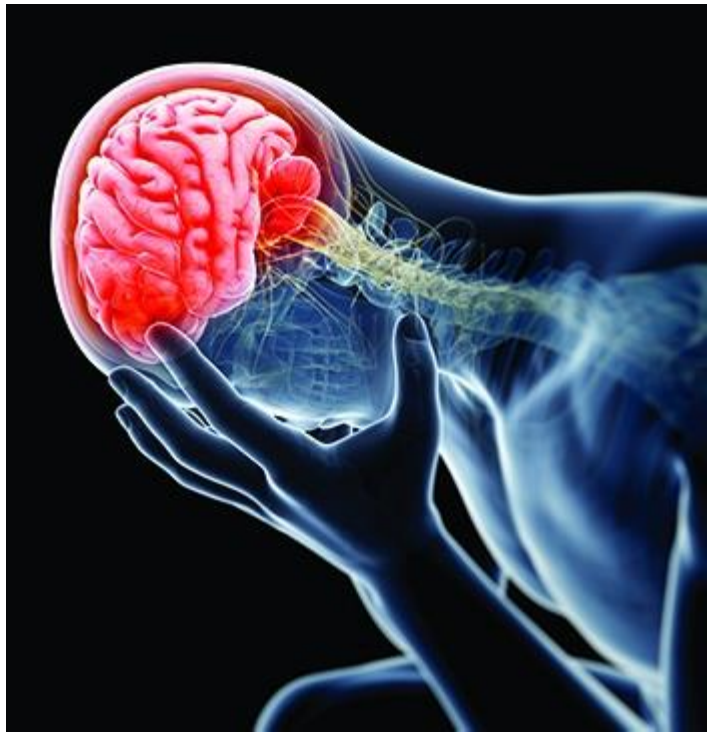
When it comes to concussions, rest is often recommended as the first line of treatment. But in the last couple of years, staying sedentary while waiting for a concussion to heal is no longer a given. Instead, physical activity is now considered a viable part of an overall treatment plan — especially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



Concussions

Wound of the brain

TREAT with HBO

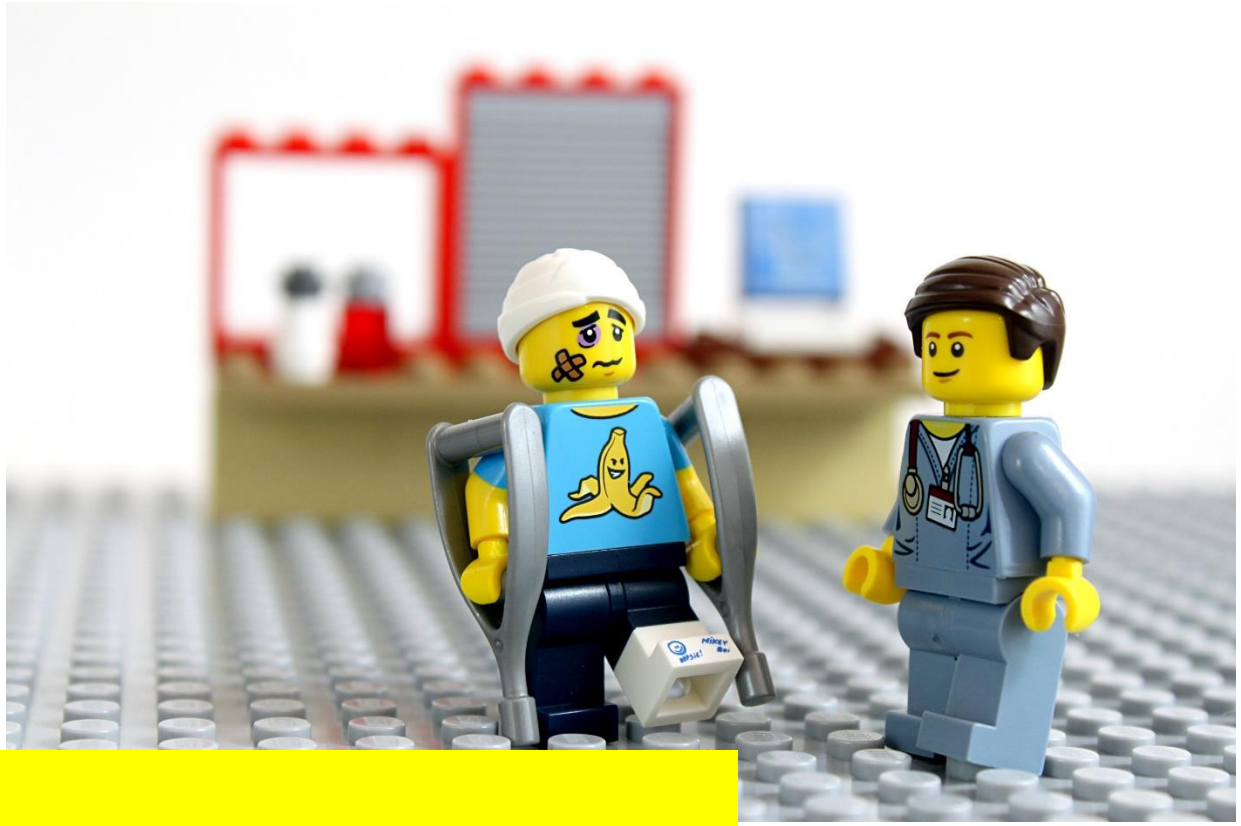
Our Experience
Since last year's conference

- 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


Full
Disclosure

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 2nd concussion
- Gender
  - 17 females
  - 30 males

- All but 1 patient completely resolved his/her symptoms in our office after hyperbaric oxygen treatment.

HBOT 2018

103 concussions (adults removed)	• 99 patients • 4 patients had 2 concussions tx
Gender	• 40 females • 59 males

Previous Concussions
103 Concussions

First	One prior	Two prior	Three prior	Four prior	Five prior	Six+ prior	No data
51	21	11	5	0	2	2	11
49.5%	20%	10.7%	4.9%	0	2%	2%	11%

Mostly first concussion

Number of Treatments Needed

1	2	3	4	5	6	7	8	9	10
26	28	20	13	6	4	1	3	2	1

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

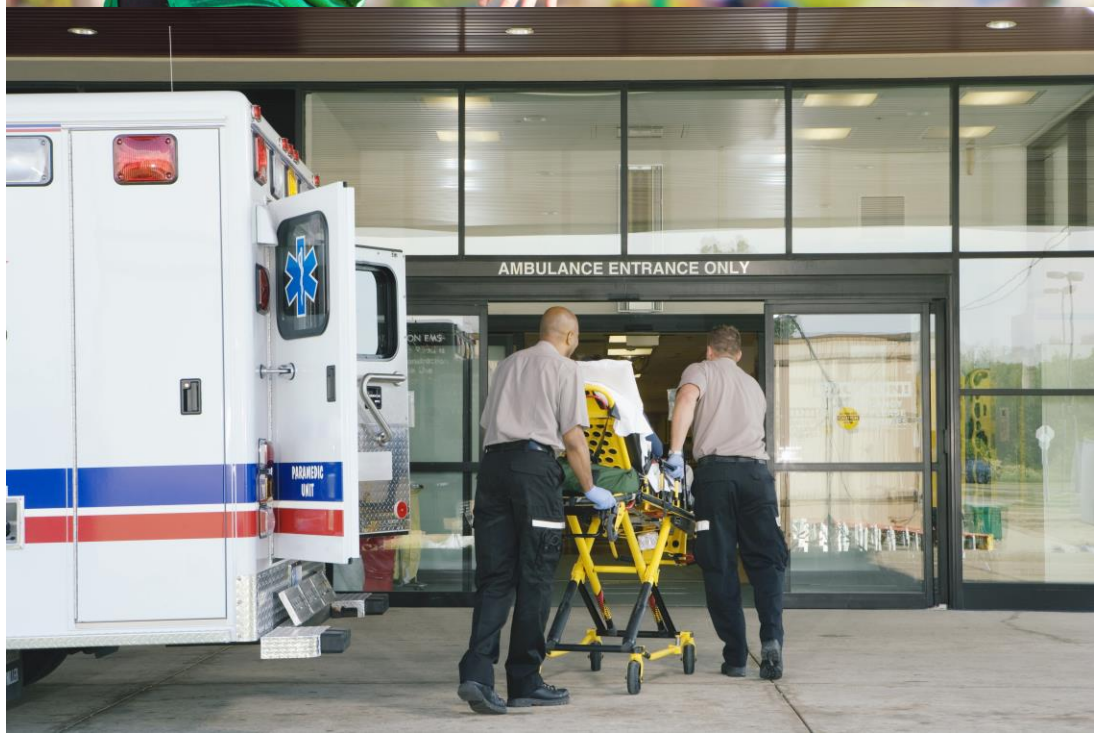
High School Senior Football Player

- 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

TREATED

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.]

3. Can we stop full extent of concussion?

What if we start treatment before full progression 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

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

Cumulative Effects Associated With Recurrent Concussion in Collegiate Football Players

The NCAA Concussion Study

Kevin M. Guskiewicz, PhD, ATC
Michael McCrea, PhD
Stephen W. Marshall, PhD
Robert C. Cantu, MD
Christopher Randolph, PhD
William Barr, PhD
James A. Onate, PhD, ATC
James P. Kelly, MD

Context Approximately 300 000 sport-related concussions occur annually in the United States, and the likelihood of serious sequelae may increase with repeated head injury.

Objective To estimate the incidence of concussion and time to recovery after concussion in collegiate football players.

Design, Setting, and Participants Prospective cohort study of 2905 football players from 25 US colleges were tested at preseason baseline in 1999, 2000, and 2001 on a variety of measures and followed up prospectively to ascertain concussion occurrence. Players injured with a concussion were monitored until their concussion symptoms resolved and were followed up for repeat concussions until completion of their collegiate football career or until the end of the 2001 football season.

Main Outcome Measures Incidence of concussion and repeat concusion; type and duration of symptoms and course of recovery among players who were injured with a concussion during the seasons.

Results During follow-up of 4251 player-seasons, 184 players (6.3%) had a concussion, and 12 (6.5%) of these players had a repeat concussion within the same season. There was an association between reported number of previous concussions and likelihood of incident concussion. Players reporting a history of 3 or more previous concussions were 3.0 (95% confidence interval, 1.6-5.6) times more likely to have an incident concussion than players with no concussion history. Headache was the most commonly reported symptom at the time of injury (85.2%), and mean overall symptom duration was 82 hours. Slowed recovery was associated with a history of multiple previous concussions (30.0% of those with ≥3 previous concussions had symptoms lasting >1 week compared with 14.6% of those with 1 previous concussion). Of the 12 incident within-season repeat concussions, 11 (91.7%) occurred within 10 days of the first injury, and 9 (75.0%) occurred within 7 days of the first injury.

Conclusions Our study suggests that players with a history of previous concussions are more likely to have future concussive injuries than those with no history; 1 in 15 players with a concussion may have additional concussions in the same playing season; and previous concussions may be associated with slower recovery of neurological function.

JAMA. 2003;290:2549-2555 www.jama.com

THE HIGH INCIDENCE OF CEREbral concussion in contact sports is well documented.[1-8] According to the Centers for Disease Control and Prevention, approximately 300 000 sport-related concussions occur annually in the United States,[9] and the likelihood of serious sequelae may increase with repeated head injury.[10] Recent publications addressing the negative consequences of recurrent concussion in sports raise questions regarding the potential long-term sequelae associated with this injury,[11-13] and recurrent concussion has forced several collegiate and professional athletes to retire early from their respective sports.

Studies from the 1970s report annual concussion incidence rates in high school football to be as high as 15% to 20% of all players in a season,[5,8] while annual incidence estimates of 10% were reported in collegiate football during the late 1980s.[14] More recently, lower in-

See also pp 2556 and 2604 and Patient Page.

Author Affiliations: Departments of Exercise and Sport Science (Drs Guskiewicz and Cantu), Orthopaedics (Drs Guskiewicz and Marshall), and Epidemiology (Dr Marshall), and Injury Prevention Research Center (Drs Guskiewicz and Marshall), University of North Carolina at Chapel Hill; Neuroscience Center, Waukesha Memorial Hospital, Waukesha, Wis (Dr McCrea); Department of Neurology, Medical College of Wisconsin, Milwaukee (Dr McCrea); Neurosurgery Service, Emerson Hospital, Concord, Mass (Dr Cantu); Chicago Neurological Institute (Drs Randolph and Kelly) and Department of Neurology, Northwestern University Feinberg School of Medicine (Dr Kelly), Chicago, Ill; Department of Neurology, Loyola University Medical School, Maywood, Ill (Dr Randolph); Department of Neurology, New York University School of Medicine, New York (Dr Barr); and Department of Rehabilitation Sciences Athletic Training Program, Sargent College of Health and Rehabilitation Sciences, Boston University, Boston, Mass (Dr Onate).

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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”

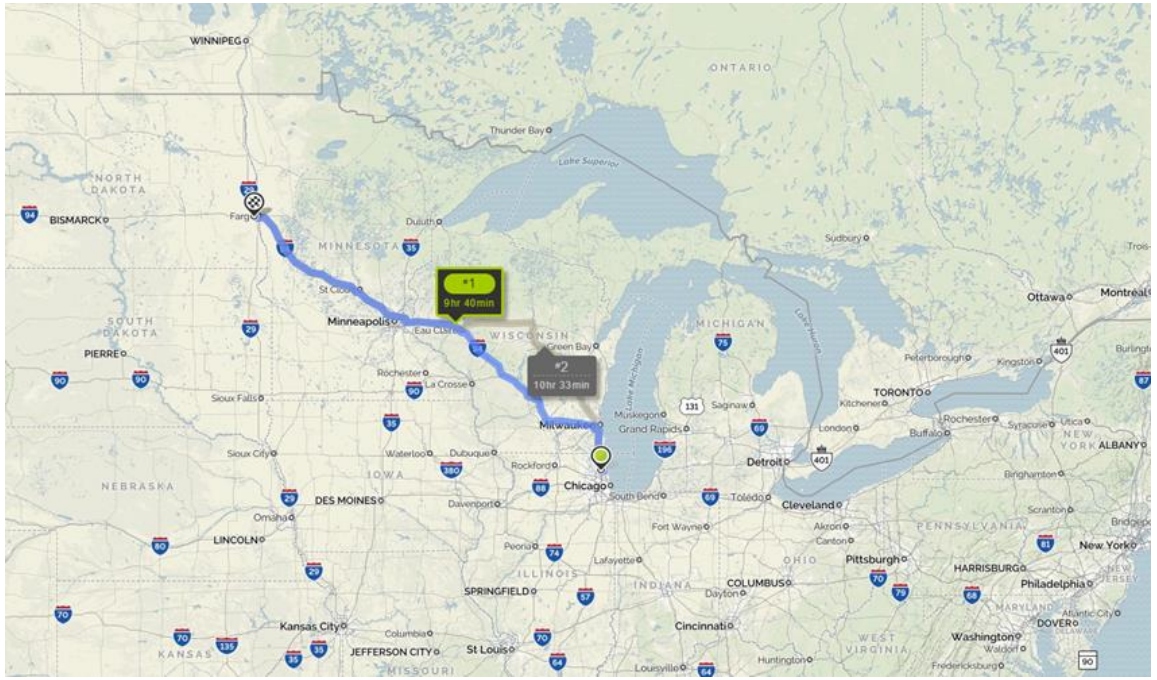
  My favorite:

  “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?

Early release, published at www.cmaj.ca on February 8, 2016. Subject to revision.

CMAJ RESEARCH

Risk of suicide after a concussion

Michael Fralick MD BScH, Deva Thiruchelvam MSc, Homer C. Tien MD MSc, Donald A. Redelmeier MD MS(HSR)

CMAJ Podcasts: author interview at https://soundcloud.com/cmajpodcasts/150790-res

Abstract

Background: Head injuries have been associated with subsequent suicide among military personnel, but outcomes after a concussion in the community are uncertain. We assessed the long-term risk of suicide after concussions occurring on weekends or weekdays in the community.

Methods: We performed a longitudinal cohort analysis of adults with diagnosis of a concussion in Ontario, Canada, from Apr. 1, 1992, to Mar. 31, 2012 (a 20-yr period), excluding severe cases that resulted in hospital admission. The primary outcome was the long-term risk of suicide after a weekend or weekday concussion.

Results: We identified 235 110 patients with a concussion. Their mean age was 41 years, 52% were men, and most (86%) lived in an urban location. A total of 667 subsequent suicides occurred over a median follow-up of 9.3 years, equivalent to 31 deaths per 100 000 patients annually or 3 times the population norm. Weekend concussions were associated with a one-third further increased risk of suicide compared with weekday concussions (relative risk 1.36, 95% confidence interval 1.14–1.64). The increased risk applied regardless of patients' demographic characteristics, was independent of past psychiatric conditions, became accentuated with time and exceeded the risk among military personnel. Half of these patients had visited a physician in the last week of life.

Interpretation: Adults with a diagnosis of concussion had an increased long-term risk of suicide, particularly after concussions on weekends. Greater attention to the long-term care of patients after a concussion in the community might save lives because deaths from suicide can be prevented.

Competing interests: None declared.

This article has been peer reviewed.

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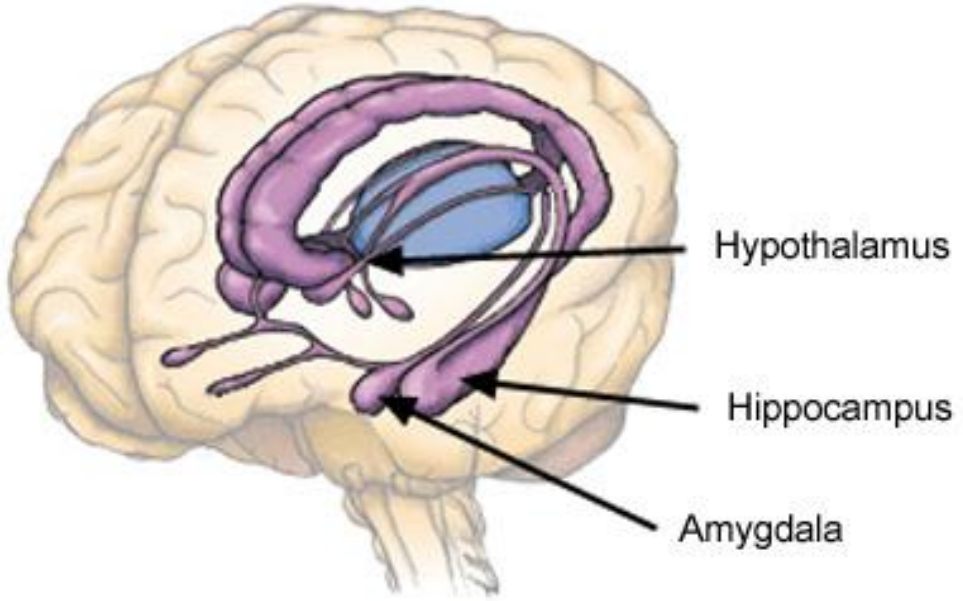
Online: Feb. 8, 2016

Correspondence to: Donald A. Redelmeier, dar@ices.on.ca

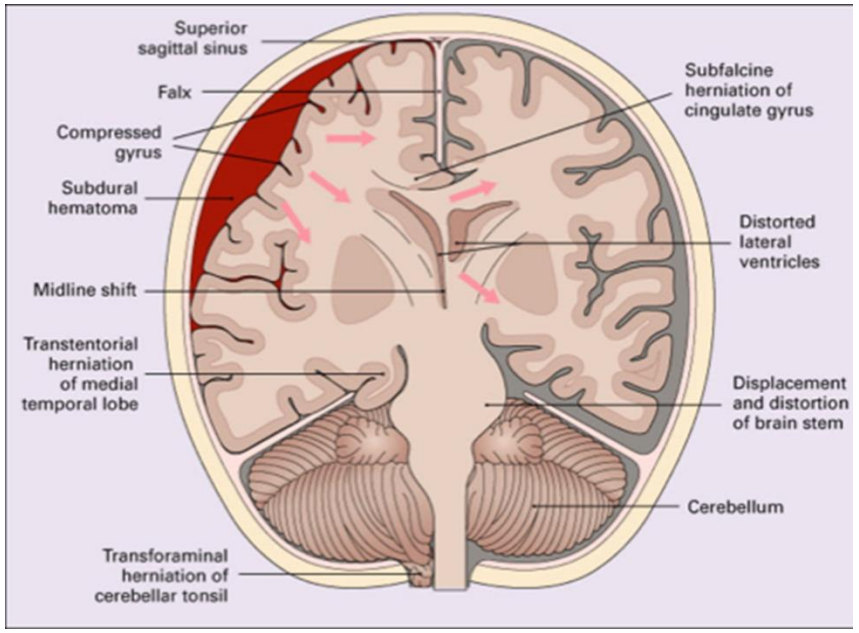
CMAJ 2016. DOI:10.1503/cmaj.150790

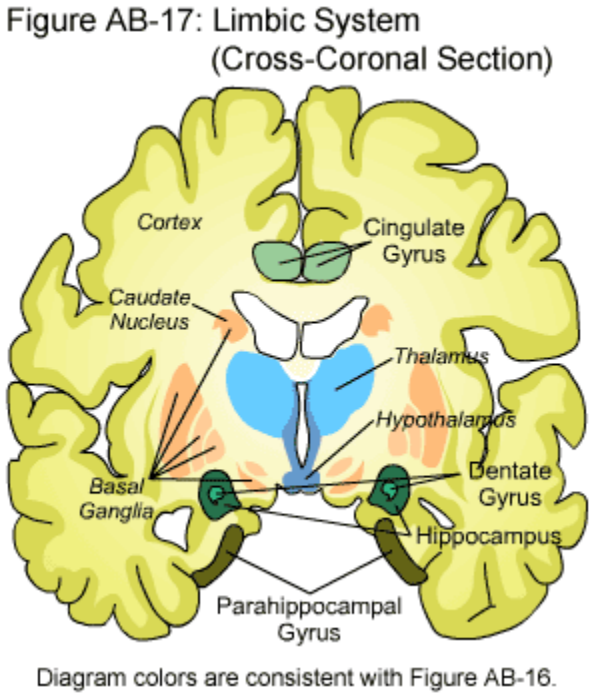
Limbic System

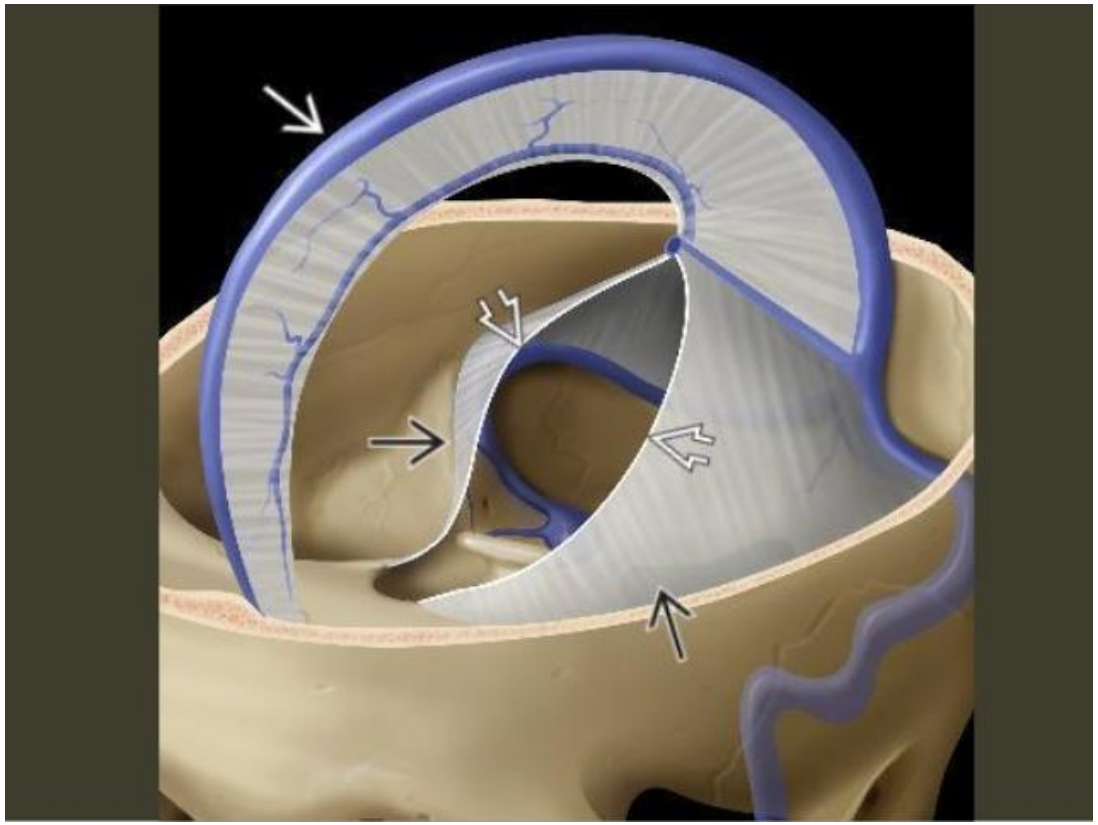
- Wikipedia: system supports a variety of functions including emotion, behavior, motivation, longterm memory, and olfaction.[5] Emotional life is largely housed in the limbic system, and it has a great deal to do with the formation of memories

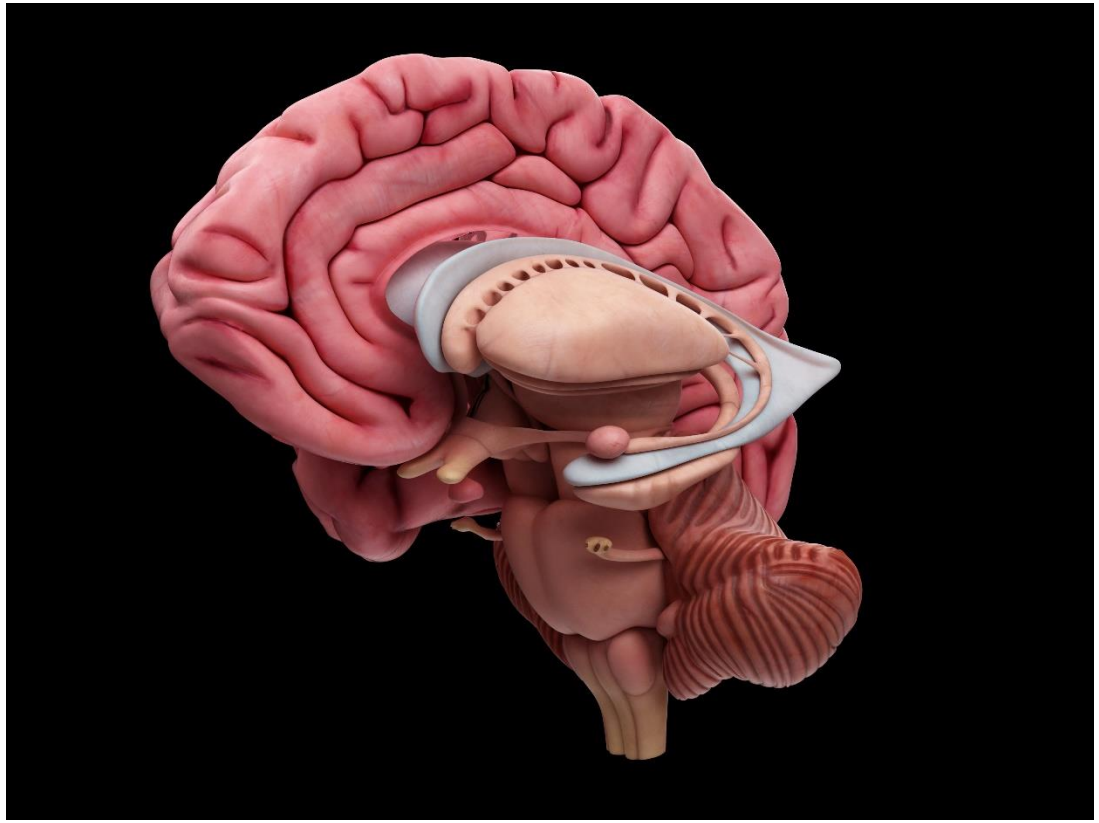


Vulnerable Areas of the brain with swelling









Black Friday Crowds

people at the doors get crushed

https://biofoundations.org/tag/arginine-pyroglutamate/

www.nature.com/scientificreports

SCIENTIFIC REPORTS

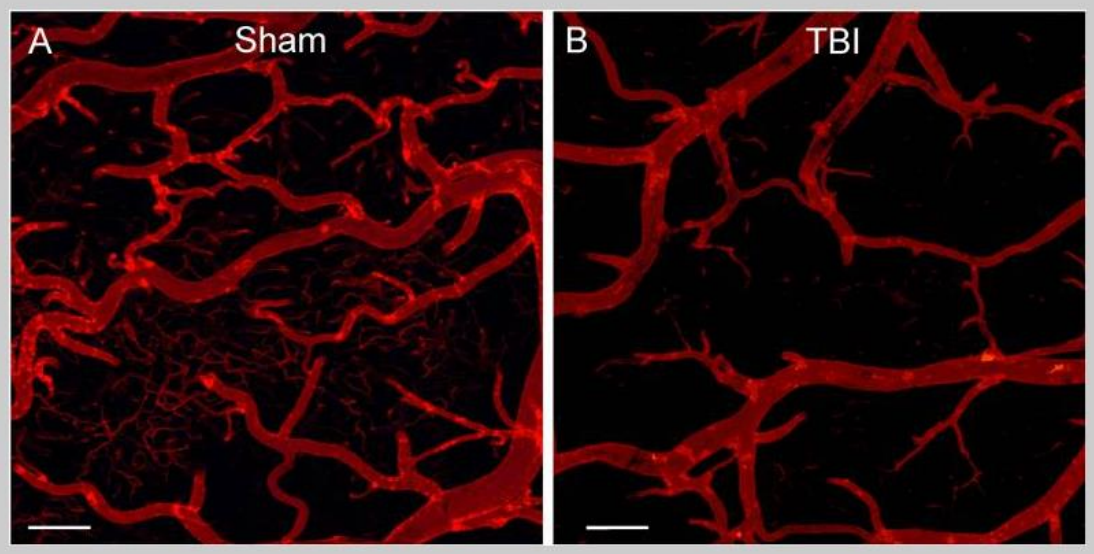
OPEN

Traumatic brain injury results in acute rarefication of the vascular network

Received: 21 July 2016
Accepted: 13 February 2017
Published online: 19 March 2017

Andre Obenaus[1], Michelle Ng[1], Amanda M. Orantes[2], Eli Kinney-Lang[1], Faisal Rashid[1], Mary Hamer[1], Richard A. DeFazio[6], Jiping Tang[3], John H. Zhang[3,4,5] & William J. Pearce[3,7]

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 (naïve, sham-operated, TBI) underwent a moderate controlled cortical impact. Animals underwent vessel painting perfusion to label the entire cortex at 1 day post TBI followed by whole brain axial and coronal images using a wide-field fluorescence microscope. Cortical vessel network characteristics were analyzed for classical angiographic features (junctions, lengths) wherein 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%, 16% 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 exacerbated at the lesion site and provide structural evidence for the bilateral hemodynamic alterations that have been reported in patients after TBI.



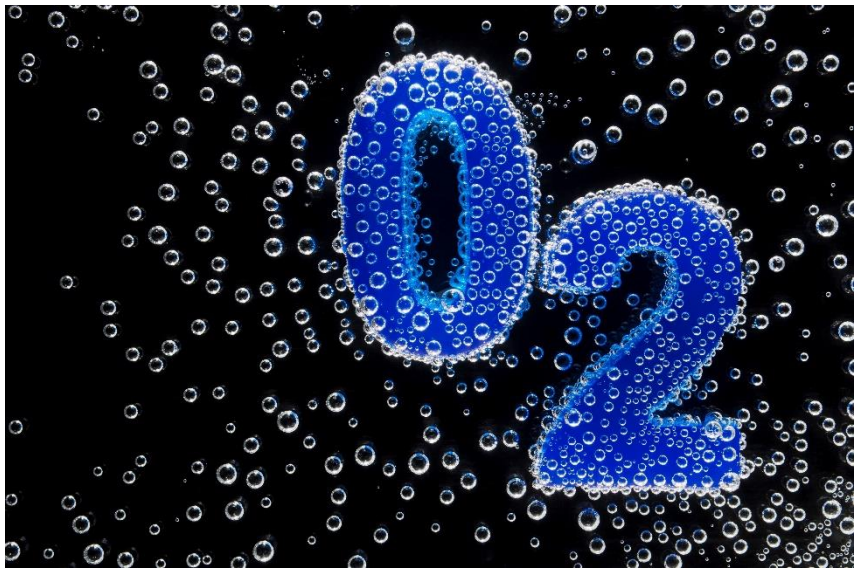
Diffuse brain vascular changes

We Can *TREAT* a Concussion

Acute
Subacute
Acute on Chronic
Chronic

Oxygen + Pressure

Oxygenate tissue—heal
Decrease swelling
Turn off the inflammation

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