



1

DISCLOSURES

- No relevant financial disclosures
- APSF Grant recipient to study cognitive outcomes after concussion

- Also, I **love** football. But I probably won't let my two year old play it
(unless he throws another tantrum, then anything is up for grabs)

2

OBJECTIVES

- Describe the **epidemiology** and health care impact of concussion and traumatic brain injury
- Understand the symptoms, **pathophysiology**, and risks for concussion and post-concussion syndrome
- **Translate** new knowledge to effectively care for patients in the perioperative setting after recent concussion

3

MILD
TRAUMATIC
BRAIN INJURY &
CONCUSSION
DEFINITIONS



4

Traumatic brain injury
(TBI) is a heterogeneous
phenomenon.

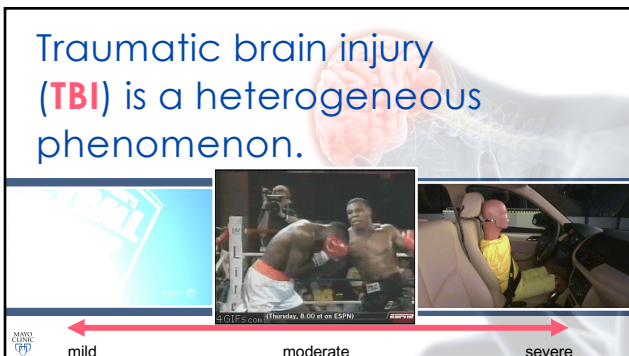
Qualities of the injury that moderate severity, symptoms and outcomes:

MECHANISM	PROTECTION
SEVERITY	PT COMORBIDITIES
LOCATION	RECOVERY



5

Traumatic brain injury
(TBI) is a heterogeneous
phenomenon.



6

This talk will not cover acute perioperative severe TBI

← mild moderate severe →

- Cerebral Edema due to TBI
- Critically elevated intracranial pressure (ICP)
- Loss of airway protection (GCS <8)
- Emergent induction/maintenance of anesthesia

7



8

DEFINITIONS

- **Traumatic brain injury (TBI):** disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury
- **Severity:**
 - Mild: GCS=13-15
 - Moderate: GCS=9-12
 - Severe: GCS=3-8

Concussion: trauma-induced alteration in mental status that may or may not involve loss of consciousness

GLASGOW COMA SCALE*	
Eye Opening	
Spontaneous	4
To sound	3
To pain	2
Never	1
Motor Response	
Obeys commands	6
Localizes pain	5
Normal flexion (withdraws)	4
Abnormal flexion	3
Extension	2
None	1
Verbal Response	
Oriented	5
Confused conversation	4
Inappropriate words	3
Incomprehensible sounds	2
None	1

*https://www.cdc.gov/traumaticbraininjury/index.html. Accessed 1/14/19. Report of the Quality Standards Committee. Neurology 1997;48:581-5

9

RECENT CONCUSSION v. POST-CONCUSSIVE SYNDROME
 A Subtle Difference in Definition

Recent Concussion

- A "recent" head injury occurred that was associated with a clinically diagnosed concussion
- Symptoms from the concussion have resolved

Post-Concussive Syndrome

- A "recent" head injury occurred that was associated with a clinically diagnosed concussion
- However, after some time (usually >10 days), one or more symptoms from the concussion persist for months

https://www.mayoclinic.org/learn/essentials/conditions/post-concussion-syndrome/symptoms/causes/diag-20063102

10

HOW I GOT INVOLVED IN PERIOPERATIVE CONCUSSION
 Football. (No I don't play, but thanks for considering.)

A teenager presented for a knee arthroscopy. His mother and he tell me that he had a hard hit last game two weeks ago and he definitely saw "stars". He had a headache for the next day.



Oct 2018, Vikings v. Rams, from ESPN

11



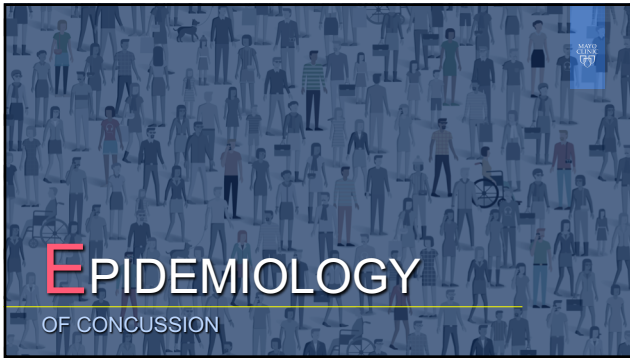
Do I need to wait?

What do I tell the surgeon?

Is there a preferred way to provide anesthesia for this young man?

How common is this?

12



13

Prevalence of Concussion

1.6-3.8 mil.² sports concussions
This does not include concussions due to falls, MVAs, military injuries, or assaults

2.5 million TBIs¹ 2013 ER visits

For perspective, each year:

- **790,000** with acute myocardial ischemia³
- **795,000** with acute stroke⁴

1. <http://www.cdc.gov/TraumaticBrainInjury/index.html> Accessed 1/13/18
 2. Langlois JA, Rutland-Brown W, Wald MM. *J Head Trauma Rehabil.* 2006;21(5):375-378.
 3. Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, et al. Heart Disease and Stroke Statistics—2017 Update: A Report From the American Heart Association. 2017; 135:e1–458. DOI: 10.1161/CIR.0000000000000485
 4. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al., on behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2016 update: a report from the American Heart Association. *Circulation* 2016; 133:e447–529.

14


EPIDEMIOLOGY OF MILD TBI MECHANISMS

Mechanism	Percentage
Falls	47%
Sports/Accidental	15%
Other	15%
MVA's	14%
Assault	8%
Other	1%

15

EPIDEMIOLOGY OF MILD TBI

Falls are the most common cause of concussion in all age groups.



https://www.cdc.gov/mmwr/volumes/66/ss/ss6609a1.htm#T3_down Accessed 1/13/18

16

EPIDEMIOLOGY OF MILD TBI

Mechanisms of TBI by age group

	0-14 y	15-55 y	> 55 y
#1	Falls (54%)	Falls (27%)	Falls (72%)
#2	Unintentionally struck (26%)	Motor Vehicle Accident (23%)	Other/indeterminate (12%)
#3	Other/indeterminate (14%)	Unintentionally struck (17%)	Motor Vehicle Accident (7%)

https://www.cdc.gov/mmwr/volumes/66/ss/ss6609a1.htm#T3_down Accessed 1/13/18

17

EPIDEMIOLOGY OF TBI

Sports-related TBI and Concussion

	HS Males	College Males	HS Females	College Females
Football	0.47	0.61		
Soccer	0.22	0.49	0.36	0.63
Ice Hockey		0.41		0.91
Wrestling	0.18	0.42		
Basketball	0.07	0.27	0.21	0.43

Rates are per 1000 athlete/exposures

Daneshtar DH. Clin Sports Med 2011;30:1-17

18

EPIDEMIOLOGY OF TBI

Gender Differences in NCAA D1 Sports

Mens Sports: out of 1124 reported Concussions

Sport	# (%)	Rate per 1000 athlete/exposures
#1: Football	603 (54%)	0.67
#2: Ice Hockey	224 (20%)	0.79
#3: Wrestling	86 (8%)	1.09
#4: Basketball	84 (7%)	0.39
#5: Soccer	55 (5%)	0.34

Women's Sports: out of 541 reported Concussions

Sport	# (%)	Rate per 1000 athlete/exposures
#1: Soccer	136 (25%)	0.63
#2: Basketball	116 (21%)	0.60
#3: Ice Hockey	85 (16%)	0.75
#4: Volleyball	56 (10%)	0.36
#5: Lacrosse	55 (10%)	0.51

Zuckerman SL. Am J Sports Med 2015;43:2654-62

19

NFL concussions continue to rise
 Jan 26, 2018
 NFL players were diagnosed with more concussions in 2017 than in any season since the league began sharing the data in 2012, according to information released Friday afternoon.

NFL preseason game concussions were up 44 percent in 2018
 Oct 15, 2019
 Chris Cwik
 Yahoo Sports Oct 15, 2019, 3:56 PM

https://sports.yahoo.com/nfl-preseason-concussions-were-up-44-percent-in-2019-205644841.html
 http://www.espn.com/nfl/story/_/id/22226487/nfl-concussions-rise-highest-level-league-began-sharing-data. Accessed 2/1/2019

20

CONCUSSIONS IN THE MILITARY

Blast injuries are commonly assoc. with concussions

- 2525 soldiers returning from Iraq
 - 124 (4.9%) injury with loss of consciousness (LOC)
 - 260 (10.3%) injury with altered mental status (AMS)
 - 435 (17.3%) head injury without LOC or AMS
- Three most common causes:
 - Blast: 388 (34%)
 - Fall: (26%)
 - Motor Vehicle: (12%)
- Risk factors:
 - Younger
 - Junior rank
 - Male

Hoge CW. New Engl J Med 2008;358:453-63

21



22

CONCUSSION: SIGNS & SYMPTOMS
Clinical Manifestations

Consensus Statement on Concussion in Sport—the 4th International Conference on Concussion in Sport Held in Zurich, November 2012

- Symptoms
 - Somatic (HA, nausea, dizziness, fatigue, sensitivity to light and noise)
 - Cognitive (feeling slowed down, feeling mentally “foggy”)
 - Emotional (sadness, nervousness, feeling more emotional)
- Physical Signs (vomiting, balance problems, LOC, amnesia)
- Behavioral Changes (irritability, personality changes)
- Cognitive Impairment (slowed reaction time)
- Sleep Disturbances (change in sleep patterns, trouble falling asleep)

McCrory P. Clin J Sports Med 2013;23:89-117

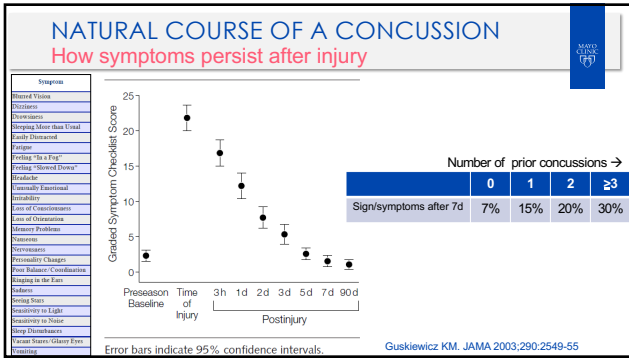
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SIGNS AND SYMPTOMS AFTER CONCUSSION
Most common symptoms

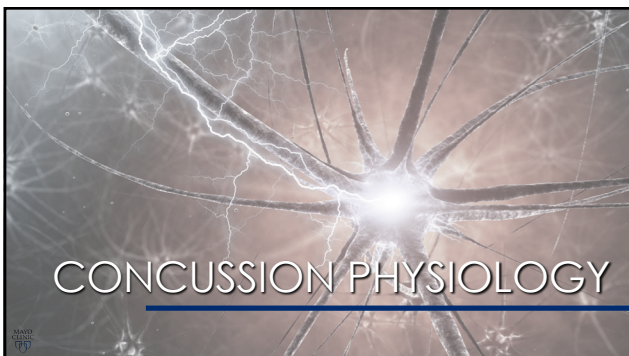
Symptom Recorded	No. of Concussions Resulting in Symptom	Percentage of Concussions Resulting in Symptom
Headache	508	93.4
Dizziness/unsteadiness	406	74.6
Difficulty concentrating	308	56.6
Confusion/disorientation	250	46.0
Vision changes/sensitivity to light	204	37.5
Nausea	157	28.9
Drowsiness	144	26.5
Amnesia	132	24.3
Sensitivity to noise	103	18.9
Tinnitus	58	10.7
Irritability	50	9.2
Loss of consciousness	25	4.6
Hyperexcitability	12	2.2
Other	41	7.5

Meehan WP. Am J Sports Med 2010;38:2405-9

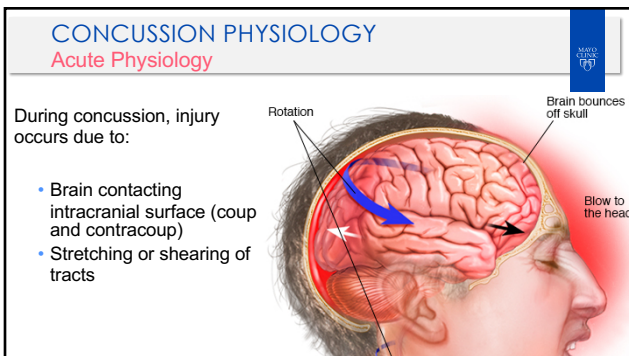
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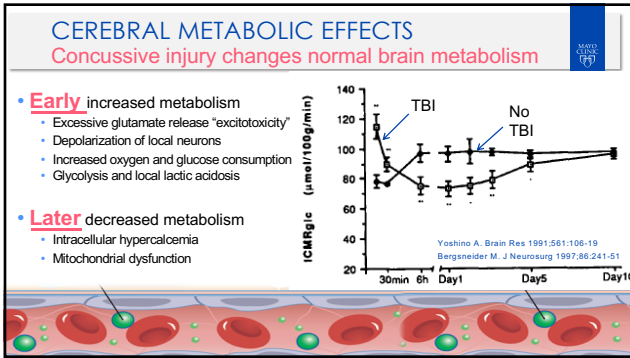
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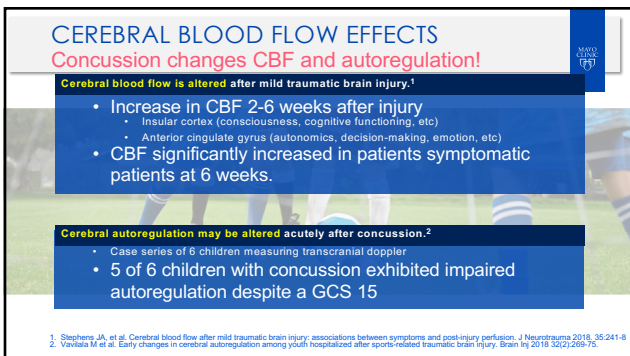
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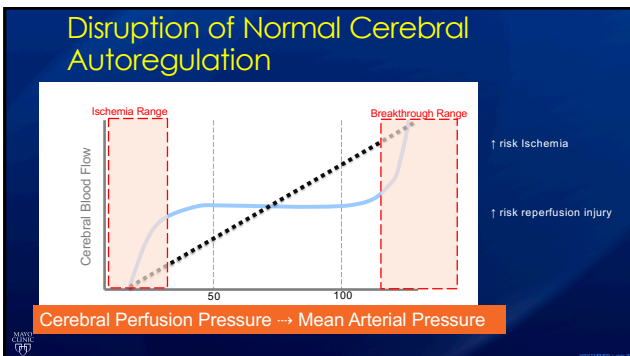
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29



30

Persistence of Concussion Pathophysiology

The neurophysiologic impact of concussion may last for **days to weeks** despite absence or resolution of clinical symptoms.

Stephani JA, et al. Cerebral blood flow after mild traumatic brain injury: associations between symptoms and post injury perfusion. J Neurotrauma 2016; 33:4118

31

Persistence of Concussion Pathophysiology

Brain injuries increase dementia risk, study finds
By Alex Thomson
Health reporter, BBC News
© 11 April 2018

Fann et al. Lancet Psychiatry. 2018 Apr 10

32

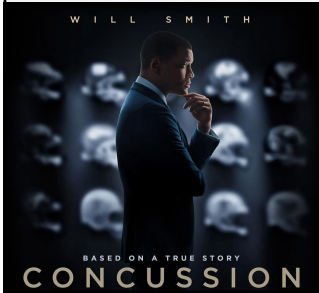
that was a lot of information...let's pause

TAKE HOME POINTS

- Despite "mild" traumatic brain injury, the brain is **not normal** following concussion.
- **Persistence** may be associated with or without symptoms

33

CONCUSSION AFTER CONCUSSION?
The burden of secondary brain injury




WILL SMITH

“Chronic Traumatic Encephalopathy” or CTE

BASED ON A TRUE STORY
CONCUSSION

34

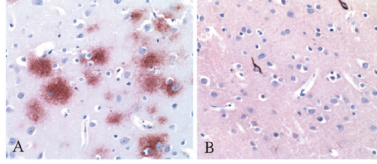
CHRONIC TRAUMATIC ENCEPHALOPATHY
Mike Webster, the sentinel patient of CTE



Mike Webster
Pittsburgh Steelers/
Kansas City Chiefs
Died 2002

SPECIAL REPORT
Omalu B. *Neurosurg* 2005;57:128-34


CHRONIC TRAUMATIC ENCEPHALOPATHY IN A NATIONAL FOOTBALL LEAGUE PLAYER



A B

35

CHRONIC TRAUMATIC ENCEPHALOPATHY



Terry Long
Pittsburgh Steelers
Suicide in 2005 (age 45)

CHRONIC TRAUMATIC ENCEPHALOPATHY IN A NATIONAL FOOTBALL LEAGUE PLAYER: PART II
Bennet L. Omalu, M.D., M.P.H., Steven T. DeGosky, M.D., Ronald L. Hamilton, M.D., Ryan L. Minster, M.S.I.S., M. Ilyas Kamboh, Ph.D., Abdulrezak M. Shakir, M.D., Cyril H. Wecht, M.D., J.D.
Neurosurgery, Volume 59, Issue 5, 1 November 2006, Pages 1086-1093.



FIGURE 1. Photomicrograph (x200) of a section of the frontal neocortex immunostained for a protein, showing frequent NFT and NPs. FIGURE 2. Photomicrograph (x200) of a section of the lower cerebral neocortex stained for a protein, showing frequent NFT and NPs.

36



37

MILD & SEVERE CTE

Lessons from Dr. Omalu's Brain Bank

JAMA | Original Investigation
Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football

Concussion Legacy Foundation "brain bank"

CTE diagnosed by presence of phosphorylated tau lesions in neurons and astrocytes

Stage	Findings
1	1-2 isolated perivascular epicenters of phosphorylated tau protein in cortex
2	Multiple epicenters of phosphorylated tau in cortex
3	Phosphorylated tau along with degeneration of amygdala, hippocampus, and entorhinal cortex
4	Phosphorylated tau distributed throughout brain and brain stem

Stage 1-2: Mild CTE
 Stage 3-4: Severe CTE

38

MILD VERSUS SEVERE CTE

Subtle, but profound differences in outcomes

If you just analyze the football players in the paper:

	MILD CTE	SEVERE CTE
Median age of death	44y (IQR=29-64y)	71y (IQR=64-79y)
#1 cause of death	Suicide (27%)	Neurodegenerative disease (47%)
Sports duration	Mostly high-school & college	Mostly college and professional
Cognitive Symptoms	85%	95%
Behavior/mood problems	96%	89%
Substance abuse	67%	49%
Dementia	33%	85%
Motor symptoms	48%	75%

39

Again, that was a lot of information...so let's pause

TAKE HOME POINTS

- **Repetitive brain injury** after a concussion, results in functional and anatomic changes in the brain.
- These changes carry profound effects on quality of life and mortality

40

Concussion Management

Avoid sedative products:
-Alcohol
- Sleep enhancers

Rest...

Return to play/sports requires clearance by a health professional.

41

THE VULNERABLE BRAIN MAY BE AT RISK DURING:

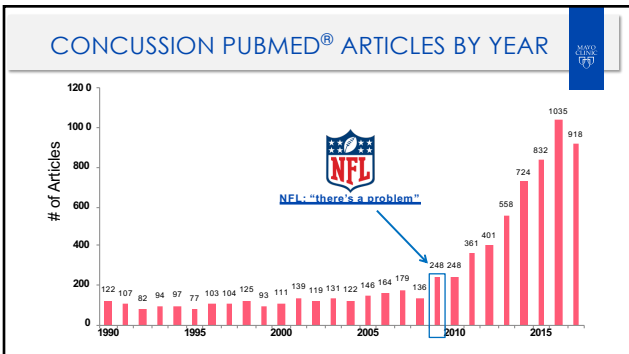
- Hypertension
- Hypotension
- Hypoxia
- Hyperoxia
- Hypercarbia
- Hypocarbia
- Hyperglycemia
- Hypoglycemia
- Hypercoagulation
- Stress response
- Inflammation
- Electrolyte abnormalities
- Impaired venous drainage
- Anesthetic-induced changes in cerebral hemodynamics

Doesn't this sound like the perioperative period?

42



43



44

"ANESTHESIA" + "CONCUSSION" ARTICLES
There's still a paucity!

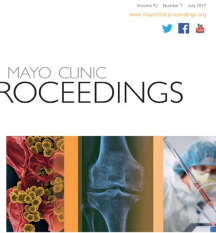
Best matches for anesthesia AND concussion:
[Anesthesia and concussion.](#)
 Tasker RC et al. *Curr Opin Anaesthesiol.* (2017)
[Exposure to Surgery and Anesthesia After Concussion Due to Mild Traumatic Brain Injury.](#)
 Abcejo AS et al. *Mayo Clin Proc.* (2017)

[Anesthesia for the patient with recently diagnosed concussion: think about the brain!](#)
 Rasouli MR, Kavin M, Stache S, Mahla ME, Schwenk ES.
Korean J Anesthesiol. 2019 Jul 1. doi: 10.4097/kja.19272. [Epub ahead of print]
 PMID: 31257815 [Free Article](#)

[Peroperative Care of the Concussed Patient: Making the Case for Defining Best Anesthesia Care.](#)
 Vavilala MS, Ferrari LR, Herring SA.
Anesth Analg. 2017 Sep;125(3):1053-1055. doi: 10.1213/ANE.0000000000002080. Review. No abstract available.
 PMID: 28514323
[Similar articles](#)

45

ABCEJO ET AL, MAYO CLINIC PROCEEDINGS
Anesthesia after recent concussion



- July 1, 2005 – June 30, 2015
- All patients with concussion who required anesthesia within 12 months of concussion
 - Direct care or supervision by MD anesthesiologist
- 1038 patients
- 1820 anesthetics

46

DEMOGRAPHICS
Anesthesia after recent concussion

Characteristics	Entire cohort (N=1038)	Motor vehicle accident (n=375)	Sports (n=209)	Fall (n=367)	Assault (n=87)	P value ^a
Age (y), mean ± SD	39±23	39±21	20±14	50±24	36±20	<.001
Male sex (No. [%])	609 (59)	236 (63)	141 (67)	176 (48)	56 (64)	<.001
Disposition (No. [%])						
Outpatient clinic	186 (18)	18 (5)	91 (44)	64 (17)	13 (15)	
Dismissed from ED	346 (33)	33 (9)	86 (41)	178 (49)	49 (56)	
Admitted via ED	506 (49)	324 (86)	32 (15)	125 (34)	25 (29)	
Timing of concussion diagnosis (No. [%])						
On date of injury	699 (67)	296 (79)	101 (48)	245 (67)	57 (66)	<.001
Within 1 wk after injury	965 (93)	349 (93)	194 (93)	341 (93)	81 (93)	.99
Within 1 mo after injury	1015 (98)	363 (97)	205 (98)	361 (98)	86 (99)	.42

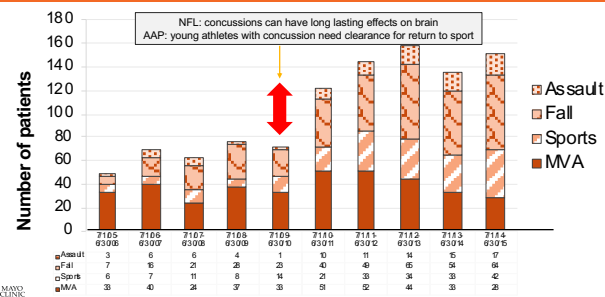
Patients with falls were older; and patients in sports injuries were younger

Concussions occurred in more males, except in falls

Overall, 7% of patients did not have a concussion diagnosis within 1 week of injury (mostly because of other distracting injuries or minor symptoms that did not resolve)

47

Surgery & Anesthesia after Concussion

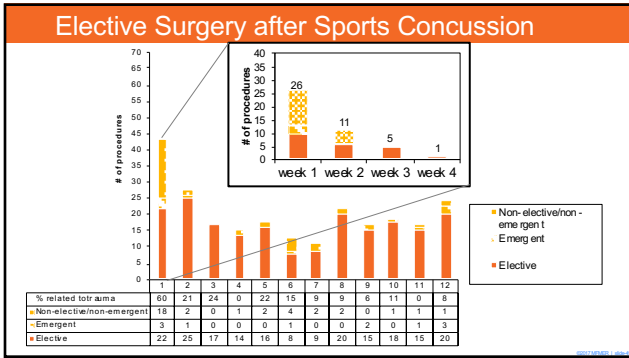


NFL: concussions can have long lasting effects on brain
AAP: young athletes with concussion need clearance for return to sport

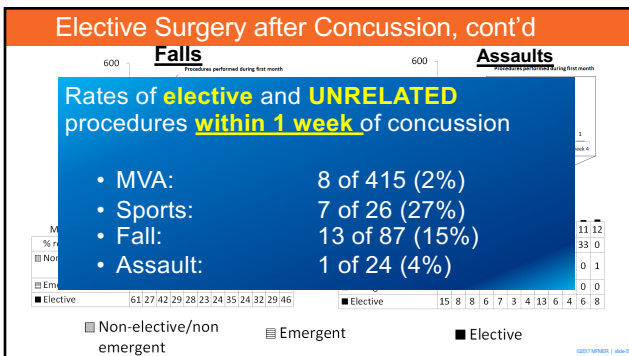
Year	Assault	Fall	Sports	MVA
2006	3	7	6	33
2007	6	8	11	40
2008	6	21	8	24
2009	4	23	14	37
2010	1	23	14	33
2011	0	40	21	38
2012	11	49	33	52
2013	14	45	34	41
2014	5	56	33	38
2015	7	64	33	28

Alcega, Pasternak, et al. Mayo Clinic Proceedings 2014

48



49



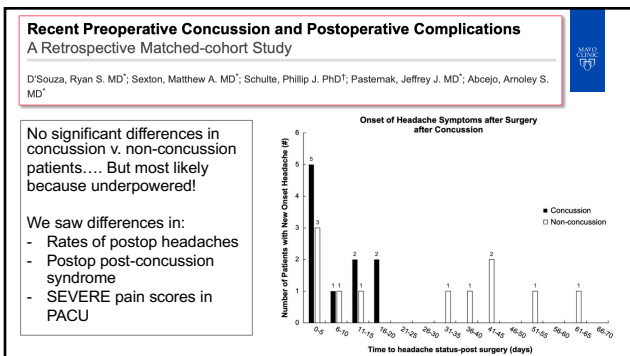
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51



52



53



54

NOW BACK TO THIS PATIENT FROM THE BEGINNING
 What should I say to him and his family?

A teenager presented for a knee arthroscopy. His mother and he tell me that he had a hard hit last game two weeks ago and he definitely saw "stars". He had a headache for the next day.

"Should we do the surgery?"

55

Recommendations

- Be aware of the physiologic **aberrations** in cerebral autoregulation, cerebral blood flow and cerebral metabolism after recent concussion
- Consider **delaying** elective procedures after recent concussions (<3 weeks??) or if concussive symptoms persist
- Consider **screening** for concussive symptoms in patients with recent head injury (<3 months)

56

Concussion/ Post-Concussion Symptoms

Adult Concussion	Child & Adolescent Concussion
<ul style="list-style-type: none"> • Headaches, dizziness, nausea/vomiting, lack of awareness • Incoordination • Delayed verbal expression • Inability to focus • Disorientation • Memory deficits • Speech impairment 	<ul style="list-style-type: none"> • Headache • Confusion & disorientation • "Blank stare" • Inattentiveness • Dizziness • Gait abnormalities • Nausea/vomiting • Emotional lability

57

SCAT5 – SCREENING TOOL
On-field Screen for Concussion

- 5 Major Assessments
 - Patient Concussion History
 - Symptom Evaluation
 - Cognition Screen
 - Neurologic Screen
 - Delayed Recall

58

Concussion & Anesthesia
Future Direction

59

IN SUMMARY,

- Concussion = a heterogeneous disease state
 - = a public health issue
 - = vulnerable brain
- Perioperative arena = a potential time for secondary injury
- Watch out for concussion and recent mild TBI!!
(not all concussions are due to sports!)
- Future studies are warranted!!

60



61
