

Sports Related Concussion: Physiology, and Long Term Consequences – Controversies and Questions

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Objectives

- Definitions
- History
- Physiology
 - sport
- Risk Factors
- One controversy in therapy
- Second Impact
- CTE
- Caveat: what will not cover!
 - My philosophy

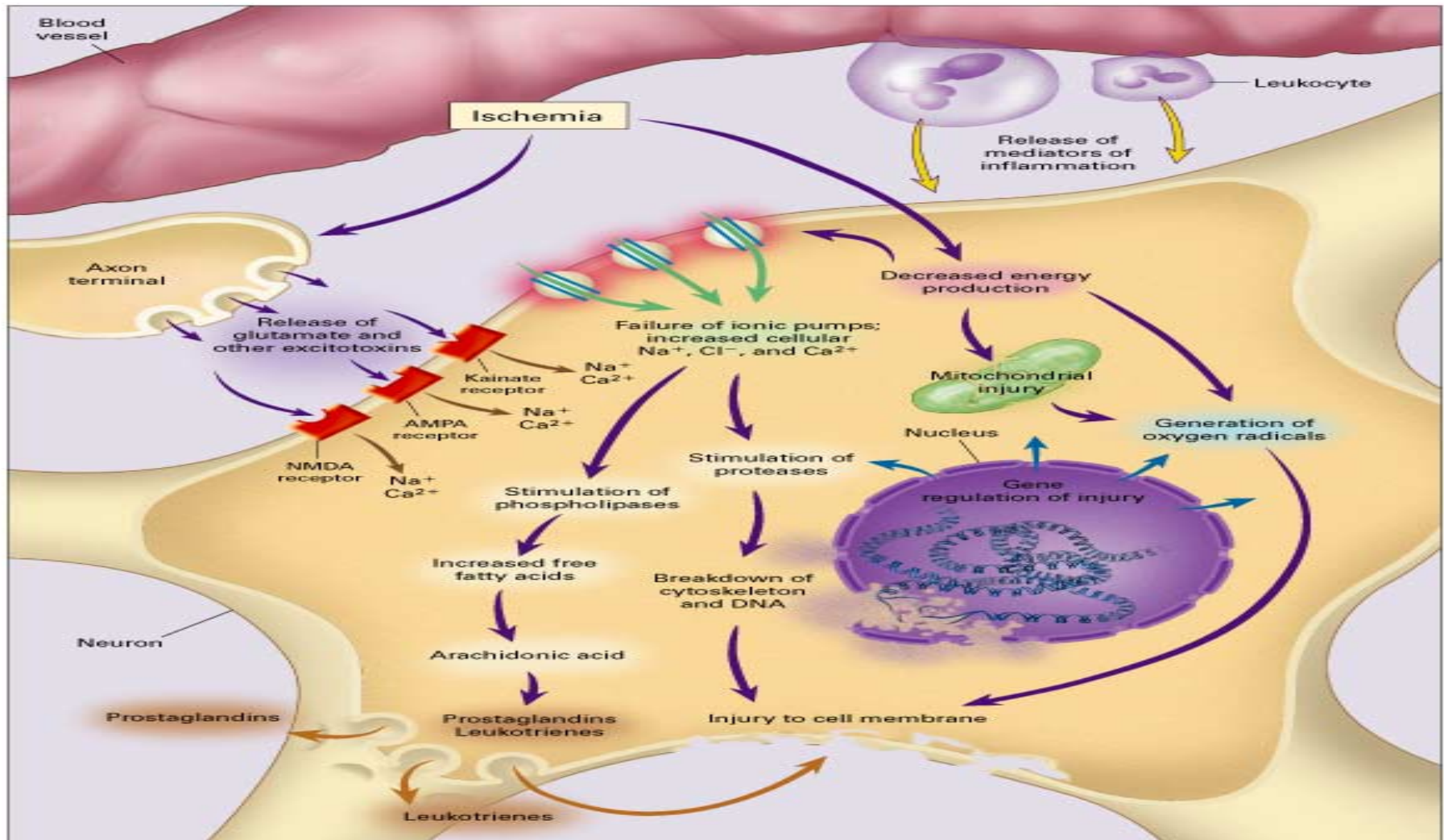


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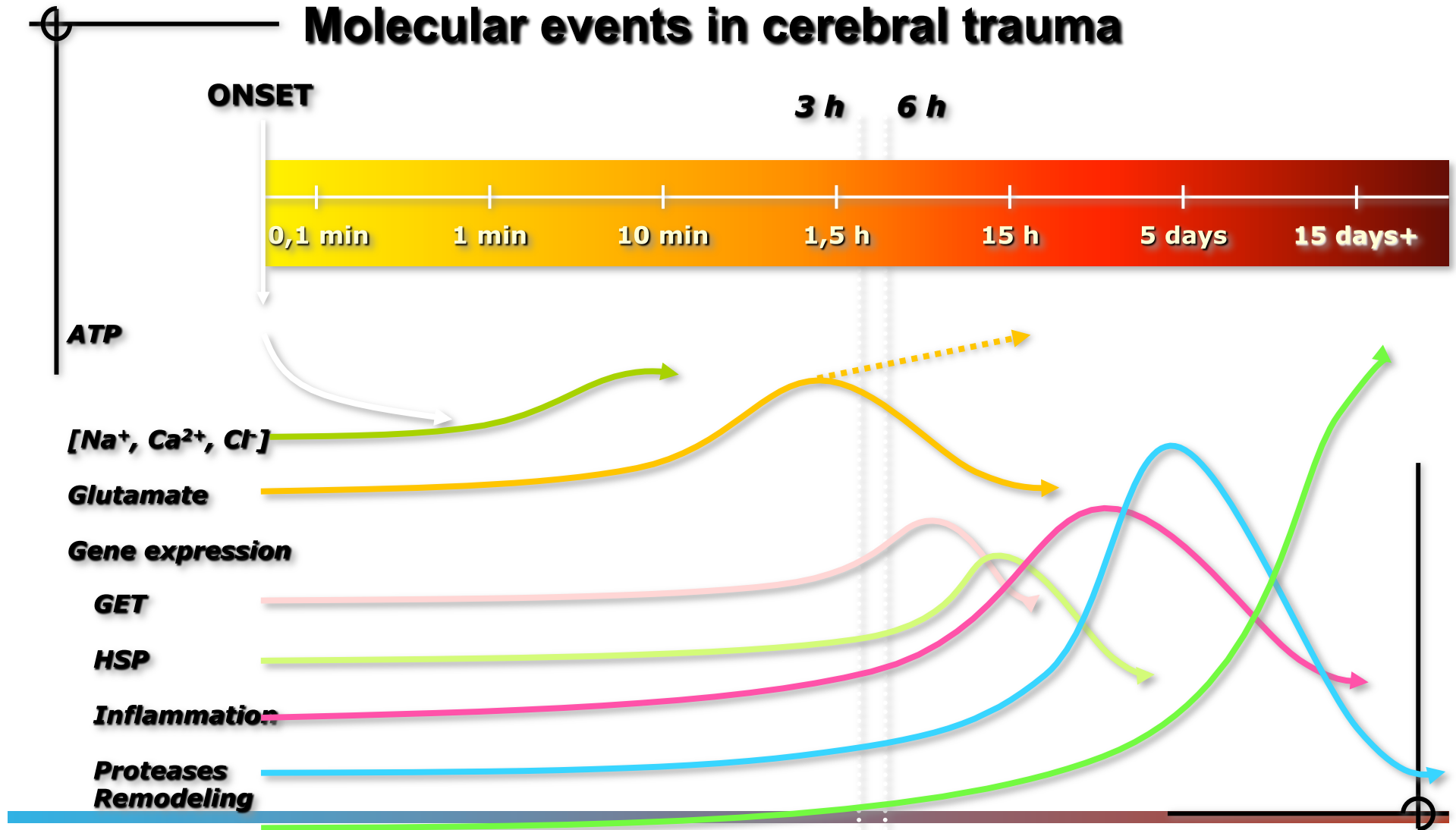
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Most complicated disease in most complicated organ



Molecular events in cerebral trauma



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Type of sport

- 300,000 ED visits per year- 60 % increase
- Sports and bicycle injury account for 26% of all mild TBI
- Highest risk: American football and Australian rugby, ice hockey
- Low risk: volleyball, softball, baseball
- Females: Soccer



Faul et al CDC 2010



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Boxing

- Sport with highest rate of TBI
- Risk factors – career length, number of bouts, poor showings in the ring, ApoE genotype
- Preventative measures
 - Guidelines for determining when a player should return to play after knockout
 - Improved monitoring by referee and an onsite physician
 - education of public and athletes of risk of sport



Caveats: Youth and Professional

- The immature brain
- Limitations in studies-drawing from older athletes
 - The natural selection process
- The exposure to trauma is greater the earlier it starts
- Clinical insufficient evidence



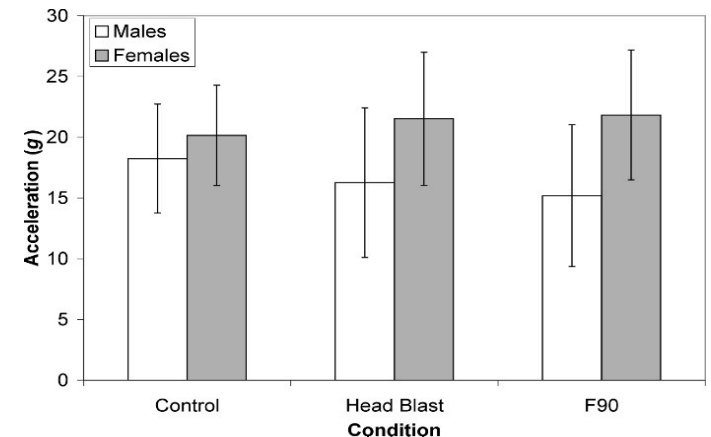
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Effect of Gender on Concussion

- Females appear to do worse
- Females concussions caused by ball or surface contact
- Hormonal factors
- Cultural expectations
- Increased head to neck peak acceleration-isometric strength, neck girth and head mass
- Evidence highly probable higher soccer and basketball



Tierney et al

The Role of Concussion History and Gender in Recovery from Soccer-Related Confusion. Am J Sports Med, May 21. Colvin, Mullen, Lovell, Collins et. al.

Dick R et al. Brit Journal Sports Med 2009



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Prevention of Concussions

- 3 strong mouth guards studies- do not prevent concussion
- Delaney et al
- 2 class I studies suggesting an impact of protective headgear on rugby related concussion



Delaney JS, Al-Kashmiri A, et. al. The effect of protective headgear on head injuries and concussions in adolescent football (soccer) players.

Br. J. Sports Med. 2008; 42; 110-115.



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Impact test comparisons of 20th and 21st century American football helmets.Bartsch A, Benzel E, Miele V, Prakash V.Source



Displace force over a larger surface area

Monitoring studies- many more impacts

Crown direct impacts

Until recently data insufficient to support or refute superiority of one helmet over another



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Collision type and Player Anticipation affect Head injury severity among youth hockey players

Milhaik et al Pediatrics 2010

- 16 players +/- age 14 instrumented helmets- 54 game season
- Measure linear and rotational acceleration
- Open ice versus against boards
- Anticipation
- Open ice collisions much higher force
- Anticipated collisions- less severe impact



Is it just practice and playing style Highest risk sports

- Force of hits in Practice
- Number of hits in practice
- Oklahoma drills
- **A 7-year review of men's and women's ice hockey** Angel et al Can J Surg 2009
- **High percentage of injuries in practice**



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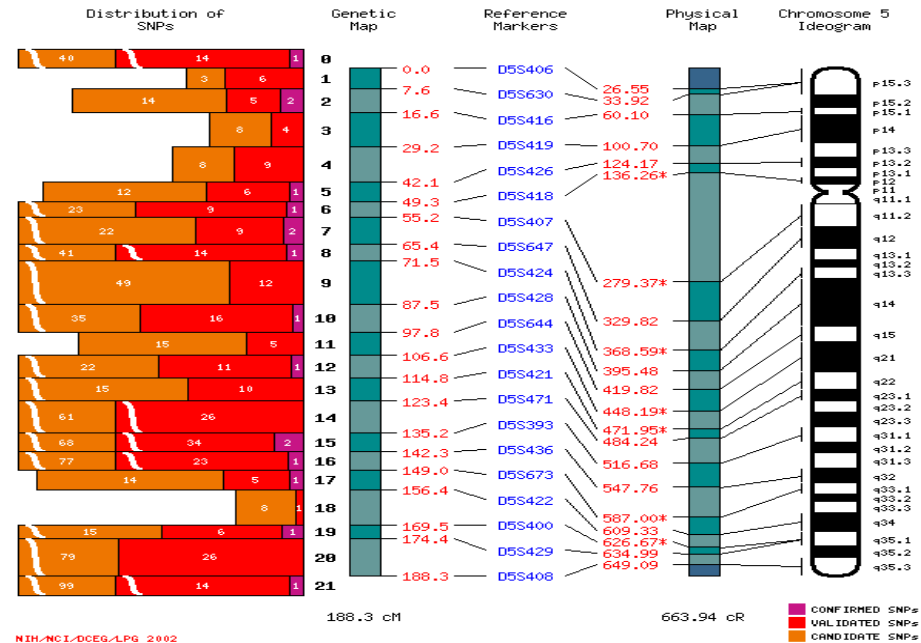
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Genetics

- **ApoE4** is associated with an increased risk for Alzheimer's Disease ?? Concussion.
- One study claimed a 3x greater risk of concussion in athletes with the **APOE promoter G-219T TT genotype**. Clin J Sport Med. 2008 Jan;18(1):10-7. Terrell TR, et.al.
- However, a prospective study of 318 patients did not find any support for an association between the apolipoprotein E4 gene and risk of concussion: Clin J Sport Med 2008 18:322-328, Kristman et. Al
- **CACNA1A gene** (calcium channel submit) ion channelopathy

Clin J Sport Med. 2008 Jan;18(1):10-7. Terrell TR, et.al.; Clin J Sport Med 2008 18:322-328, Kristman et. al



Jordan et al Boxers
Multiple exposures

DrD2 DAT, ANKK1*, COMT,



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Functionally-Detected Cognitive Impairment in High School Football Players Without Clinically-Diagnosed Concussion Talvadge et al J NeuroTrauma 2010

- (HIT system), neurocognitive testing (ImPACTTM), and functional MRI (fMRI).
- Longitudinal assessment (including baseline)
- High school football players-those with concussion and those with no clinically diagnosed concussion
- Third concerning group with no diagnosis of concussion but multiple hits on HIT measures and noted working memory and abnormalities in DLPFC



Effect of Previous Concussion on Future Injury

- Athlete with a history of prior concussion has a greater risk of sustaining a second concussion by a risk factor of 1.5 – 5.8
- Effect of a second or more concussion on neurocognitive testing is less clear
- 10 day risk –Class I and Class II

Am J Sports Med. 2009 May 21. The Role of Concussion History and Gender in Recovery From Soccer-Related Concussion. [Colvin AC](#), [Mullen J](#), [Lovell MR](#), [West RV](#), [Collins MW](#), [Groh M](#).



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Problems problems (Iverson et al)

TABLE 23-4
Percentages of subjects endorsing symptoms at a mild or moderate-severe level (British Columbia Postconcussion Symptom Inventory.)

ITEMS	HEALTHY COMMUNITY VOLUNTEERS		PATIENTS WITH DEPRESSION		PATIENTS WITH FIBROMYALGIA	
	MILD	MODERATE- SEVERE	MILD	MODERATE- SEVERE	MILD	MODERATE- SEVERE
Headaches	19.6	3.2	59.4	28.1	72.2	37.0
Dizziness/light-headed	11.4	1.3	31.2	10.9	37.0	7.4
Nausea/feeling sick	13.3	0.0	40.6	10.9	35.2	18.5
Fatigue	27.8	5.1	85.6	57.8	96.3	79.6
Extra sensitive to noises	11.4	1.3	50.0	18.8	68.5	44.4
Irritable	21.5	5.1	76.6	35.9	53.7	25.9
Sadness	18.4	1.3	76.6	56.3	55.6	33.3
Nervous or tense	16.5	1.3	65.6	35.9	59.3	33.3
Temper problems	15.8	5.1	37.5	15.6	27.8	7.4
Poor concentration	16.5	3.2	78.1	46.9	75.9	44.4
Memory problems	13.3	3.8	70.3	42.2	74.1	44.4
Difficulty reading	8.2	1.9	40.6	23.4	48.1	24.1
Poor sleep	22.8	5.1	78.1	53.1	87.0	59.3

Healthy adults (N = 158), patients with depression (N = 64), and patients with fibromyalgia (N = 54). Patients with depression were diagnosed by their family physician or psychiatrist, and their diagnosis was confirmed using the SCID-I. Their average age was 41.1 years (SD = 12.5), and their average education was 14.6 years (SD = 3.2). Approximately 71% of the sample was female. The patients with fibromyalgia were mostly women (94%). Their average age was 51.4 years (SD = 12.8, Range = 17 - 75). Their average education was 13.5 years (SD = 2.4, Range = 7 - 20)

Outcome TRACK-TBI study

- McMahon et al
- 375 mTBI subjects
- Followed from ED
- At 3 months 33% functionally impaired on GOS-E
- At 1 year 22.4% with functional status impairment

McMahon et al J Neurotrauma 2013



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Early Rest ??? – the rules-- do we know?

- True rest??
- No school
 - School collaboration
- No practice
- No computer/
Video games



Concussive seizures

- McCorry et al
- Impact oriented
- Probably non epileptic
- Assure no other cause
- No anticonvulsant treatment warranted
- Prolonged absence not needed



Neuroendocrine dysfunction

- Kelley et al J Neurotrauma 2014
- 68 subjects evaluated
- Poor QOL
- Associated with Hormonal disturbance
- Growth Hormone(19%)
- Testosterone(9%)
- Metabolic syndrome(50%)
- Associated sexual dysfunction
- Not associated with number of concussions
- Not associated - years as a professional



Amateurs and Heading the ball???

- 4 class 1 describe an association
- 5 class I studies do not show an association
- Unclear Class II data ie heading the ball in soccer- prof versus amateur
- ? Exposures- Lipton et al



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Pathology

- Perivascular foci of p-tau- immunoreactive tangles and neurofibrillary tangles
- *Irregular cortical p-tau- depth of cerebral sulci
- Clusters of astrocytic tangles in cortex, BG and brainstem
- Superficial layers
- 68/85 subjects

McKee et al



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Clinical Chronic Traumatic Encephalopathy

Variable	All Symptomatic		
	Subjects (N=33)	Behavior/Mood Group (N=22) ¹	Cognition Group (N=11) ¹
Cognitive Features			
Memory Impairment	84.8%	77.3%	100%
Executive Dysfunction	78.8%	72.7%	90.9%
Attention & Concentration Difficulties	72.7%	63.6%	90.9%
Language Impairment	57.6%	54.5%	63.6%
Visuospatial Difficulties	54.5%	54.5%	54.5%
Behavioral Features			
Explosivity	57.6%	72.7%*	27.3%*
Impulse Control Problems	45.5%	54.5%	27.3%
"Out of Control"	51.5%	63.6%*	27.3%*
Physically Violent	51.5%	68.2%*	18.2%*
Verbally Violent	48.5%	73.6%*	18.2%*
Disinhibited Speech	0%	0%	0%
Disinhibited Behavior	3.0%	0%	9.1%
Socially Inappropriate	3.0%	0%	9.1%
Paranoia	18.2%	22.7%	9.1%
Mood Features			
Sadness/Depression	63.6%	86.4%*	18.2%*
Anxiety/Agitation	15.2%	13.6%	18.2%
Manic Behavior/Mania	3.0%	4.5%	0%
Suicidal Ideation/Attempts	30.3%	31.8%	27.3%
Hopelessness	63.6%	72.7%	45.5%
Apathy	6.1%	9.1%	0%

Behavior/ Mood
Younger??

Cognition
Older??

Neurology 2013



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CTE stages

Stern et al

- CTE- Behavioral variant
- CTE- Mixed
- CTE- Memory

Jordan et al

- Improbable
- Possible
- Probable



Modern CTE in athletes

	McKee	Omalu	Hazrati	NIH	Total	Percent
Number of autopsy cases	61	17	6	1	85	-
Pure CTE neuropathology	15	2	0	0	17	20.0
CTE + other neuropathology	31	9	3	1	44	51.8
Neuropathology but no CTE	0	1	3	0	4	4.7
No neuropathology	15	5	0	0	20	23.5

Gardner and Iverson 2013



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Prior concussion in professional athletes

- Link to depression
 - 1-2 concussions 1.5x
 - >3 concussions 3x
- Link to mild cognitive impairment and self reported memory dysfunction
- Earlier age of AD
 - Guskiewicz et al

Recording and estimation



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Suicide

- Complex issue and concerns
- Since 2011-2013 – 6 deaths from suicide- former NFL players
- 1960-2007-9 cases
- Men higher
- Men in 50's greatest risk
- Causal relationship difficult
- Chronic Pain-48.6% in survey- Schwenk et al
- Opioid utilization- 52% history of use
- Anabolic steroids
- Psychosocial
- *** Circular logic- Petito Principii



Concussion Conclusions

- Concussion is a complex metabolic event-associated with energy crisis
- Probably very early activation is not helpful and could be harmful
- Younger athletes require more caution
- Long term concerns need further definition
- AAN guidelines available
- Lots of fundamental questions exist!

