Chronic Traumatic Encephalopathy in the Black Community

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July 21, 2022, 12:00 PM

SAMHSA
Substance Abuse and Mental Health Services Administration

MHTTC
Mental Health Technology Transfer Center Network
Funded by Substance Abuse and Mental Health Services Administration

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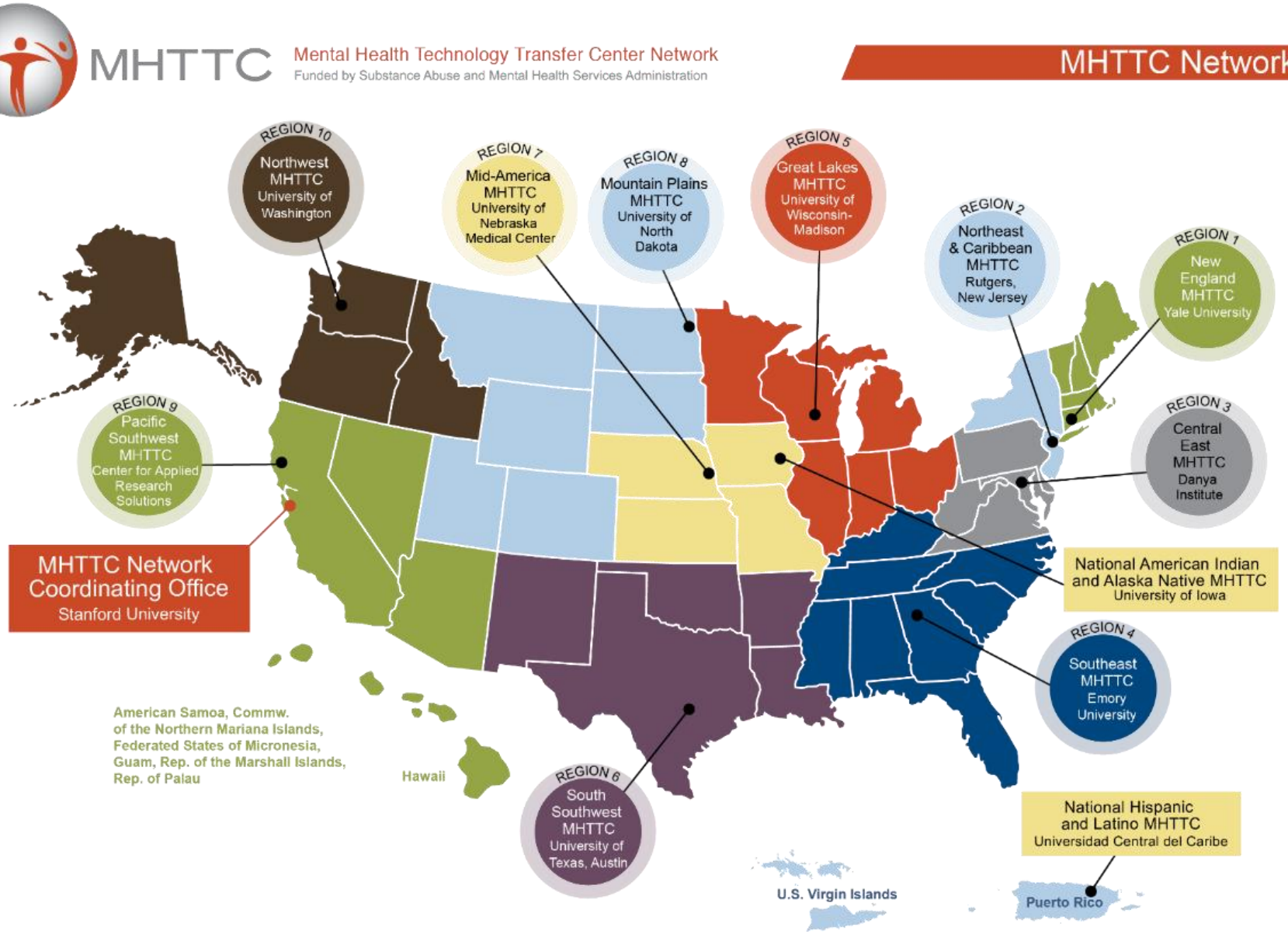
The purpose of the MHTTC Network is technology transfer - disseminating and implementing evidence-based practices for mental disorders into the field.

Funded by the Substance Abuse and Mental Health Services Administration (SAMHSA), the MHTTC Network includes 10 Regional Centers, a National American Indian and Alaska Native Center, a National Hispanic and Latino Center, and a Network Coordinating Office.

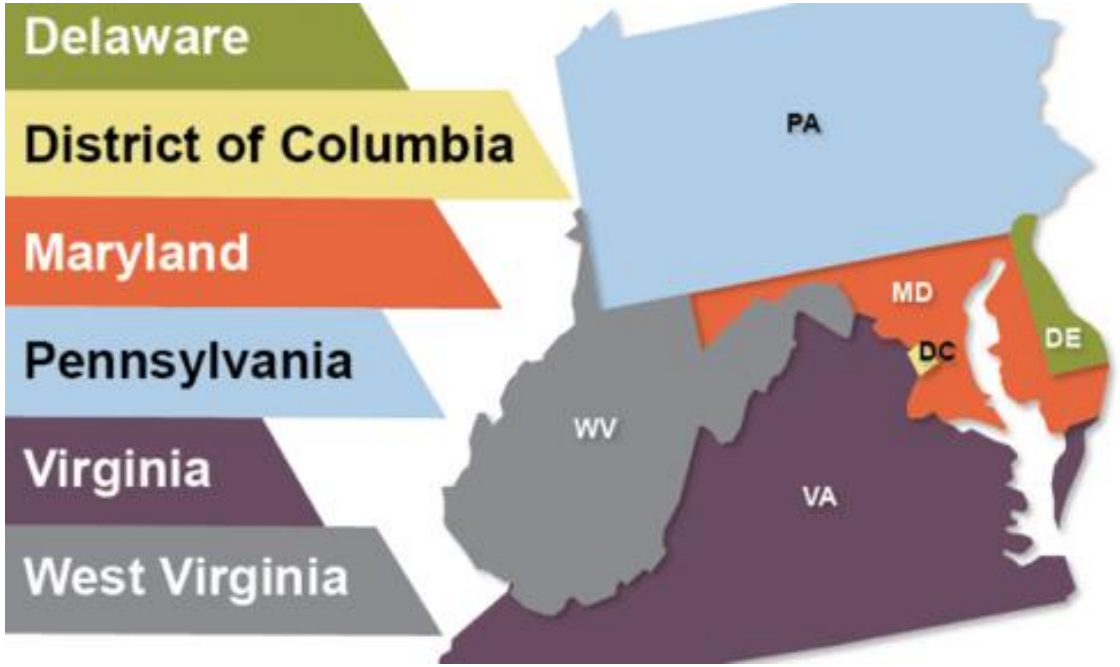
Our collaborative network supports resource development and dissemination, training and technical assistance, and workforce development for the mental health field. We work with systems, organizations, and treatment practitioners involved in the delivery of mental health services to strengthen their capacity to deliver effective evidence-based practices to individuals.
Our services cover the full continuum spanning mental illness prevention, treatment, and recovery support.

SAMHSA
Substance Abuse and Mental Health Services Administration

MHTTC Network



Central East Region 3



Central East (HHS Region 3)

MHTTC Mental Health Technology Transfer Center Network

Funded by Substance Abuse and Mental Health Services Administration

The MHTTC Network uses affirming, respectful and recovery-oriented language in all activities. That language is:

- Strengths-based and hopeful
- Inviting to individuals participating in their own journeys
- Person-first and free of labels
- Inclusive and accepting of diverse cultures, genders, perspectives, and experiences
- Non-judgmental and avoiding assumptions
- Respectful, clear and understandable
- Healing-centered and trauma-responsive
- Consistent with our actions, policies, and products

Adapted from: https://mhcc.org.au/wp-content/uploads/2019/08/Recovery-Oriented-Language-Guide_2019ed_v1_20190809-Web.pdf

Acknowledgment

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At the time of this publication, Miriam E. Delphin-Rittmon, Ph.D, served as Assistant Secretary for Mental Health and Substance Use in the U.S. Department of Health and Human Services and the Administrator of the Substance Abuse and Mental Health Services Administration.

The opinions expressed herein are the views of the authors and do not reflect the official position of the Department of Health and Human Services (DHHS), SAMHSA. No official support or endorsement of DHHS, SAMHSA, for the opinions described in this document is intended or should be inferred.

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Presented 2022

Chronic Traumatic Encephalopathy in the Black Community

Thursday, July 21, 2022

Presenter: Benjamin Roy, MD

Moderator: Annelle Primm, MD, MPH

Council of Elders, Black Psychiatrists of America

COVID-19: An Unprecedented Disaster

- Over 1M deaths since 2020, with disparate levels of mortality, illness, disability and economic fallout in Black and other racially marginalized communities
- As a result of the pandemic, people with traumatic brain injury (TBI) avoided medical care, and received fewer rehabilitative services with the increase in use of telemedicine for remote rehabilitative therapy
- This pattern was superimposed on pre-existing racial disparities in TBI care

Today's Program

- Special thanks to the CE-MHTTC for its support of this session of the Black Psychiatrists of America Health Equity Webinar Series
- Focus is regional on DE, MD, PA, VA, DC, and WV, yet information has national relevance
- Ben Roy, MD, Immediate Past President of the Black Psychiatrists of America, is our featured speaker

Epidemiology of Traumatic Brain Injury

- 2.8 Million Americans suffer TBI each year
- 300,000 sports-related TBI each year
- Approximately 21,000 TBI go undiagnosed each year
- 56,000 TBI-related deaths each year
- Causes of TBI
  - 80% falls (in psychiatric population neuroleptics correlate with falls)
  - 60% self-inflicted
  - 56% striking objects
  - 24% motor vehicle accidents
  - 18% assaults
- TBI-Related Deaths
  - Homicide for infants up to age 4
  - Motor vehicle accidents ages 15 to 24
  - Self-harm ages 45 to 64
  - Falls ages 65 and older

Adult and Pediatric Glasgow Coma Scales

- Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974; 2:81-84
- Holmes JF et al. Performance of the pediatric Glasgow coma scale in children with blunt head trauma. Acad Emerg Med 2005; 12:814
- Grade scores assigned to three core behaviors and their responses:
  - Eye opening response (spontaneous > to speech > to pain > no response)
  - Verbal responses (oriented x 3 > malapropisms > incomprehensible > no response)
  - Motor responses (to commands > to pain > > decorticate (flexion) > decerebrate (extension)) > no response
- **Ohio State University Research Criteria Traumatic Brain Injury Identification**

Concussion Grading Systems

Concussion Grade	2001 Cantu Grading System	1991 Colorado Medical Society Guidelines	1997 American Academy of Neurology Guidelines
Grade 1	No loss of consciousness Posttraumatic amnesia or Post-concussion signs < 30 min	Transient confusion No loss of consciousness No posttraumatic amnesia	Transient confusion No loss of consciousness Concussion signs < 15 min
Grade 2	Loss of consciousness < 1 min Posttraumatic amnesia or concussion > 30 min but < 24 hours	No loss of consciousness Confusion with posttraumatic amnesia	No loss of consciousness Post-concussion signs > 15 min
Grade 3	Loss of consciousness > 1 min Posttraumatic amnesia > 24 hours Post-concussion signs > 7 days	Loss of consciousness	Loss of consciousness

Fencing Response of Traumatic Brain Injury

Donald Parham injury, Chargers vs. Chiefs, Thursday Night Football, 12/16/21 (snippet)

Biomechanics and CTE

- Contact
- Head Motion: linear and rotational forces contribute to concussion
  - Linear acceleration-deceleration
  - Rotation acceleration – accounts for loss of consciousness; effect is below the cortex (white matter is stiffer than gray matter; the hemispheres move but the brain stem does not)
  - Angular acceleration – neck too weak to keep the head stable (children, elderly , and unconditioned especially)
- Impulsive head motion –
  - Momentum of the head is the product of mass (kg) and velocity (m/s): $p = mv$
  - Impulse refers to the force (Newton) acting on the head over time (s), (Ft) that changes its velocity and therefore its momentum: $Ft = m\Delta v$ or $I = Ft = \Delta p$
    - $N \cdot s = kg \cdot m/s$
    - $F = \Delta p/\Delta t = m\Delta v/\Delta t = ma$ (Newton's Second Law)

Biomechanics of Traumatic Brain Injury

- Research into motor vehicle crashes in which the head accelerates and decelerates describe the forces acting on the head in multiples of gravity (g). Normal gravitational force at rest is 1g. Changes in acceleration or direction of speed increase g relative to the rate of change[1].
- Three dimensional space is represented by three axes each with its own g - force: front-to-back (gx), left-to-right (gy), and up-to-down (gz). When gx forces increase, the body is pulled forward or pinned to the seat; gy forces push the body up against the side of the car (such as when riding a roller-coaster). When an increase in gz force occurs, the body will feel heavier.
  - [1] Tillery B. *Physical Science: Physics Customized*. New York: McGraw Hill, 2002.

- **Rotation or angular acceleration induces the most severe injuries, i.e., subdural hematoma, concussion bruises, and diffuse axonal injury** but not epidural hematoma which is usually a consequence of skull fracture[2].
- Diffuse axonal injury occurs at angular acceleration above 10 krad/s^2 at change in rotational velocity greater than 100 rad/s.
  - [2] Gennarelli TA & Thibault LE. Biomechanics of acute subdural hematoma. J. Trauma 1982; 22 (8):680-686.

Gross Neuropathology of TBI

- Skull Fracture – Epidural Hematoma
- Contusion
- Subdural Hematoma
- Subarachnoid Hemorrhage
- **Diffuse Axonal Injury**

History of Chronic Traumatic Encephalopathy
Postconcussional Syndrome F07. 81 (ICD-10)

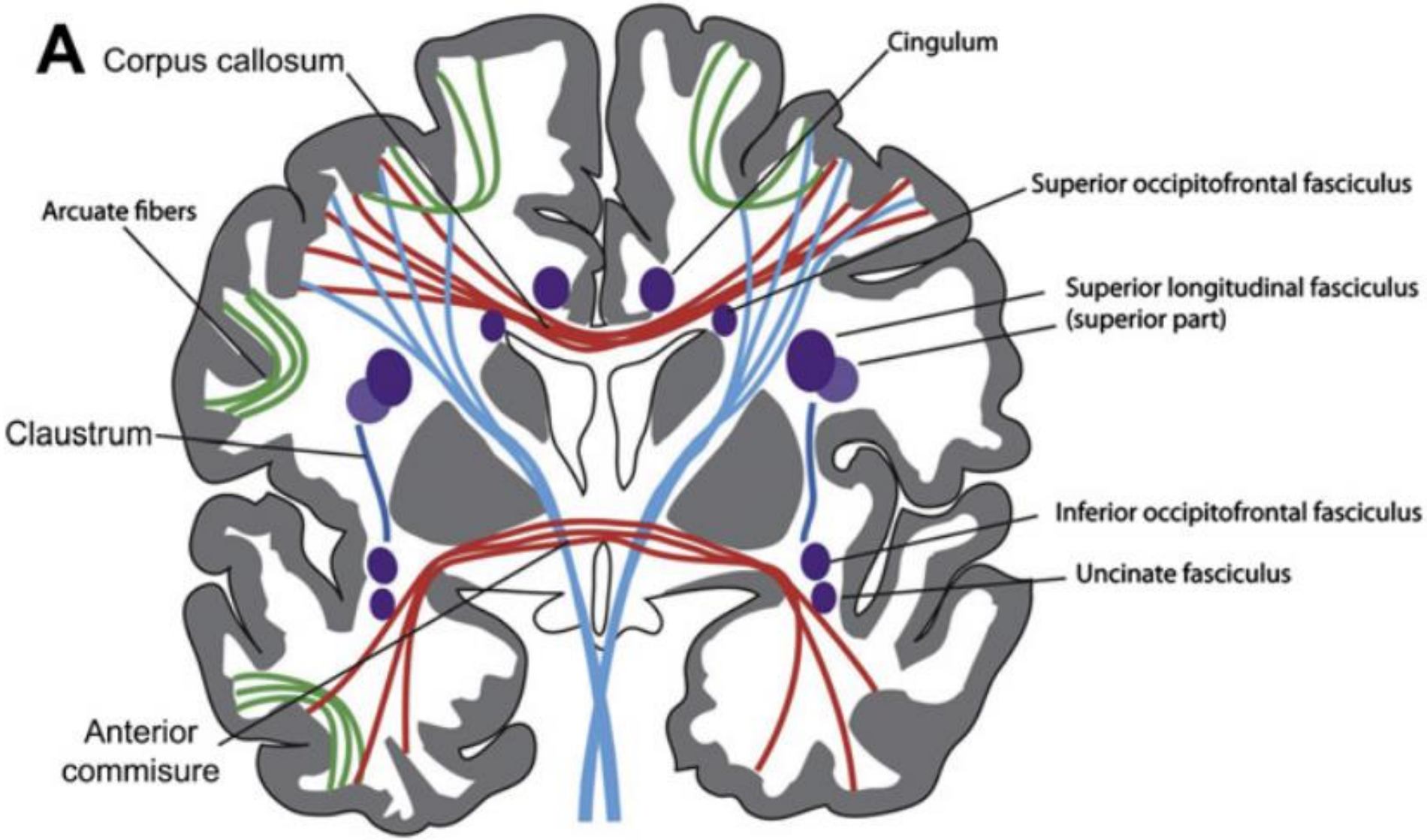
- 1928: Harrison Martland decribed “punch drunk” mental status in boxers
- 1937: J A Millspaugh named it *dementia pugilistica*
- 1949: Macdonald Critchley coined the term “chronic traumatic encephalopathy”
- 1969: A H Robert reports neurological impairment in retired fighters
- 1969: John Corsellis describes the pathology of CTE
- 2005: Bennett Omalu reported postmortem findings of CTE in NFL player Mike Webster (subject of 2015 film *Concussion*)
- 2017: Ann McKee finds 86% of 177 NFL brains displayed CTE

CTE is a Chronic Neurodegenerative Disease

- CTE is a post-mortem diagnosis
- Hyperphosphorylated tau in sulci and peri-vascular regions
- Microgliosis
- Astrogliosis
- spindle-shaped and threadlike neutrophil neuritis
- Apoprotein (Aβ) – Alzheimer's Disease
- Transactive Response (TAR) DNA-binding protein 43 kDa (TDP-43) – Amyotophic Lateral Sclerosis and Frontotemporal Lobar Degeneration

White Matter Anatomy

Wycoco V et al. White matter anatomy. What the radiologists need to know. Neuroimag Clin N Am 23 (2013) 197–216



CTE Neuropathological Stages

	P-TAU	TAR DNA-BINDING PROTEIN 43 (TDP-43)	GROSS ANATOMY
Stage I	Focal neurofibrillary tangles (NFTs)	Perivascular and periventricular inclusions in cortex, medial temporal lobe, and brain stem	Enlarged ventricles
Stage II	Multiple neurofibrillary tangles	Neuronal cytoplasmic inclusions in cortex, medial temporal lobe, and brain stem	Enlarged third ventricle and cavum septum pellucidum
Stage III	Dense NFTs in temporal lobe, hippocampus, amygdala, and entorhinal cortex	"	Cortical atrophy and loss of melanin in locus coeruleus and substantia nigra
Stage IV	Hippocampal sclerosis, gliosis, and NFTs in cerebellum and brain stem	Intraneuronal and intraglial inclusions of TDP-43/P-Tau in cortex, cortex, medial temporal lobe, brain stem, and white matter	Extensive cortical atrophy

CTE Neuropathological Stages (cont.d)

- Static loading
- Dynamic loading
  - Impulsive head
- Strain
  - Compressive
  - Tension - elongation
  - Shear
  - Dilational (volumetric)

Chronic Traumatic Encephalopathy Stages

- Stage 1:
  - Headaches
  - Attention deficit
- Stage 2:
  - Depression and mood instability
  - Executive dysfunction, impaired judgment
- Stage 3
  - Cognitive impairment; memory loss
  - Explosivity
  - Paranoia
  - Visuospatial dysfunction
- Stage 4:
  - Dementia
  - Involuntary movements (parkinsonism)
  - Gait disturbance

Traumatic Encephalopathy Syndrome (TES)

Montenigro et al. Alzheimer's Research & Therapy 2014

- General criteria for TES
  - History of multiple impacts
    - Mild TBI
    - Moderate/Severe TBI – loss of consciousness ≥ 30 min; Glasgow score < 13
    - Subconcussive trauma
  - Source of exposure
    - Contact sports minimum of 6 years, at least 2 years at the college level or higher
    - Military
    - Motor vehicle accidents (automobile, motorcycle, all terrain vehicles, bicycles, tricycles)
    - Other (domestic abuse; headbanging [autism; raves]; first responders; backyard brawls; falls [elderly; ice; stairs; balconies; swing sets])
  - No chronic neurological disease
  - Duration of 12 months or more
  - At least one of the core clinical features
  - At least two supportive features

Traumatic Encephalopathy Syndrome (TES)

- Core clinical features of TES
  - Cognitive
    - Self-report or clinician report
    - ≥ 1.5 standard deviation on mental status or neuropsychological testing
  - Behavioral
    - Explosive – verbal or physical threats or assaults; Intermittent Explosive Disorder diagnosis
  - Mood
    - Depressed mood or diagnosis of Major Depressive Disorder

Traumatic Encephalopathy Syndrome (TES)

- Supportive features of TES
  - Impulsivity
  - Anxiety
  - Apathy
  - Paranoia
  - Suicidality
  - Headache
  - Motor – parkinsonism (dysarthria, dysgraphia, bradykinesia, tremor, rigidity, gait disturbance, falls)
  - Documented progressive decline
  - ≥ 2 years delayed onset

Traumatic Encephalopathy Syndrome (TES)

- Traumatic encephalopathy syndrome diagnostic subtypes}
  - TES behavioral/mood variant (TES-BMv)
  - TES cognitive variant (TES-COGv)
  - TES mixed variant (TES-MIXv)
  - TES dementia (TES-D)
    - Progressive
    - Functional impairment
    - Difficulty distinguishing from Alzheimer's disease
- Clinical modifiers
  - With motor features
  - Progressive
  - Stable

Traumatic Encephalopathy Syndrome (TES)

- Biomarkers of TES
  - Cavum septum pellucidum
  - Cavum vergae
  - Normal beta amyloid cerebrospinal fluid (CSF) levels
  - Negative PET amyloid imaging
  - Positive PET paired helical filament tau imaging
  - Cortical thinning
  - Cortical atrophy

Chronic Traumatic Encephalopathy Classification

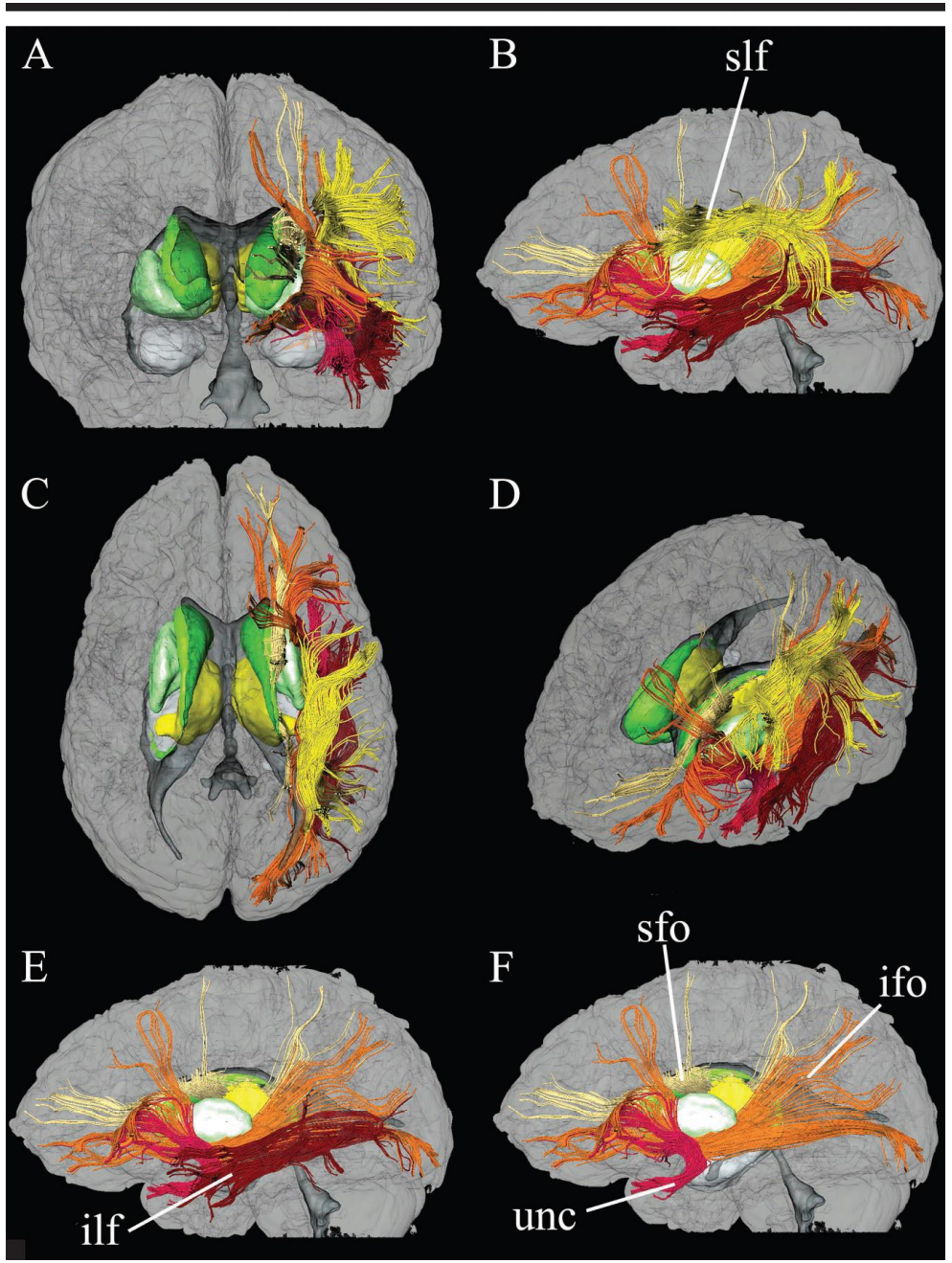
- **Probable CTE**. Meets classification for any TES subtype, progressive course; does not meet diagnostic criteria for another disorder more consistently than TES; and has a minimum of one positive potential biomarker for CTE
- **Possible CTE**. Meets classification for any TES subtype, progressive course, and (1) no biomarker testing, (2) negative results on one or more biomarkers with the exception of PET tau, or (3) meets the diagnostic criteria for another disorder
- **Unlikely CTE**. Does not meet TES diagnostic criteria or has had a negative PET tau imaging scan or both.

Neuroimaging of Chronic Traumatic Encephalopathy

- MRI
- Fluid Attenuated Inversion Recovery (FLAIR)
- High-Resolution Structural MRI - brain structure
- Susceptibility-Weighted Imaging (SWI)- micro-hemorrhages
- Diffusion Tensor Imaging (DTI) - tissue microarchitecture
- Magnetic Resonance Spectroscopy (MRS) - brain metabolism
- Positron emission tomography (PET) – brain metabolism
- Functional MRI – brain function
- Functional Connectivity MRI- brain function
- Single-Photon Emission Computer Tomography (SPECT) - regional blood flow

Diffusion Tensor Imaging

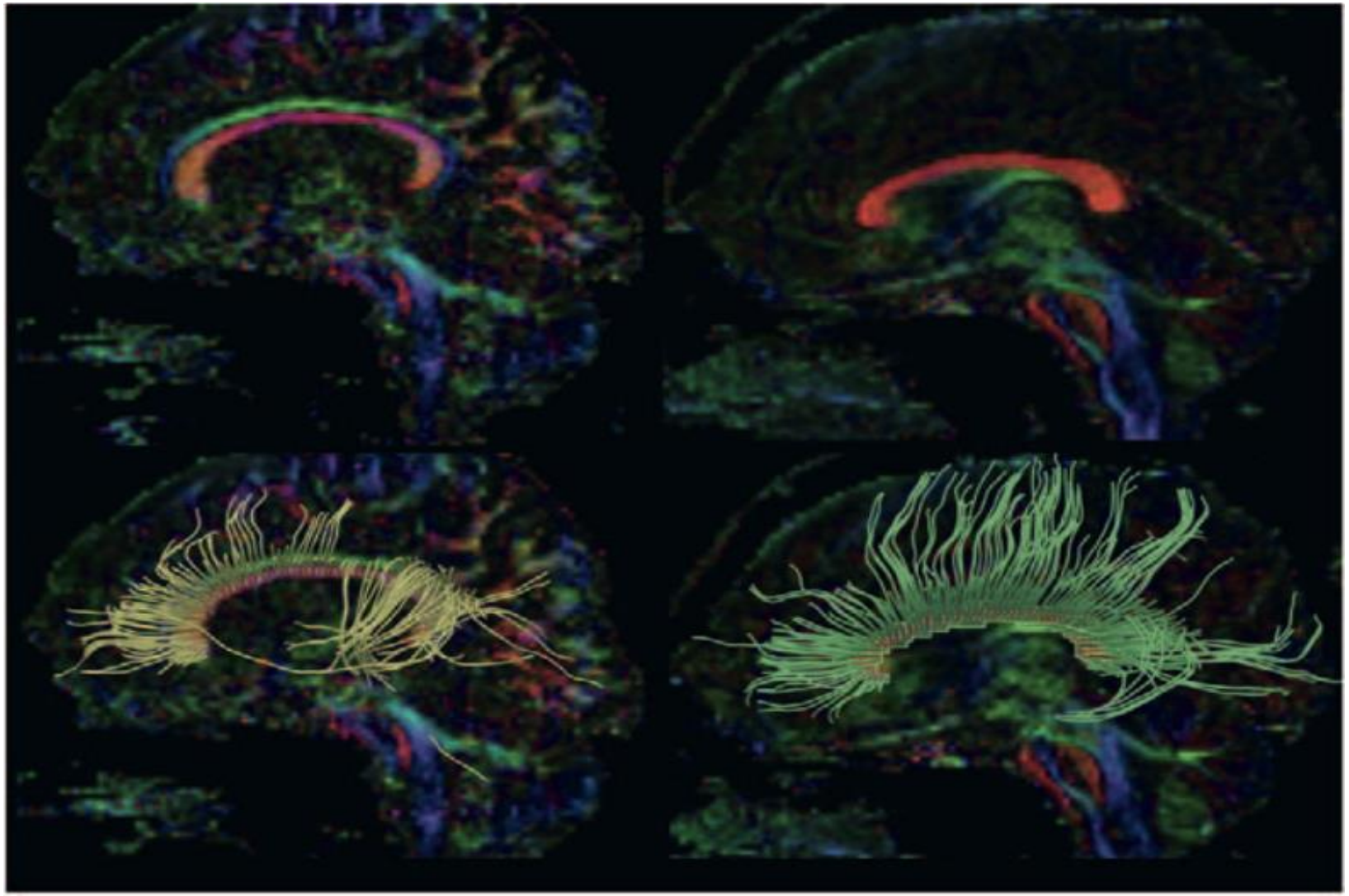
- **Anisotropy:** myelin arranges water parallel to the length of axons and restricts diffusion perpendicular to the axon
- **Fractional Anisotropy (FA):**
  - Degree of anisotropy: values 0 – 1; 0 is disorganized (isotropic) and 1 is highly organized (anisotropic)
  - Mean Diffusivity (MD): mean rate of diffusion in all directions
  - Axial diffusivity (AD): rate of diffusion parallel to white matter tract
  - Radial diffusivity (RD): rate of diffusion perpendicular to white matter tract
- **Fiber Tractography:** H_2O diffusion is color-coded
  - Blue: projection fibers (superior - inferior)
  - Green: association fibers (anterior – posterior)
  - Red: commissural fibers (right to left)



Wakana S et al. Fiber tract-based atlas of human white matter. Radiology 2004; 230:77-87.

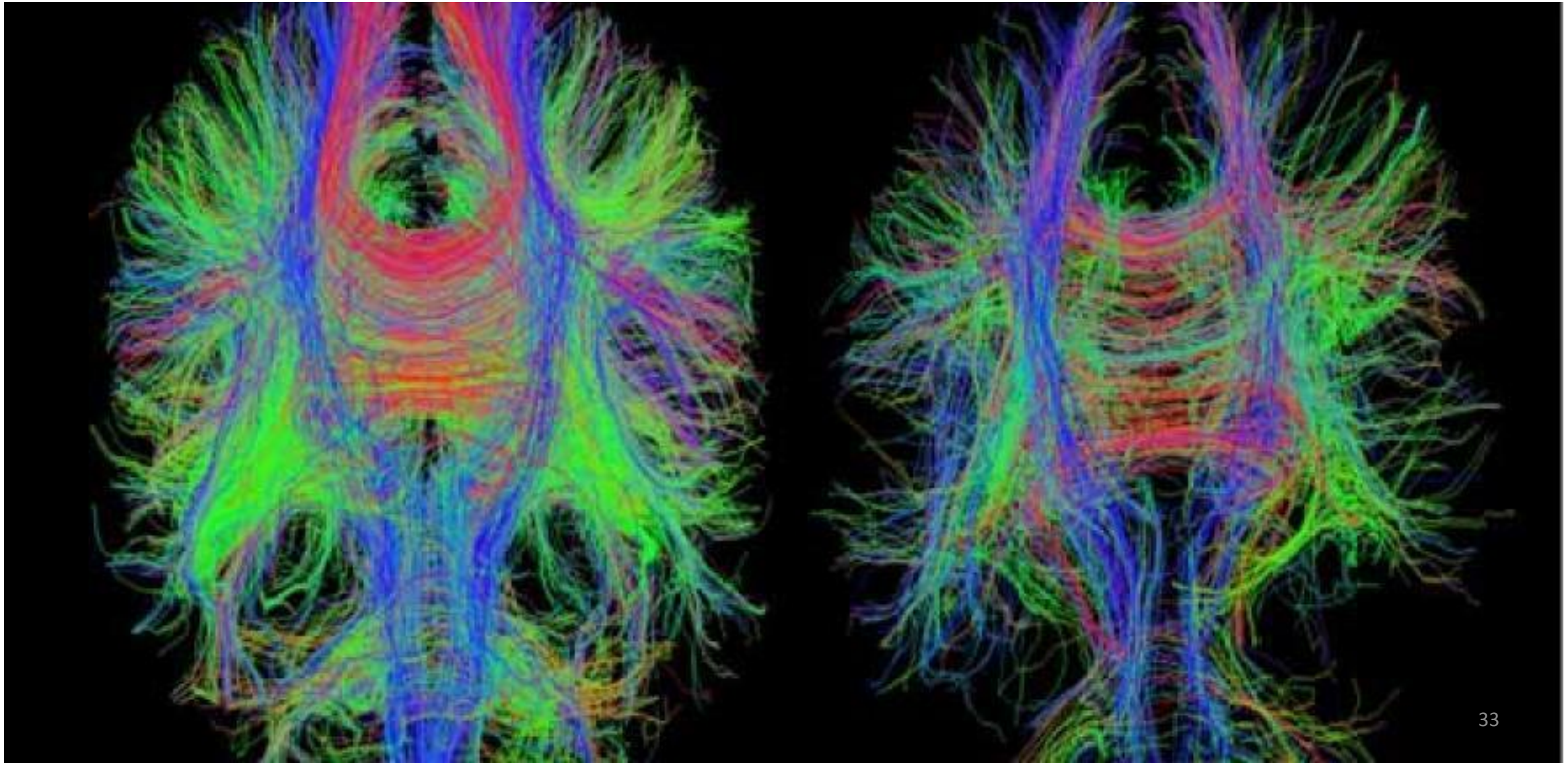
Diffusion Tensor Imaging of CTE

Gavett BE et al. Clinical appraisal of chronic traumatic encephalopathy: current perspectives and future directions. Curr Opin Neurol 2011; 24:525–531. DOI:10.1097/WCO.0b013e32834cd477



Normal Brain vs. Repetitive Subconcussive Head Injury

Virginia Newcombe, Division of Anaesthesia. University of Cambridge



Traumatic Brain Injury Psychiatric Outcomes

- Behavioral Dyscontrol
- Irritability
- Aggression
- Personality Change
- Bipolar Disorder
- Major Depressive Disorder
- Suicide
- Substance Abuse
- Psychogenic Nonepileptic Seizures

NATIONAL INSTITUTES OF HEALTH CONSENSUS DEVELOPMENT CONFERENCE
STATEMENT REHABILITATION OF PERSONS WITH TRAUMATIC BRAIN INJURY, OCTOBER 26-28, 1998

Sports-Related Chronic Traumatic Encephalopathy

Pfister T et al. The incidence of concussion in youth sports: a systematic review and meta-analysis. *Br J Sports Med*. 2016; 50:292-297

- Rugby (4.18; Pacific Islanders and South Africans; 400 early deaths; Carl Hayman, New Zealand All Blacks)
- Cricket (3.19; number one sport among Afro-Caribbeans and South Asians; Houston, TX; 77% skull fractures, 18% contusions, and 11% concussions with open wounds; West Indies batsman Phil Simmons and Jeremy Solozano; Indian cricketer Nari Contractor)
- Hockey (1.20; number one sport among Afro-Canadians)
- Football (0.53)
- Basketball
- Baseball (number one sport among Afro-LatinX of the Caribbean; 242,731 TBI from 2000 to 2016)
- Bobsled/Skeleton: "Sled Head," bobsledder Bill Schuffenhauer; [Elana Meyers Taylor and Sylvia Hoffman (Bronze Medalists two-woman bobsled for USA); Jamaica]
  - Speeds averaging 90 mph generate a force wave stretches axons, particularly the corpus callosum
  - Skeleton: head drags on ice due to fatigue on corners of run generating forces ~ 85 g by accelerometer (Alexis Morris, Mt. Royal University, Calgary – skeleton athlete and biophysicist)
- Soccer (number one sport among Afro-LatinX of Central and South America; Afro-Brazilians) – Brianna Curry
- Volleyball (Stephanie Cahill; Hayley Hodson)
- Lacrosse
- Cheerleading
- Snowboarding and Skiing

NFL Race Norming ("Racial Correction")

- Neuropsychologists required to use race-based norms evaluating a player
- Assumption is Blacks have lower IQ than Whites, therefore, a lesser loss of cognitive function codified by ***The Bell Curve: Intelligence and Class Structure in American Life*** *(*Richard J Herrnstein and Charles Murray*)*
- **Halstead-Reitan Neuropsychological Test Battery (**Halstead, W.C. (1947). *Brain and Intelligence*. Chicago, IL: University of Chicago Press; Reitan, R.M. (1955). Investigation of the validity of Halstead's measures of biological intelligence. *Archives of Neurology and Psychiatry, 73*, 28-35**)**
  - **Wechsler Adult Intelligence Scale** (**WAIS**)
  - 'working memory', 'fluency', 'verbal episodic memory', 'visuospatial cognition' (visuospatial memory and problem solving),
  - 'perceptual-motor speed' (speed for processing visual/tactile material and hand-motor execution), 'perceptual attention' (attention to sensory-perceptual information),
  - 'semantic knowledge' (knowledge acquired through education and culturally-based experiences), and 'phonological decoding' (grapheme-phoneme processing essential for sounding-out words). 'Perceptual-motor speed' and 'perceptual attention'
- **Heaton Norms created in 1991 updated in 2004 published by Psychological Assessment Resources**
  - **Robert K. Heaton et al. Comprehensive norms for an expanded Halstead-Reitan Battery: Demographic corrections, research findings, and clinical applications 1991**
  - **Robert K. Heaton et al. Revised Comprehensive Norms for an Expanded Halstead-Reitan Battery: Demographically Adjusted Neuropsychological Norms for African American and Caucasian Adults 2004**
- **The Heaton, Miller, Taylor, and Grant's (2004) Deficit Scale consistently finds normal brain function where the Reitan and Wolfson's (1993) Neuropsychological Deficit Scale finds abnormal function**

NFL Race Norming ("Racial Correction")

- The Civil Rights Act of 1991 prohibited race-based norms
- 2013: 4,500 NFL players win class action suit against the NFL for $765m
- Kevin Henry (8 years defensive lineman Pittsburgh Steelers) and Najeh Davenport (6 years running back for 3 teams) sued the NFL in 2020 – suit was dismissed
- More than 1000 claims for chronic traumatic encephalopathy denied

Sports-Related CTE Suicide and Murder-Suicide

- 1980: Jim Tyrer, age 41, NFL, murder-suicide
- 2003: Eugenio Monti, age 75, bobsled, suicide
- 2006: Andre Waters. age 44, NFL, suicide
- 2007: Chris Benoit, age 40, WWE, family annihilation-suicide
- 2010: Owen Thomas, U. Penn football, age 21, suicide
- 2010: Ryan Freel, age 36, Cincinnati Reds, suicide
- 2011: Dave Duerson, age 50, NFL, suicide
- 2011: Rick Rypien, age 27, NHL, suicide
- 2011: Derek Boogaard, age 28, NHL, suicide
- 2011: Wade Belak, age 35, NHL, suicide
- 2012: Jovan Belcher, age 25, NFL, murder-suicide
- 2012: Ray Easterling, age 62, NFL, suicide
- 2013: Mosese Fotuaika , age 20, rugby, suicide
- 2013: Alex Elisala, age 20, rugby, suicide
- 2013: Junior Seau, age 43, NFL, suicide
- 2013: Adam Wood, age 32, bobsled, suicide
- 2014: Travis Bell, age 42, bobsled, suicide
- 2015: Todd Ewen, age 49, NHL, suicide
- 2015: Steve Montador, NHL, suicide
- 2015: Regan Grieve, age 18, rugby
- 2015: Francis Winterstein, age 19, rugby, suicide
- 2016: Bill Schuffenhauer, bobsled, attempted suicide (African American)
- 2017: Steven Holcomb, age 37, 2010 Olympic gold medalist bobsled
- 2017: Aaron Hernandez, age 27, NFL, murder and suicide
- 2018: Tyler Hilinski, age 21, NFL, suicide, Washington State quarterback
- 2019:: Kelly Catlin, age 23, cyclist, suicide
- 2020: Tyler Amburgey, age 29, NHL, COVID-19
- 2021: Phillip Adams, age 32, NFL, murder-suicide
- 2021: Vincent Jackson, age 38, NFL, suicide

Psychogenic Non-Epileptic *Spells*

- **50% of non-veterans and 87% of veterans with psychogenic non-epileptic spells have mild traumatic brain injury**
- Once known as “conversion reaction” and pseudo-seizures, now recategorized as “spells;” the connotation is purely psychological and not a brain dysfunction
- No electrical discharge on EEG at video-EEG monitoring
- There are true seizures without detectable electrical discharges that are misdiagnosed as PNES, i.e., false negatives
  - Before video-EEG monitoring most frontal lobe seizures were diagnosed as “pseudo-seizures”
  - Most frontal lobe seizures are now recognized by monitoring except for supplementary motor seizures
  - Mesial Temporal Lobe seizures (panic)
- Pseudo-pseudo seizures are focal complex partial seizures that originate in the medial and/or orbital frontal lobe and are misdiagnosed as non-epileptic spells (especially in children). Normal EEG

“Psychogenic” Seizures White Matter Lesions

- Diffusion Tensor Imaging (DTI) found significantly higher fractional anisotropy in the following regions: left corona radiata, left internal and external capsules, left superior temporal gyrus, and left uncinate fasciculus. Mean diffusivity (MD) was unaffected.
  - White matter diffusion abnormalities in patients with psychogenic non-epileptic seizures, 2015 (S. Lee, et al)
- DTI of Japanese patients with PNES showed decreased FA and increased MD. White matter microstructure evidenced increased path length, decreased network efficiency, altered nodal topology, and reduced regional connectivity in the right posterior areas.
  - Widely impaired white matter integrity and altered structural brain networks in psychogenic non-epileptic seizures. Neuropsychiatric Disease and Treatment, 2019: 15 3549–3555. (D. Sone, et al.)

Common Community Causes of TBI

- Vehicle collision (roll; vault)
  - Position (driver's seat, front or rear passenger, driver's side or not)
  - Wearing a seat belt or not
  - Human collision
  - Head rotation with or without ejection
  - Head strikes interior structures (wheel, windshield, side windows, etc.)
  - Ejection
- Jumping from a moving vehicle
- Domestic abuse
- Falls to sidewalks, pavement, or stairs

Head Injury Criterion (HIC_{15})

National Highway Traffic Safety Administration

- $HIC_{15} \geq 250$ corresponds to a concussion (15 msec or 0.015 seconds) secondary to linear translation forces
- $HIC_{15} \geq 700$ in an adult denotes severe traumatic brain injury (brain contusion; subdural hematoma; subarachnoid hemorrhage; and diffuse axonal injury)
- $HIC_{15} \geq 500$ in a child older than 3 years of age correlates with severe traumatic brain injury

$$HIC = \left\{(t_2 - t_1)\left[\frac{1}{t_2 - t_1}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}\right\}max$$

National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT). Occupant Crash Protection – Head Injury Criterion S6.2 of MVSS 571.208, Docket 69-7, Notice 17. NHTSA, Washington, DC, 1972.

Head Injury Criterion

Dummy Type	Large-Sized Male	Mid-Sized Male	Small-Sized Female	6-Year Old Child	3-Year Old Child	1-Year Old Infant
HIC_{15} Limit	700	700	700	700	570 (68g)	390 (58g)

Brain Injury Criteria for Angular Acceleration

Takhounts EG et al. Development of Brain Injury Criteria (BrIC). Stapp Car Crash Journal 2013; 57: 243-266

$$BRIC = \sqrt{\left(\frac{\omega_{coronal}}{\omega_{cr,coronal}}\right)^2 + \left(\frac{\omega_{sagittal}}{\omega_{cr,sagittal}}\right)^2 + \left(\frac{\omega_{horizontal}}{\omega_{cr,horizontal}}\right)^2}$$

HIC_{15} for Automobile Collisions

MPH	Km/h	m/s	Δt	a	g	HIC_{15}
20	32	8.9	0.015	596	60.8	432.7
25	40	11.1	0.015	745	76.0	755.9
35	56	15.6	0.015	1043	106.4	1753.2
45	72	20.0	0.015	1334	136.2	3244.4

Acceleration: $a = \Delta v/\Delta t$

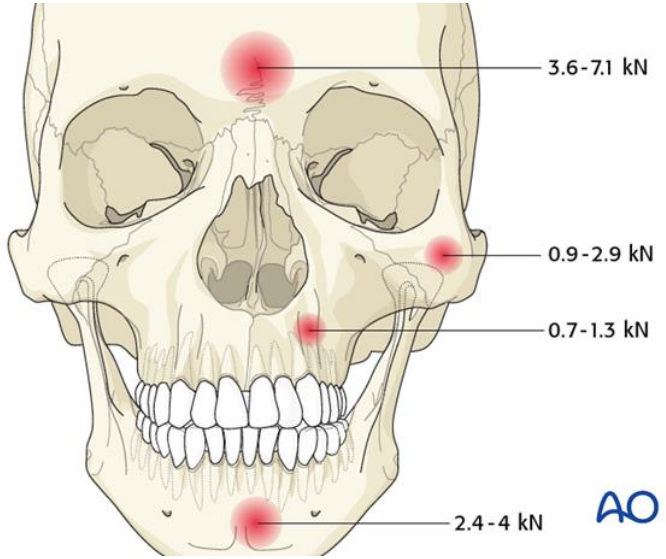
G-force expresses acceleration relative to acceleration due to gravity ($g = 9.80665\ m/s^2$);
it is not a measure of force but provides a means to compare acceleration in disparate situations

CTE: Biophysics of Pugilistic Trauma

	Male	Female
Straight Right Punch	2592 N	1170 N
Roundhouse Kick	2072 N	1511 N

N= 1 Newton = 1 kg m s^{-2}

(Busko K et al.) Measuring the force of punches and kicks among combat sport athletes using a modified punching bag with an embedded accelerometer. *Acta of Bioengineering and Biomechanics* 2016; 18(1):47-54. DOI: 10.5277/ABB-00304-2015-02



Source: Surgical approaches for fractures of the anterior wall of the frontal sinus - a review of the literature and five case reports, 2015 (E. Fiamoncini, et. al.)

S Fusetti, B Hammer, R Kellman, C Matula, EB Strong, A Di Ieva. Frontal sinus fracture, posterior table. AO Surgery Reference

Craniomaxillofacial Trauma. AO Surgery Reference

S Fusetti, B Hammer, R Kellman, C Matula, EB Strong, A Di Ieva. Frontal sinus fracture, posterior table/definition. AO Surgery Reference

Same Sex Intimate Partner Violence (SSIPV)

- Lifetime prevalence of SSIP
  - 49.3% of bisexual women
  - 29.4% of lesbian women vs. 23.6% heterosexual women
  - 16.4% of homosexual men vs. 13.9% heterosexual men
    - Breiding, M. J., Chen, J., and Walters, M. L. (2013). *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Findings of Victimization by Sexual Orientation*. Atlanta, GA: National Center for Injury Prevention and Control.
  - 50% of transgender persons victimized. 50% attempt suicide.
    - Messinger AM and Guadalupe-Diaz XL, eds. *Transgender Intimate Partner Violence*. NYU Press, 2020.
- COVID-19 male SSIPV prevalence was 15.17%, 1/3 was new or more frequent
  - Victimization prevalence was 14.95%, 1/2 was new or more frequent
  - Outside sexual partners increased victimization by 70%
    - Walsh AR et al. Intimate Partner Violence Experiences During COVID-19 Among Male Couples. J Interpersonal Violence 2021; DOI: 10.1177/0886260521005135.
- 90% of murdered transgender are Black, 68% in the South, 81% < 30

Headbangers

Headbanging Compilation – YouTube (0:08-1:09)

Chronic Traumatic Encephalopathy and Crime

- History of TBI in 60% of adult offenders and 30% juvenile offenders
- Recidivism higher with mild or more severe TBI
- No causal relationship established as yet
- Scottish study of 109 incarcerated women (McMillan TM et al. *Lancet Psychiatry* 2021; 8: 512–520):
  - 85 (78%) had TBI
  - 34 (40%) had associated disability.
  - 71 (84%) of the 85 women had repetitive head injury from domestic abuse
  - 3 times more likely to have a history of violent offences
  - 3 times more likely to spend longer time in prison than women without TBI

Video monitoring of Children Wearing Headband Sensors (SIM G) to Measure Fall Events

- Children in daycare
- Fall heights ranged from 0.1 to 1.2 m
- Maximal linear head acceleration was 50.2 g
- Maximal rotational head acceleration was 5388 rad/s2
- Maximal linear head velocity was 3.8 m/s and maximal rotational head velocity was 21.6 rad/s.
  - Gina Bertocci et al. Head biomechanics of video recorded falls involving children in a childcare setting. Scientific Reports 2022; 12:8617

Fetal and Newborn Traumatic Brain Injury

- Birth injury
  - Forceps delivery
  - Vacuum evacuation
- Motor vehicle accidents
- Assaults
- Shaken Baby Syndrome
- Non-Traumatic Subarachnoid Hemorrhage masquerading as TBI
  - Beta-Thalassemia (mistaken for shaken baby syndrome in children)
  - Sickle Cell Disease
  - Moya Moya
  - Systemic Lupus Erythematosus
  - Vasculitis
  - Autoimmune Hemolytic Anemia
  - Immune Thrombocytopenia
  - Primary biliary cirrhosis
  - Addison's disease
  - Thrombocytopenic purpura

Blast Injury is not CTE

Shively SB et al. Characterisation of interface astroglial scarring in the human brain after blast exposure: a post-mortem case series. Lancet Neurology 2016 Aug;15(9):944-953. doi: 10.1016/S1474-4422(16)30057-6

- Blast injury to the brain is not accompanied by diffuse axonal injury and tau pathology is inconsistent
- Astroglial scarring occurs at subpial glial plate, penetrating cortical blood vessels, and grey–white matter junctions -- structures with different density
- Liquid in the brain is confined at scales from 1 cm to 0.1 μm
- Positive pressure develops under the point of impact
- A small cavity, opposite the impact, forms due to negative pressure (tension)
- Subsequent collapse of cavities is a mechanism of injury
- Cavitation more likely if the head accelerates before the head strike

Questions

Appreciation

Contact Us

Central East (HHS Region 3)
MHTTC Mental Health Technology Transfer Center Network
Funded by Substance Abuse and Mental Health Services Administration

a program managed by

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Let's connect: