



**Eastern Association for the Surgery of Trauma**

**28<sup>th</sup> Annual Scientific Assembly**

**Sunrise Session 6**

**Management of Mild TBI**

**Military Lessons and the Public Health Care Crisis in America**

**January 15, 2015**

**Disney's Contemporary Resort**

**Lake Buena Vista, Florida**



## Management of Mild TBI – Military Lessons Learned

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 Military Sunrise Session EAST  
 January 15, 2015

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### Agenda





- mTBI screening and evaluation
- Care models
- Defense Department Policy and Guidelines

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- The assertions herein are my views and are not to be construed as reflecting the views of the United States Air Force or the United States Government.
- No financial disclosures.

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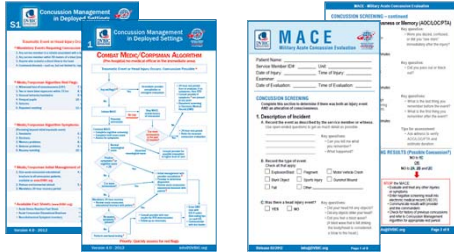
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## Presentation Guidance



This presentation is best reviewed with a copy of the *Concussion Management in Deployed Settings and Military Acute Concussion Evaluation (MACE)* pocket cards in hand



Contact info@DVBIC.org to obtain these pocket cards

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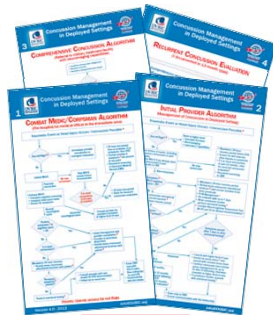
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## Clinical Algorithms



- Department of Defense (DoD) policy includes four concussion management clinical algorithms
  - Combat Medic/Corpsman
  - Initial Provider
  - Comprehensive Concussion
  - Recurrent Concussion
- Clinical algorithms were updated in 2012. Current version is 4.0.



Version 4.0 - 2012

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## Mild TBI is also known as Concussion



- “Mild” does not refer to the symptoms, but rather the injury severity
- Concussion is the preferred term when discussing this diagnosis with service members and their family



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## Identifying Concussion



- Per DoD definition, a concussion occurs when two conditions are met:
  - An injury event
  - AND at least one of the following**
    - An alteration of consciousness (AOC) lasting < 24 hours
    - A loss of consciousness (LOC) lasting < 30 minutes
    - Post-traumatic amnesia (PTA) caused by the injury event lasting < 24 hours
- MACE questions 1 and 2 help obtain the above information



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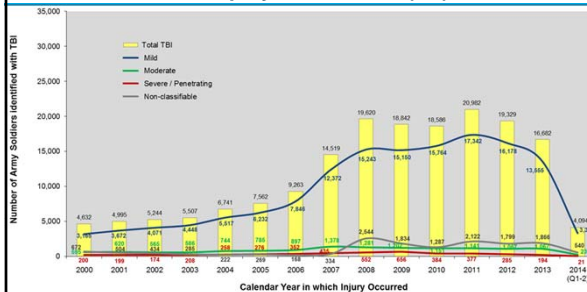
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## Army Worldwide TBI Cases Garrison and Deployed 2000-2014(Q2)



The vast majority of TBIs occur in the garrison setting. Therefore, TBI will remain a military concern long after 2014 Afghanistan troop withdrawal.

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## Potentially Concussive Events Requiring Evaluation



- Exposure to the following events mandates prompt command and medical concussion evaluation, event reporting and a 24-hour rest period



Involvement in a vehicle blast event, collision, or rollover

Presence within 50 meters of a blast (inside or outside)

A direct blow to the head or witnessed loss of consciousness

Exposure to more than one blast event (the service member's commander shall direct a medical evaluation)

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Impact of Concussion

- Concussion symptoms may decrease a Soldier's effectiveness and ability to do his/her job and negatively impact the Soldier's unit

Common concussion symptoms:

- Headache
- Sleep disturbance
- Fatigue
- Dizziness/Balance problems
- Visual disturbance/Light sensitivity
- Ringing in ears
- Slowed thinking
- Difficulty finding words
- Poor concentration
- Memory problems
- Anxiety/Depression
- Irritability/Mood swings

As a result, Soldiers may experience:

- Difficulty sleeping at night
- Decreased energy and alertness
- Reduced work performance
- Trouble multi-tasking
- Easily distracted
- Difficulty processing multiple sources of information
- Interpersonal problems

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IED HEADS Checklist

Injury	Physical damage to the body or body part of a service member?	(Yes/No)
Evaluation	<b>H</b> – Headaches and/or vomiting? <b>E</b> – Ear ringing? <b>A</b> – Amnesia, altered consciousness, and/or loss of consciousness? <b>D</b> – Double vision and/or dizziness? <b>S</b> – Something feels wrong or is not right?	(Yes/No) (Yes/No) (Yes/No) (Yes/No) (Yes/No)
Distance	Was the service member within 50 meters of the blast? Record the distance from the blast.	(Yes/No) N/A

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The Concussion Care Center Model

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graph LR
    BLAST[BLAST] --> BAS[Battalion Aid Station BAS]
    BAS -- "1 up to 48 hrs" --> CCC[Concussion Care Center CCC]
    CCC -- "1-7 days" --> CSCC[Concussion Specialty Care Center CSCC]
    CSCC --> LevelIV[Level IV Landstuhl Regional Medical Center Continental U.S.]
    LevelIV --> TheaterTreatment[Theater Treatment]
    TheaterTreatment --> BAS
  
```

Level I

- Medic/corpsman
- Unit physician
- MACE Screening

Level II

- Occupational therapist (OT)
- OT Tech
- Level II physician
- Cognitive testing

Level III

- OT, physical therapist (PT)
- Neurologist
- Neuropsychologist
- Sports Medicine
- Imaging (CT)

Level IV

Landstuhl Regional Medical Center Continental U.S.

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## Concussion Management: 24-hour Recovery



- Minimum 24-hr mandatory recovery period
- 24-hr clock starts at **time of injury** and not from time of evaluation
- Sports and activities with risk of repeat concussion are **prohibited** until service member is medically cleared
- Commanders may waive the mandatory recovery period but must document in BECIR

2

- Mandatory 24-hour recovery period
- Review acute concussion educational brochure with service member if not done previously
- PCM Management
- Re-evaluate daily up to 7 days
- When symptoms resolve, perform serial testing
- Consider NeuroCognitive Assessment Tool (NCAT) per DCAE clinical recommendations

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## Concussion Management: Primary Care Management



- Goal of Primary Care Management (PCM): Optimize recovery
  - Restful environment & quality sleep
  - Headache, sleep & pain management
  - Duty restriction implementation, if necessary
- Re-evaluate daily up to seven days
- If PCM is not effective, seek specialty consultation (e.g., Theater Neurology Consultant or Role III facility)

2

- Mandatory 24-hour recovery period
- Review acute concussion educational brochure with service member if not done previously
- PCM Management
- Re-evaluate daily up to 7 days
- When symptoms resolve, perform serial testing
- Consider NeuroCognitive Assessment Tool (NCAT) per DCAE clinical recommendations

S2

1. Give acute concussion educational brochure to all concussion patients, available at: [www.DWBIC.org](http://www.DWBIC.org)
2. Reduce environmental stimuli
3. Mandatory 24-hour recovery period
  - Use acetaminophen q 6 hrs x 48 hrs
  - After 48 hours may use naproxen prn
5. Avoid benzodiazepines, excessive opiates and narcotics
6. Consider nortriptyline q HS or amitriptyline q HS for persistent headache > 7 days. Prescribe no more than 10 pills.
7. Implement duty restrictions
8. Address any sleep issues. Ambien 350mg po QHS may be considered for short term (2 weeks) sleep regulation
9. Pain management if applicable
10. Send consult to [TBL.concussion.army.mil](mailto:TBL.concussion.army.mil) for further guidance if needed
11. Consider evacuation to higher level of care if clinically indicated
12. Document concussion diagnosis in EHR

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## Important Information to be Documented



- Detailed Description of Event
- MACE score
- Number of concussions in the past 12 months (3 or more mandate a recurrent concussion evaluation)
- Symptoms
- Sleep quality
- Results of any screenings

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## MACE Guidance

- The MACE is a standardized concussion interview and assessment tool
- Consistent administration of the MACE in the proper sequence is crucial to obtain accurate results.
- MACE should always be used in conjunction with clinical judgment
- Mean score in NON-concussed individuals is 28, so a score <30 does not necessarily imply a concussion has occurred
  - Sleep deprivation, medication, anxiety, pain may affect the cognitive score

The image shows the MACE (Military Acute Concussion Evaluation) form. It includes fields for Patient Name, Service Member ID#, Date of Injury, Time of Injury, Examiner, Date of Evaluation, and Time of Evaluation. Below these are sections for 'CONCUSSION SCREENING' and '1. Description of Incident'. The screening section asks if the patient has any symptoms and if they are able to perform tasks. The incident section asks for a description of the event and the type of injury.

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## NeuroCognitive Assessment Tool NCAT

- Consider post-injury NeuroCognitive Assessment Tool (NCAT) prior to RTD
  - Multiple concussions
  - Persistent symptoms after 48 hrs
- ANAM NCAT available at level II and level III Concussion Care Center
- Serial testing may be performed to evaluate a service members progress

The image shows a card labeled 'S3' with the following text: 'Mandatory 24-hour recovery period. Review acute concussion educational brochure \* with service member if not done previously. PCO Management. Re-evaluate daily up to 7 days. When symptoms resolve, perform exertional testing. Consider NeuroCognitive Assessment Tool (NCAT) per DCoE clinical recommendation.'

### <sup>†</sup> DCoE NeuroCognitive Assessment Tool (NCAT) Recommendation:

Current DoD policy is that all service members must be tested with a neurocognitive assessment tool (NCAT) prior to deployment. Among several tests that are available, the DoD has selected the Automated Neuropsychological Assessment Metrics (ANAM) as the NCAT to use for both pre-deployment baseline testing and for post-concussion assessment in theater. Detailed instructions for administering a post-injury ANAM are provided at [www.DVBIC.org](http://www.DVBIC.org).

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## Comprehensive Management

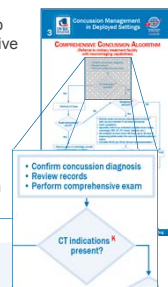
- Service members with persistent symptoms or who require neuroimaging are referred for comprehensive concussion management
- Upon arrival to referred facility:
  - Corroborate concussion diagnosis
  - Review records
  - Perform a comprehensive exam
- If positive findings or CT indications exist - as seen on card S3 (superscript K) - perform CT scan

**S3**

### <sup>\*</sup> CT Indications:<sup>\*</sup>

1. Physical evidence of trauma above the clavicles
2. Seizures
3. Vomiting
4. Headache
5. Age > 60
6. Drug or alcohol intoxication
7. Coagulopathy
8. Focal neurologic deficits

<sup>\*</sup>Haydel MJ, Preston CA, Mills TJ, Luber S, Blandeau E, DeBileux PM. Indications for computed tomography in patients with minor head injury. N Engl J Med. 2000 Jul 13;343(2):100-5.



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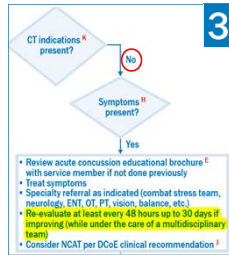
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## Neuroimaging Not Indicated



- If CT indications *are not* present, proceed with symptom assessment
- If symptoms *are* present:
  - Review acute concussion educational brochure
  - Treat symptoms
  - Consider specialty referral - may include neurology, ENT, OT, PT, vision, etc.
  - Re-evaluate every 48 hours (minimum) for up to 30 days if improving
  - Consider NCAT testing



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## Concussion Care Center



### Level II

- Utilize MACE and other screenings
- No Neurologist, psychologist, TBI dedicated physician
- OT/tech available
- Works closely with medical company (C-MED)
- Trained Doc and PA at C-MED on mTBI care
- Teletraining provided to outlying outposts
- Line leaders/units more directly available

### Level III

- Utilize MACE and other screenings
- OT/PT/neurologist, behavioral health available
- Works closely with Role III staff
- Trained providers and medics at Regional Command
- Teletraining provided to outlying outposts
- Line leaders/units conferred with via phone/email

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## What Activities HELP Recovery?



### Cognitive (i.e. "Thinking")

- Maximize downtime or rest during the day
- Adequate sleep at night

### Physical

- Keep the heart rate low
  - Stay out of the heat
  - Limited physical activity

*Soldiers may respond differently to physical and cognitive rest*

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## What Activities HURT Recovery?

**Avoid these Cognitive (i.e. "Thinking") Activities**

- Mental exertion
  - Writing reports
  - Activities requiring intense concentration
  - Playing video games
- Inadequate sleep
  - Caffeine or "energy enhancers" that prevent proper sleep
  - Irregular sleep schedule

**Avoid these Physical Activities**

- Exertion
  - Working
  - Heavy lifting
  - Exercising
  - Sports
  - Combatives

*Soldiers must prevent another concussion while the brain is recovering*

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## Concussion Care Centers






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## Exertional Testing & Functional Assessment

- Perform exertional testing **only** if the service member is **ASYMPTOMATIC**
- Exertional testing assesses whether or not symptoms recur during or after strenuous activity
- If symptoms recur during exertion, stop testing

**Exertional Testing:**

1. Exert to 65-85% of target heart rate (THR=220-age) using push-ups, sit-ups, running in place, step aerobic, stationary bike, treadmill and/or hand crank
2. Maintain this level of exertion for approximately 2 minutes
3. Assess for symptoms (headache, vertigo, photophobia, balance, dizziness, nausea, visual changes, etc.)
4. If symptoms/red flags exist with exertional testing, stop testing, and consult with provider

**Flowchart:**

```

graph TD
    Start(( )) --> Q1{Symptoms resolved?}
    Q1 -- Yes --> A1[Perform exertional testing]
    Q1 -- No --> Q2{Symptoms return?}
    A1 --> Q2
    Q2 -- No --> A2[Consider functional assessment  
Consider NCAT per DCOE clinical recommendation]
    Q2 -- Yes --> S2((S2))
    
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## Concussion Management: Exertional Testing

- Perform exertional testing **only** if the service member is asymptomatic
- Exertional testing assesses whether or not the service member remains asymptomatic during strenuous activity
- While performing exertional testing:
  - Maintain heart rate for approximately 2 minutes at 65-85% of target heart rate (THR= 220 minus age)
  - Assess for symptoms after testing

**Exertional Testing:**

- Exert to 65-85% of target heart rate (THR=220-age) using push-ups, sit-ups, running in place, step aerobic, stationary bike, treadmill and/or hand crank
- Maintain this level of exertion for approximately 2 minutes
- Assess for symptoms (headache, vertigo, photophobia, balance, dizziness, nausea, visual changes, etc.)
- If symptoms/red flags exist with exertional testing, stop testing, and consult with provider

**2**

Mandatory 24-hour recovery period

Review acute concussion educational brochure with service member if not done previously

Re-evaluate daily up to 7 days

When symptoms resolve, perform exertional testing

Consider NeuroCognitive Assessment Tool (NCAT) per DCOE clinical recommendation

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## Exertional Testing & Functional Assessment

- If asymptomatic after exertional testing, consider functional assessment and NCAT testing

**3**

Symptoms resolved? **Yes** → Perform exertional testing

Symptoms return? **No** → Consider functional assessment

Consider NCAT per DCOE clinical recommendation

**Functional Assessment:**

Assess the service member's performance of military-relevant activities that simulate the multi-system demands of duty in a functional context. Selected assessment activities should concurrently challenge specific vulnerabilities associated with mTBI including cognitive (such as executive function), sensorimotor (such as balance and gaze stability), and physical endurance. Rehabilitation providers should not only evaluate the service member's performance but also monitor symptoms before, during and after functional assessment.

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## Cumulative Concussion

- Cumulative concussions will influence length of downtime

1 documented concussion within past 12 months

• RTD delayed 24-hrs from time of injury

2 or more documented concussions within past 12 months

• RTD delayed 7 days following symptom resolution

3 documented concussion within past 12 months

• RTD delayed until concussion evaluation has been completed

**3**

Concussion Management in Deployed Settings

Comprehensive Concussion Assessment

- If 1st concussion in past 12 months, mandatory 24-hour recovery period
- If 2nd concussion in the past 12 months, mandatory 7-day recovery period following symptom resolution before RTD
- If 3rd concussion in the past 12 months, refer for recurrent concussion evaluation

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## Concussion Treatment & Recovery



- The majority of Soldiers can expect a full recovery with symptoms resolving within hours to days
- Full recovery is expected with multiple concussions. However, recovery may take longer
- Cornerstones of recovery:
  - Patient education: emphasize recovery
  - Physical & mental rest
  - Treat symptoms (i.e., headaches)



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## Protecting Our Strongest Weapon: Our Warriors



### Clinical algorithms contribute to mission accomplishment

- Algorithms standardize care and facilitate early diagnosis and treatment from point of injury through RTD
- Education and rest facilitate recovery
- Recovery periods and recurrent concussion protocols promote healing while protecting from further injury
- Proper documentation of the injury event and medical care improves care of the service member



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## Management of Mild TBI

### Military Lessons and the Public Health Crisis in America

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January 15, 2015

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  - NIH Blueprint Human Connectome Project (U01MH093765)
  - DOD (W81XWH-13-2-0067)
  - Center for Integration of Medicine & Innovative Technology
  - American Academy of Neurology & American Brain Foundation
- Departmental Funding:
  - MGH Department of Neurology
  - MGH Athinoula A. Martinos Center for Biomedical Imaging
  - BWH Department of Neurology

### Financial Disclosures and Conflicts of Interest:

- None

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## Objectives

- 1) Indications for Head CT in Mild TBI
- 2) Prognostic Utility of Conventional MRI
- 3) Advanced Imaging Techniques
  - a) Susceptibility-weighted Imaging (SWI)
  - b) Diffusion Tensor Imaging (DTI)
  - c) Resting-state Functional MRI (rs-fMRI)
- 4) Implications for Military & Civilian Practice
  - a) Return to battle and sports
  - b) Differentiation of Post-Concussion Syndrome from PTSD
  - c) Biomarkers for Chronic Traumatic Encephalopathy & Alzheimer's Dz

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## Motivation for Imaging Biomarkers of TBI

- Identifying lesions that require neurosurgical intervention
- Differentiating symptoms of mild TBI from PTSD
- Identifying patients at risk for persistent post-concussion syndrome
- Identifying patients at risk for chronic traumatic encephalopathy and/or Alzheimer's Disease
- Guiding therapy and rehabilitation

## Decision Rules for CT in Mild TBI

- New Orleans Criteria and Canadian CT Head Rule -

Table 4. Traumatic CT Findings (n = 312)\*

CT Finding	No. (%) of Patients
Skull fracture	188 (60.3)
Skull base	55 (17.6)
Depressed	19 (6.1)
Linear	114 (36.5)
Subdural effusion	2 (0.6)
Subdural hematoma	67 (21.5)
Epidural hematoma	36 (11.2)
Subarachnoid hemorrhage	89 (27.9)
Intraparenchymal lesions	142 (45.5)
Hemorrhagic contusion	118 (37.8)
Nonhemorrhagic contusion	15 (4.8)
Diffuse axonal injury	14 (4.5)
Intraventricular hemorrhage	5 (1.6)
Critically important lesions†	243 (77.9)

Abbreviation: CT, computed tomography.  
 \*Some patients had more than 1 CT finding.  
 †Defined as any intracranial traumatic CT finding, including depressed skull fractures but excluding isolated linear fractures.

Table 1. Decision Rules for Indications for CT Scan in Patients With Minor Head Injury

Study	Patient Population	Indications for CT Scan	Reported Validity, %*	
			Sensitivity	Specificity
Haydel et al., 2000 (NOC)	GCS score of 15, loss of consciousness, no neurological deficit, aged >15 y	Headache, vomiting, seizure, intoxication, short-term memory deficit, aged >60 y, or injury above clavicles	100	24.5
Stell et al., 2001 (CCHIR)	GCS score of 13-15, loss of consciousness, no neurological deficit, no seizure, no anticoagulation, aged >16 y	High-risk patients: GCS score <15 at 2 h postinjury, suspected skull fracture, any sign of basal skull fracture, vomiting (>2 times), aged <65 y Medium-risk patients: retrograde amnesia >30 min, dangerous mechanism (pedestrian vs motor vehicle; ejected from motor vehicle; fall from height >1 m or <5 stories)	98.4	49.6

Abbreviations: CCHIR, Canadian CT Head Rule; CT, computed tomography; GCS, Glasgow Coma Scale; NOC, New Orleans Criteria.

\*Validity for identifying patients with traumatic CT findings.

†High-risk patients in whom a CT scan is mandatory.

‡Medium-risk patients in whom a CT scan is recommended but close clinical observation is an alternative.

Smits et al. JAMA 2005;294:1519.

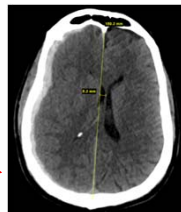
## Indications for CT in Mild TBI

### General Principles:

- Symptoms and/or deficits
- Intoxication
- Anticoagulation
- Unable to reliably observe after discharge

### Epidemiology of Abnormal CT:

- 10% of all mild TBI (GCS 13-15)
- 8% of GCS 15
- 16% of GCS 14
- 25% of GCS 13
- 0.5-1.0% of mild TBI pts require neurosurgery →



59M s/p assault, GCS 15

# Conventional MRI

- Advantages & Limitations -

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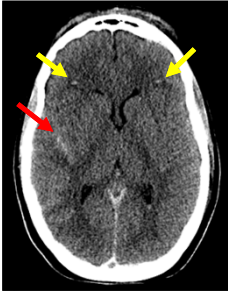
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## Traumatic Axonal Injury in “Mild” TBI

- 19F pedestrian hit by a car going 40 mph
- LOC = 5 min
- Initial GCS score = 14 (E4M6V4)



Initial Head CT

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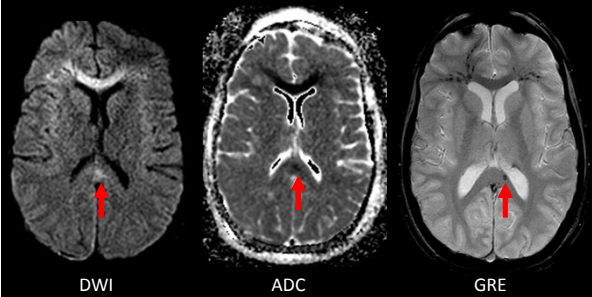
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## Traumatic Axonal Injury in “Mild TBI”



DWI      ADC      GRE

Day 7 Conventional MRI

Edlow & Diamond. Neurology 2010; 75:e69

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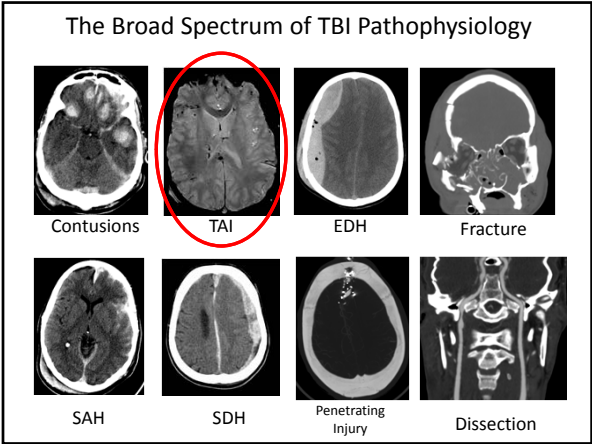
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**Traumatic Axonal Injury**  
- A Pathophysiologic & Radiologic Spectrum -

	Mild TBI	Moderate TBI	Severe TBI
<b>Axonal Pathology</b>	↓ ionic homeostasis	↓ ionic homeostasis ↓ axoplasmic transport	↓ ionic homeostasis ↓ axoplasmic transport 1° or 2° axotomy
<b>DAI Grade</b>	Grade 1 Cerebral Hemispheres	Grade 2 Hemispheres + Callosum	Grade 3 Hemispheres + Callosum + Brainstem
<b>Schematic</b>			

Smith et al. 2013;30:307-323.

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**Advanced Imaging Techniques**  
- Susceptibility-Weighted Imaging (SWI) -

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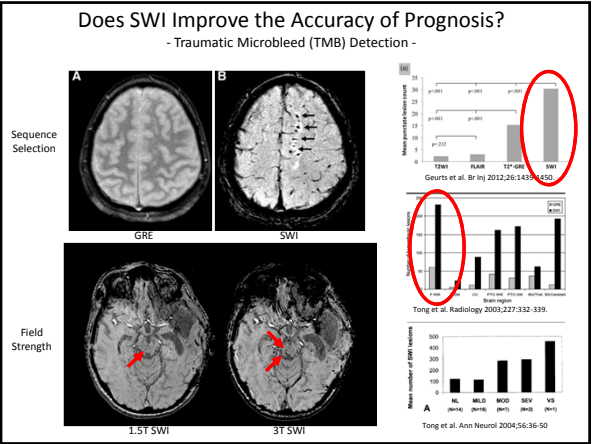
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**Advanced Imaging Techniques**  
- Diffusion Tensor Imaging -

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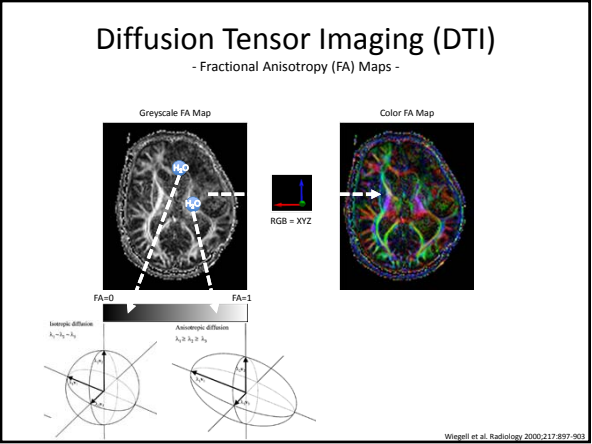
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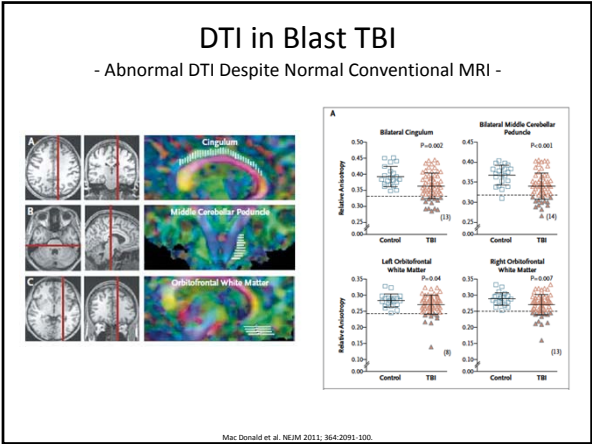
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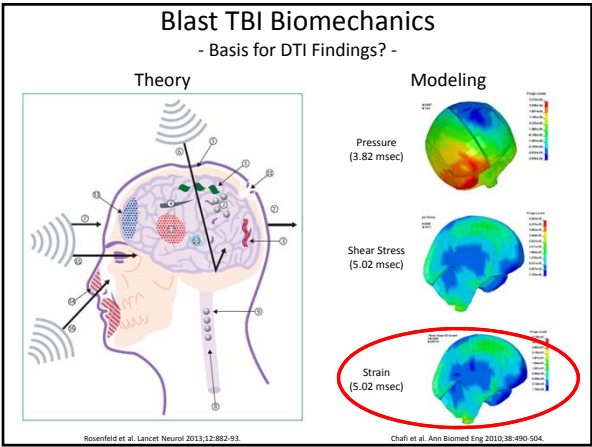
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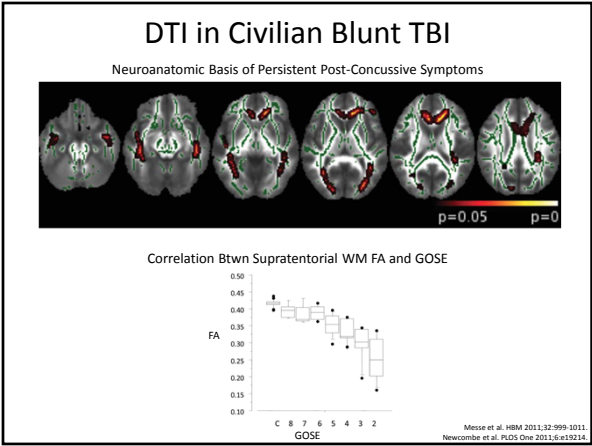
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## Advanced Imaging Techniques

### - Resting-state functional MRI (rs-fMRI) -

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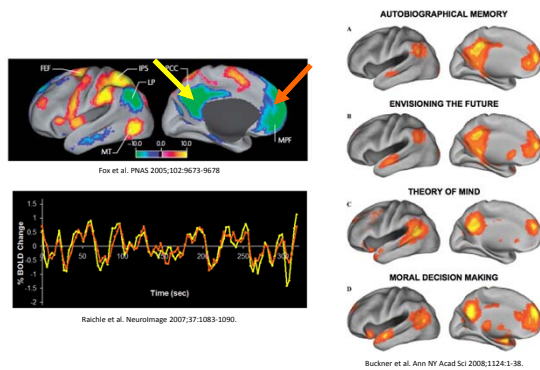
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## Resting State fMRI

- Blood Oxygen Level-Dependent (BOLD) Signal in the Default Mode Network -




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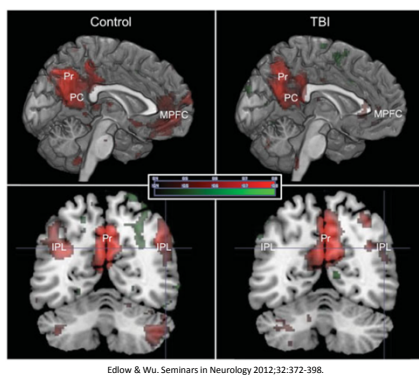
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## Default Mode Network Disconnections in Mild TBI




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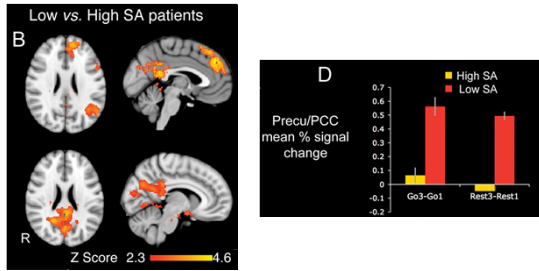
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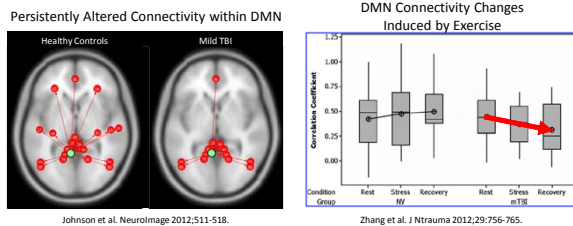
## Default Mode Network Disconnections in Mild TBI - Correlations with Impaired Attention -



Bonnelle et al. J Neurosci 2011;31:13442-13451.

## Implications for Return to Battle & Sports

## Default Mode Network Dysfunction in Mild TBI Patients *Cleared for Sports*



*Is there a role for imaging in guiding decisions about return to sports and/or battle?*

# Implications for Therapy and Rehabilitation

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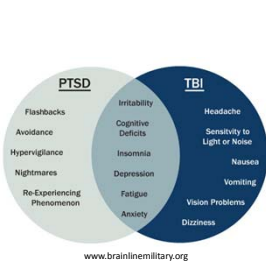
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## TBI & PTSD

- Disentangling a Complex Web of Overlapping Symptoms -



**TABLE 3** Regional DTI indices associated with PTSD, TBI, or blast before adjustment for multiple comparisons

Structure	DTI parameter	Nominal covariate-adjusted P value*
Associated with PTSD		
Inferior cerebellar peduncle	FA	.018
Corticospinal tract	FA	.033
Corticospinal tract	MD	.003
Medial lemniscus	FA	.012
Anterior limb of internal capsule	MD	.024
Caudate nucleus	MD	.039
Pons	FA	.039
Associated with TBI		
Inferior cerebellar peduncle	FA	.019
Caudate nucleus	MD	.046
Associated with blast		
Forma forni	FA	.008
Superior cerebellar peduncle	MD	.008
Midbrain	FA	.022
Splenium of corpus callosum	FA	.032

Bazarian et al. J Neuro Trauma 2015;28:1-12.

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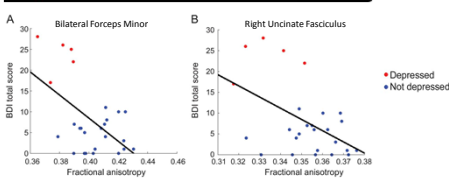
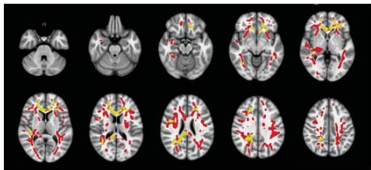
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## TBI & Depression

- Retired NFL Players -

Correlations btwn FA and Beck Depression Inventory Score



Strain et al. Neurology 2013;81:1-8.

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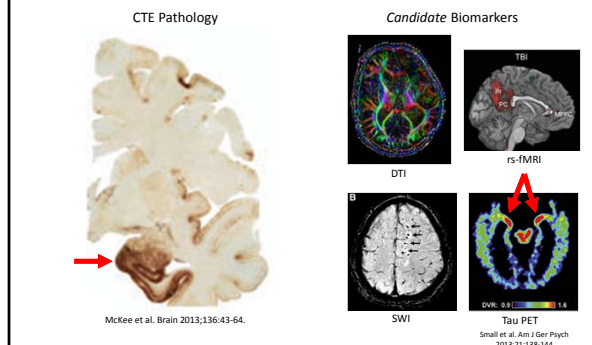
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## Imaging Biomarkers of CTE and AD

- More Questions than Answers -



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## Advanced Imaging in Mild TBI

- Limitations and Barriers -

- 1) Need for standardization of hardware (i.e. MRI scanner) and software (i.e. DTI and rs-fMRI sequences)
- 2) Heterogeneity of TAI neuroanatomic distribution
- 1) Limited access to advanced imaging technologies

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## Conclusions and Recommendations

- If CT unrevealing despite persistent symptoms and/or deficits, request MRI with SWI (3T if available) to enhance detection of hemorrhagic TAI.
- The sensitivity and specificity of advanced neuroimaging biomarkers for predicting functional outcomes and persistent post-concussion syndrome in mild TBI remain unknown.
- There are no validated imaging tests for predicting CTE or post-traumatic AD.
- In the absence of a “gold standard” for predicting recovery, a multimodal approach that combines 1) neurocognitive testing and 2) imaging tools is warranted.

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