



Robert J. Barth, Ph.D.
Fellow, National Academy of Neuropsychology


Brain Injury

Impairment Without Disability, 2015
Mayo Clinic, Rochester, MN


*Originally prepared for
American College of Occupational and Environmental Medicine, 2014*

*Robert J. Barth
Parkridge Hospital Plaza Two
2339 McCallie Ave, Suite 202
Chattanooga, TN 37404
423/624-2000*


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Brain Injury
What's in your handout?


The Powerpoint portion of your handout 

Unique considerations for scrutinizing scientific findings regarding brain injury.

The Powerpoint portion of your handout 


Mild Traumatic Brain Injury (mTBI)
(~85% of brain injuries are mild)

- **Definitions**
- **Diagnosis**
- **The excellent prognosis (rapid and complete recovery)**

The Powerpoint portion of your handout 

Mild Traumatic Brain Injury

- **The premise that a small minority do not experience rapid and complete recovery is not supported by scientific findings.**
- **Imaging findings do not appear to change the prognosis.**

The Powerpoint portion of your handout 

Mild Traumatic Brain Injury

- **The premise that repeated/multiple mTBIs have a cumulative effect is not supported by scientific findings.**
- **Persistent postconcussional syndrome is not actually caused by concussion.**

The Powerpoint portion of your handout



Mild Traumatic Brain Injury

- **Credible treatment for mTBI = reassurance.**
- **Credible treatment for persistent complaints = cognitive behavioral psychotherapy.**


The Powerpoint portion of your handout



Mild Traumatic Brain Injury

- **Persistent “posttraumatic” headache is not caused by head trauma.**
- **The unreliable nature of scientific findings regarding diffusion tensor imaging (DTI)**


The Powerpoint portion of your handout



Mild Traumatic Brain Injury (mTBI)

- **Military mTBIs appear to have the same prognosis**
- **Blast mTBIs appear to have the same prognosis**
- **Sport mTBIs appear to have the same prognosis**


The Powerpoint portion of your handout



Mild Traumatic Brain Injury (mTBI)

- **The premise that football causes chronic traumatic encephalopathy is not supported by scientific findings.**

The Powerpoint portion of your handout



More severe traumatic brain injuries

Outcome/prognosis

What's in your handout?

1. **A copy of these slides**
2. **Detailed discussion of The AMA Impairment Guides and mild traumatic brain injury.**
3. **Detailed discussion of the inadequacy of SPECT for evaluating mTBI claims (a model for how to scrutinize the use of any imaging for such claims)**
4. **Detailed discussion of scientific findings regarding claims of persistent “posttraumatic” headaches.**



*For this specific area of study, some unique research design elements **MUST** be considered...*

Unique research design considerations

- **Did the project use a control group comprised of people who had been injured, but their injuries did not involve the brain?**
- **Was credible validity testing used to exclude participants from the research project?**
- **Were claimants/plaintiffs excluded from the research project?**

Did the project use a control group comprised of people who had been injured, but their injuries did not involve the brain?

By using “trauma controls” we control for the effects of...

- **SES**
- **Generic non-specific experience of injury**
 - **Pain**
 - **Litigation**
- **Pre-injury neuropsychological characteristics / injury-proneness**

(Larrabee. Forensic Neuropsychology 2nd Ed. 2012)

Did the project use a control group comprised of people who had been injured, but their injuries did not involve the brain?

When trauma controls have been used in scientific research, relative impairment that might otherwise be attributed to brain injury disappears for TBI participants who did not follow commands for 24 hours after their TBI

- **Larrabee. Forensic Neuropsychology 2nd Ed. 2012.**
- **Dikmen, S. S., et al (1995). Neuropsychological outcome at one year post head injury. Neuropsychology, 9, pp. 80-90.**

Did the project use a control group comprised of people who had been injured, but their injuries did not involve the brain?

Bijur PE, et al. Cognitive outcomes of multiple mild head injuries in children. J Dev Behav Pediatr. 1996, Jun;17(3):143-8.

- **found that increasing numbers of mTBI in children were significantly related to lowered scores on measures of intelligence, and reading and math,**
- **but the same negative impact on cognition was found for number of non brain-injury traumas**
- **leading the authors to conclude that :“cognitive deficits associated with multiple mild head injury are due to social and personal factors related to multiple injuries and not to specific damage to the head”**

Was credible validity testing used to exclude participants from the research project?

Green P, et al.

Effort has a greater effect on test scores than severe brain injury in compensation claimants.

BRAIN INJURY, 2001, VOL. 15, NO. 12, 1045-1060.

Was credible validity testing used to exclude participants from the research project?

Nelson NW, et al. Evaluation context impacts neuropsychological performance of OEF/OIF veterans with reported combat-related concussion. Arch Clin Neuropsychol. 2010 Dec;25(8):713-23.

- The majority of veterans who were seeking benefits demonstrated inadequate effort on neuropsychological testing.
- “After controlling for effort, the research concussion and the research non-concussion groups demonstrated comparable neuropsychological performance.”

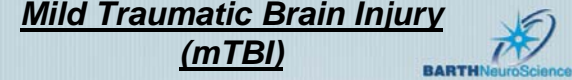
Were claimants/plaintiffs excluded from the research project?

Scientific findings have shown an effect for litigation/compensation even after validity testing is used to exclude participants

- Curtis KL, et al. Assessment, 16, 401-414, 2009.
- Greve KW, et al. Archives of Clinical Neuropsychology, 18, 245-260, 2003.
- Heiny MT. Assessment, 12, 429-444, 2005.




Mild Traumatic Brain Injury
(mTBI)
85% of all brain injuries
(Larrabee. Forensic Neuropsychology, 2nd Ed., 2012)



Mild Traumatic Brain Injury
(mTBI)
The term “mTBI” is preferable to “concussion” because:

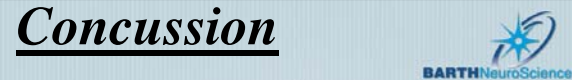
- published definitions of “concussion” are contradictory of one another
- Common usage of “concussion” implies mTBI, but at least one prominent definition indicates “concussion” applies to injuries of any severity



Concussion

International Neuropsychological Society
Dictionary of Neuropsychology, 1999

“mild traumatic brain injury characterized by at least a brief loss of consciousness or brief post-traumatic amnesia”



Concussion

Dorland’s Illustrated Medical Dictionary
32nd Edition, 2012

“concussion of the brain”

“*loss of consciousness* as the result of a blow to the head or sudden movement of the brain within the head as from violent shaking of the head. In *mild* concussion there is transient loss of consciousness with possible impairment of higher mental functions, such as retrograde amnesia and emotional lability. In *severe* concussion there’s prolonged unconsciousness with impairment of the functions of the brain stem, such as transient loss of respiratory reflex, vasomotor activity, and dilatation of the pupils.”

Mild Traumatic Brain Injury



Definition and Diagnostic Protocol World Health Organization Based on review of >38,000 scientific citations

Mild Traumatic Brain Injury World Health Organization definition

WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury Operational Definition of MTBI

Holm L, et al. J Rehab Med, 2005, 37(3): 137-41.

WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury Operational Definition of MTBI

- **MTBI is an acute brain injury resulting from mechanical energy to the head from external forces**
- **Operational criteria for clinical identification include...**

WHO Operational criteria for clinical identification include...

A. One or more of the following

- 1. Confusion or disorientation*
- 2. Loss of consciousness for 30 minutes or less*
- 3. post-traumatic amnesia for less than 24 hours*
- 4. Other transient neurological abnormalities such as focal signs, seizure, intracranial lesion not requiring surgery*

(continued)

WHO Operational criteria for clinical identification include...

B. Glasgow Coma Scale score of 13-15 after 30 minutes postinjury or later upon presentation for healthcare

C. These manifestations of MTBI must not be:

- 1. Due to drugs, alcohol, medication*
- 2. Caused by other injuries or treatment for other injuries*
- 3. Caused by other problems*
- 4. Caused by penetrating craniocerebral injury*

mTBI: Diagnosis and definition

Ropper AH, et al.(2014). Adams and Victor's Principles of Neurology, Tenth Edition.

“In almost all patients with cerebral concussive injury, there remains a gap in memory (traumatic amnesia) spanning a variable period from before the accident to some point following it. This gap is permanent...”

mTBI: Diagnosis and definition

Pape TLB, et al. Diagnostic Accuracy Studies in Mild Traumatic Brain Injury: A Systematic Review and Descriptive Analysis of Published Evidence. *Physical Medicine and Rehabilitation*, 2013;5:856-881.

“Conclusions: Findings indicate that no well-defined definition or clinical diagnostic criteria exist for mTBI and that diagnostic accuracy is currently insufficient for discriminating between mTBI and co-occurring mental health conditions for acute and historic mTBI. Findings highlight the need for research examining the diagnostic accuracy for acute and historic mTBI.”

Mild Traumatic Brain Injury



Outcome / Prognosis

mTBI: Outcome



All of the following organizations have published attempts at comprehensively reviewing the scientific literature...

All of these organizations have published attempts at comprehensively reviewing the scientific literature...



...and their reviews revealed that there is **insufficient scientific support** for claims of permanent impairment from a mild traumatic brain injury (or even persistent impairment)...

Insufficient scientific support for claims of permanent impairment from mild TBI...



- **World Health Organization**
- American Academy of Clinical Neuropsychology
- **American Medical Association**
- **Institute of Medicine**
- Department of Veterans Affairs / Department of Defense

Examples of relevant literature

World Health Organization

“Volume 1”: 1980–2000

Carroll LJ, Cassidy JD. PROGNOSIS FOR MILD TRAUMATIC BRAIN INJURY: RESULTS OF THE WHO COLLABORATING CENTRE TASK FORCE ON MILD TRAUMATIC BRAIN INJURY. *J Rehabil Med* 2004; Suppl. 43: 84–105.

World Health Organization

- reviewed more than 38,000 scientific citations
- "The stronger studies, utilizing appropriate control groups and controlling for confounding factors, suggest that post-concussion symptoms are largely resolved within three months to a year."
- "Studies that examined the relationship between *litigation and/or compensation issues* and slower recovery after mild traumatic brain injury consistently reported an association between them."

World Health Organization

reviewed more than 38,000 scientific citations

"The stronger studies, utilizing appropriate control groups and controlling for confounding factors, suggest that post-concussion symptoms are largely resolved within three months to a year."

(continued)

World Health Organization

reviewed more than 38,000 scientific citations

"Studies that examined the relationship between *litigation and/or compensation issues* and slower recovery after mild traumatic brain injury consistently reported an association between them."

Replication

World Health Organization

"Studies that examined the relationship between *litigation and/or compensation issues* and slower recovery after mild traumatic brain injury consistently reported an association between them."

Kashluba S et al.

Persistent Symptoms Associated with Factors Identified by the WHO Task Force on Mild Traumatic Brain Injury.

The Clinical Neuropsychologist,

22: 195-208, 2008.

Replication of WHO Finding Regarding Risk Factors for Persistent Symptoms

Kashluba S, et al., 2008.

**Compared
mTBI with persistent symptoms
to
mTBI without persistent
symptoms**

(continued)

Replication of WHO Finding Regarding Risk Factors for Persistent Symptoms

Kashluba S, et al., 2008.

"Compensation-seeking status and premorbid mental health related factors were the only variables associated with persistent symptom complaints."

(continued)

Replication of WHO Finding Regarding Risk Factors for Persistent Symptoms

Kashluba S, et al., 2008.

“Injury severity factors did NOT differ between the groups.”

(continued)

Replication of WHO Finding Regarding Risk Factors for Persistent Symptoms

Kashluba S, et al., 2008.

“Studies investigating the relationship between litigation and/or compensation issues and slower recovery post-MTBI usually report an association.”

(several references listed)

World Health Organization

“Volume 2”: 2001-2012

77,914 scientific citations considered

Linda J. Carroll, et al.

Systematic Review of the Prognosis After Mild Traumatic Brain Injury in Adults: Cognitive, Psychiatric, and Mortality Outcomes: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil, 2014 Mar;95(3 Suppl):S152-73.

World Health Organization

“Volume 2”: 2001-2012

“...some evidence suggests complete recovery may take 6 months or a year.”

NOTE: None of the referenced studies compared mTBI subjects to subjects who had experienced some other type of injury.

World Health Organization

“Volume 2”: 2001-2012

NOTE:

- **No mention of whether the included studies excluded subjects who failed symptom validity tests or performance validity tests.**
- **No mention of whether the included studies excluded claimants/plaintiffs.**

World Health Organization

“Volume 2”: 2001-2012

In regard to the possibility of impairment lasting longer than three months in some populations...

- **The nature of the possible impairment is not reliable**
- **The possible impairment is of questionable clinical importance**
- **The relevant studies lack sufficient rigor to credibly support claims of persistent impairment**

World Health Organization

“Volume 2”: 2001-2012

“Three **experimental** studies suggest that negative expectations may negatively affect test performance in persons with mTBI.”

World Health Organization

“Volume 2”: 2001-2012

Godbolt AK, et al. Systematic Review of the Risk of **Dementia and Chronic Cognitive Impairment** After Mild Traumatic Brain Injury. Arch Phys Med Rehab, 2014, 95 (3 Suppl 2), S245-56.

“There is a lack of evidence of an increased risk of dementia after **MTBI.**”

World Health Organization

“Volume 2”: 2001-2012

Cancelliere C, et al. Systematic Review of

Return to Work

After Mild Traumatic Brain Injury. Arch Phys Med Rehab, 2014, 95 (3 Suppl 2), S201-9.

“**MTBI is not a significant risk factor for long-term work disability.**”

World Health Organization

“Volume 2”: 2001-2012

Cancelliere C, et al. Systematic Review of Prognosis and Return to Play after

Sport Concussion.

Arch Phys Med Rehab, 2014, 95 (3 Suppl 2), S210-229.

“**It generally appears that cognitive function is not significantly impaired, or if impaired resolves within a few days to a few weeks for most high school, collegiate, and professional athletes after concussion.**”

World Health Organization

“Volume 2”: 2001-2012

Marras C, et al. Systematic Review of the Risk of

Parkinson’s Disease

After Mild Traumatic Brain Injury. Arch Phys Med Rehab, 2014, 95 (3 Suppl 2), S238-44.

“**The best available evidence argues against an important causal association between MTBI and PD.**”

Insufficient scientific support for claims of permanent impairment from mild TBI...



American Academy of Clinical Neuropsychology

Examples of relevant literature

**American Academy of Clinical Neuropsychology
Mild Traumatic Brain Injury And Postconcussion Syndrome.**

**Author: McCrea MA.
Oxford University Press. 2008.**

*American Academy of Clinical Neuropsychology
Mild Traumatic Brain Injury
And Postconcussion Syndrome.*

**Key points provided
in the text portion of your handout.
(e.g., in research subjects who are free from
known financial incentives to claim
impairment: symptoms,
postural stability,
and neuropsychological testing,
all normalize within 7 days,
consistent with animal experiments regarding
post-mTBI neurometabolic cascade)**

**Insufficient scientific support for claims of
permanent impairment from mild TBI...**



American Academy of Clinical Neuropsychology
Is the education division of...
**American Board of Clinical Neuropsychology
(ABCN)**
Also known as
**American Board of Professional Psychology –
Clinical Neuropsychology
(ABPP-CN)**

**Insufficient scientific support for claims of
permanent impairment from mild TBI...**



**American
Medical
Association**

Examples of relevant literature

**American Medical Association
Guides to the Evaluation of
Permanent Impairment
6th Edition (2008,2009)**

**“the symptoms of MTBI generally
resolve in days to weeks, and
leave the patient with no
impairment”**

AMA Guides 6th Edition

**“the symptoms of MTBI generally
resolve in days to weeks, and leave
the patient with no impairment”**

**Summaries of the literature
referenced by the Guides is
provided in the text portion
of your handout.**

Insufficient scientific support for claims of permanent impairment from mild TBI...



Institute of Medicine

*Gulf War and Health:
Volume 7: Long-Term
Consequences of Traumatic
Brain Injury, 2008.*

Institute of Medicine, 2008



Reviewed over 30,000 scientific citations

“the committee found
...inadequate and insufficient
evidence of an association
between mild TBI and
neurocognitive deficits”

Institute of Medicine, 2008



Reviewed over 30,000 scientific citations

“the committee concluded that there was inadequate and insufficient evidence of an association between mild TBI and long-term adverse social functioning, including unemployment, diminished social relationships, and decrease in the ability to live independently.”

Insufficient scientific support for claims of permanent impairment from mild TBI...



**Department of Veterans Affairs
& Department of Defense**
*Clinical Practice Guideline for
Management of Concussion /
Mild Traumatic Brain Injury,
2009*

Veterans Affairs / Defense, 2009



“Concussion/mTBI is a common injury, with a time-limited and predictable course. The majority of patients with concussion/mTBI do not require any specific medical treatment”

Veterans Affairs / Defense, 2009



“The vast majority of patients who have sustained a concussion/mTBI improve with no lasting clinical sequelae”

Veterans Affairs / Defense, 2009



BARTH NeuroScience

“Patients should be reassured and encouraged that the condition is transient and full recovery is expected. The term 'brain damage' should be avoided.”

Veterans Affairs / Defense, 2009



BARTH NeuroScience

- The vast majority of patients recover within hours to days, with a small proportion taking longer. In an even smaller minority, symptoms may persist beyond six months to a year
- The symptoms associated with Post-Concussion Syndrome are not unique to mTBI. The symptoms occur frequently in day to day life among healthy individuals and are also found often in persons with other conditions such as chronic pain or depression.

Veterans Affairs / Defense, 2009



BARTH NeuroScience

- Patients sustaining a concussion/mTBI should return to normal activity (work/duty/school/leisure) post-injury as soon as possible
- A gradual resumption of activity is recommended

Veterans Affairs / Defense, 2009



BARTH NeuroScience

“In patients with persistent post-concussive symptoms (PPCS), which have been refractory to treatment, consideration should be given to other factors including psychiatric, psychosocial support, and compensatory/litigation.”

Veterans Affairs / Defense, 2009



BARTH NeuroScience

“Early education of patients and their families is the best available treatment for concussion/mTBI and for preventing/reducing the development of persistent symptoms”

Veterans Affairs / Defense, 2009



BARTH NeuroScience

- Medication for ameliorating the neurocognitive effects attributed to concussion/mTBI is not recommended
- Medications for headaches, musculoskeletal pain, or depression/anxiety must be carefully prescribed to avoid the sedating properties, which can have an impact upon a person's attention, cognition, and motor performance

Insufficient scientific support for claims of permanent impairment from mild TBI...



Other major publications

Examples of relevant literature **“Arguably the best prospective outcome study”**

(Larrabee. *Forensic Neuropsychology* 2nd Ed., 2012)

Dikmen, S. S., et al (1995).
Neuropsychological outcome at one year post head injury. *Neuropsychology*, 9, pp. 80-90.

Dikmen SS, et al (1995).

No differences in 1-year outcomes for TBI participants versus trauma controls, even when TBI participants were included...

- **whose LOC lasted up to an hour**
- **who had brain imaging findings**

Almost no difference when LOC lasted up to 24 hours

Examples of relevant literature

Meta-Analysis of neuropsychological test data:

Binder, L. M., Rohling, M. L., and Larrabee, G. J. (1997). A Review of Mild Head Trauma, Part I. *Journal of Clinical and Experimental Neuropsychology*, 19, pp. 421-431.

Meta-Analysis of neuropsychological test data:

The short-term/transient effect size for mTBI is ~1/4 of the effect sizes associated with either...

- **Litigation/compensation**
- **Hypertension**

Another meta-analysis

Belanger HG, et al. Factors moderating neuropsychological outcomes following mild traumatic brain injury: a meta-analysis. *J Int Neuropsychol Soc.* 2005 May;11(3):215-27.

- **“In unselected or prospective samples, the overall analysis revealed no residual neuropsychological impairment by 3 months postinjury”**
- **“samples including participants in litigation were associated with greater cognitive sequelae”**
- **“litigation was associated with stable or worsening of cognitive functioning over time”**

Examples of relevant literature

Review of all relevant meta-analyses up until 2012

Rohling ML, et al.(2012).

The “Miserable Minority” Following Mild Traumatic Brain Injury: Who Are They and do Meta-Analyses Hide Them.

The Clinical Neuropsychologist, 26 (2), pp. 197-213.

Review of all relevant meta-analyses up until 2012

Rohling ML, et al.(2012). The Clinical Neuropsychologist, 26 (2), p. 197-213.

“Several comprehensive meta-analytic reviews of patients suffering a single uncomplicated mild traumatic brain injury (MTBI) have reported effect sizes for long-term outcome (i.e., **greater than three months post-trauma**) that are **not significantly different than zero**”.

(The publication references the previously published meta-analyses.)



What about the miserable minority?

Rohling ML, et al.(2012).

The “Miserable Minority” Following Mild Traumatic Brain Injury: Who Are They and do Meta-Analyses Hide Them.

The Clinical Neuropsychologist, 26 (2), pp. 197-213.

What about the miserable minority?

Rohling ML, et al.(2012). The Clinical Neuropsychologist, 26 (2), p. 197-213.

Since 1994, it has been theorized that a minority of mTBI survivors are outliers who do not experience the scientifically established complete and rapid recovery.

What about the miserable minority?

Rohling ML, et al.(2012). The Clinical Neuropsychologist, 26 (2), p. 197-213.

In order for such a minority to exist in spite of the scientific findings which have emerged historically, the effect of mTBI on this minority could not be much larger than one IQ point.

What about the miserable minority?

Rohling ML, et al.(2012). *The Clinical Neuropsychologist*, 26 (2), p. 197-213.

The effect on mTBI on this minority could not be much larger than one IQ point – for example, a maximum difference of an IQ index of 103 versus 102.

Not a meaningful or clinically significant difference (we obtain a larger difference by simply administering a relevant test two times to one healthy person).

What about the miserable minority?

Rohling ML, et al.(2012). *The Clinical Neuropsychologist*, 26 (2), p. 197-213.

Given such a small maximum effect, any method that is supposedly established for identifying an outlier who is experiencing persistent impairment from a mTBI would result in more false positives than true positives.

Therefore, any diagnostic conclusion of persistent impairment from mTBI is probably incorrect.



Complicated mTBI

Hanlon RE, et al. Effects of acute injury characteristics on neuropsychological status and vocational outcome following mild traumatic brain injury. *Brain Inj.* 1999 Nov;13(11):873-87.

“There was no difference, with respect to neuropsychological status or vocational outcome, between patients who had positive findings on **computerized tomography (CT)** versus those who were CT negative.” (approximately 6 months post-injury)

Complicated mTBI

McCauley SR, et al. Postconcussional Disorder Following Mild to Moderate Traumatic Brain Injury: Anxiety, Depression, and Social Support as Risk Factors and Comorbidities. *Journal of Clinical and Experimental Neuropsychology*, 2001, 23, 6, 792-808.

Brain imaging findings were not predictive of the development of a persistent PCD (three months after injury)

Complicated mTBI

Hughes DG, et al. Abnormalities on **magnetic resonance imaging** seen acutely following mild traumatic brain injury: correlation with neuropsychological tests and delayed recovery. *Neuroradiology*. 2004 Jul;46(7):550-8.

- “There was no significant correlation (of imaging findings) with a questionnaire for PCS and return to work status” (six months post-injury)
- “standard MRI techniques are not helpful in identifying patients with MTBI who are likely to have delayed recovery.”

Complicated mTBI

Lange RT, et al. Neuropsychological outcome from **uncomplicated mild, complicated mild, and moderate traumatic brain injury** in US military personnel. Arch Clin Neuropsychol. 2012 Aug;27(5):480-94.

“There were no significant differences between the three groups on the majority of neurocognitive measures. Similarly, there were no significant differences between the three groups on the majority of PAI clinical scales (all $p > .05$), with the exception of two scales. The uncomplicated MTBI group had significantly higher scores on the Anxiety-Related Disorders and Aggression scales compared with the complicated MTBI group, but not the moderate TBI group.”

Complicated mTBI

Iverson GL, et al. Outcome from Complicated versus Uncomplicated Mild Traumatic Brain Injury. Rehabil Res Pract. 2012: 1-7.

Complicated mTBI participants “did not perform more poorly on neurocognitive measures or report more symptoms, at 3-4 weeks after injury compared to patients with uncomplicated MTBIs.”

World Health Organization

“Volume 2”: 2001-2012

Linda J. Carroll, et al.

Systematic Review of the Prognosis After Mild Traumatic Brain Injury in Adults: Cognitive, Psychiatric, and Mortality Outcomes: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil, 2014 Mar;95(3 Suppl):S152-73.

World Health Organization

“CT abnormalities do not reliably predict the presence of deficits”

(e.g. No predictive value for CT findings when other variables are controlled for)



Repeated mTBI **Meta-analysis**

Belanger HG, et al. Neuropsychological performance following a history of multiple self-reported concussions: a meta-analysis. J Int Neuropsychol Soc. 2010 Mar;16(2):262-7.

“The overall effect of multiple MTBI on neuropsychological functioning was minimal and not significant.”

World Health Organization
"Volume 2": 2001-2012

Linda J. Carroll, et al.

Systematic Review of the Prognosis After Mild Traumatic Brain Injury in Adults: Cognitive, Psychiatric, and Mortality Outcomes: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil, 2014 Mar;95(3 Suppl):S152-73.

"...prior TBI did not predict cognitive deficits."

Repeated mTBI

Silverberg ND, et al. Post-concussion symptom reporting after multiple mild traumatic brain injuries. J Neurotrauma. 2013 Aug 15;30(16):1398-404.

"Having one or two previous remote MTBIs was not associated with worse outcome from subsequent MTBI in this sample."

Repeated mTBI: Military


Ivins BJ, et al. Performance on the Automated Neuropsychological Assessment Metrics in a nonclinical sample of soldiers screened for mild TBI after returning from Iraq and Afghanistan: a descriptive analysis. J Head Trauma Rehabil. 2009 Jan-Feb;24(1):24-31.

"There also were no associations between poor ANAM performance and the number of lifetime TBIs"


Repeated mTBI: Blast Injuries

Lippa SM, et al. Postconcussive symptoms after blast and nonblast-related mild traumatic brain injuries in Afghanistan and Iraq war veterans. J Int Neuropsychol Soc. 2010 Sep;16(5):856-66.

No difference between one and multiple blast injuries



Postconcussion Syndrome (PCS)



Postconcussion Syndrome
International Classification of Diseases, 10th Revision (1992)
ICD-10
The only formalized definition & diagnostic protocol

ICD-10



“Postconcussion^{al} Syndrome”

ICD-10



“Postconcussional Syndrome”

“The syndrome occurs following head trauma (usually sufficiently severe to result in loss of consciousness), ...”

“Postconcussional Syndrome”



“and includes a number of disparate symptoms such as **headache**, **dizziness** (usually lacking the features of true vertigo), **fatigue**, **irritability**, difficulty in **concentrating** and **performing mental tasks**, impairment of **memory**, **insomnia**, and...”

“Postconcussional Syndrome”



“and reduced tolerance to
• **stress**,
• **emotional excitement**, or
• **alcohol. ...”**

“Postconcussional Syndrome”



“These symptoms may be accompanied by feelings of **depression or anxiety**, resulting from some **loss of self-esteem** and **fear of permanent brain damage**. Such feelings enhance the original symptoms and a **vicious circle** results. ...”

“Postconcussional Syndrome”



“Some patients become **hypochondriacal**, embark on a search for diagnosis and care, and may adopt a **permanent sick role. ...”**

“Postconcussional Syndrome”



This passage is basically saying that the syndrome might simply be psychological, rather than neurological or injury-related.

“The etiology of the symptoms is not always clear, and both organic and psychological factors have been proposed to account for them. The nosological status of this condition is thus somewhat uncertain. There is little doubt however, that the syndrome is common and distressing to the patient....”

“Postconcussional Syndrome”



“Diagnostic guidelines

At least three of the features described above should be present for a definite diagnosis. Careful evaluation with laboratory techniques (electroencephalography, brainstem evoked potentials, brain imaging, oculonastagmography) may yield objective evidence to substantiate the symptoms but results are often negative. The complaints are not necessarily associated with compensation motives.”

Postconcussion Syndrome



NOTE:

A different definition and diagnostic protocol was actually formulated for potential inclusion in the American Psychiatric Association’s diagnostic system (DSM), but it was rejected.

DSM-IV, rejection specified p. 703-706

DSM-IV-TR, rejection specified p. 759-762

DSM-5, not indexed

Is postconcussion syndrome caused by MTBI – concussion?

NO...

Postconcussion syndrome is NOT caused by MTBI – concussion

Meares S, et al. The Prospective Course of Postconcussion Syndrome: The Role of Mild Traumatic Brain Injury. *Neuropsychology*, 2011, 25, 4, 454-465.

“Prospective consecutive admissions to a Level 1 trauma hospital were assessed a mean **4.9 days** and again **106.2 days** post-injury. The final sample comprised 62 mTBI and 58 non-brain-injured trauma controls.”

“MTBI did not predict PCS.”

Postconcussion syndrome is NOT caused by MTBI – concussion

Ponsford J, et al. Predictors of postconcussive symptoms 3 months after mild traumatic brain injury. *Neuropsychology*. 2012 May;26(3):304-13.

- Compared mTBI patients to people who had experienced injuries that did not involve the head
- mTBI NOT predictive of PCS as of three months post-injury
- Predictors of PCS: pre-injury physical or psychiatric problems

Postconcussion syndrome is NOT caused by MTBI – concussion

PCS in the non-brain-injured general population...

Iverson GL & Lange RT. *Applied Neuropsychology*, 2003, 10: 137-144.

How many people without a history of head injury satisfied diagnostic criteria for PCS?

DSM-IV Criteria

79.6%

How many people without a history of head injury satisfied diagnostic criteria for PCS?

ICD-10 Criteria

72.1%

PCS in the non-brain-injured general population

Bottom Line:

The historical-formal conceptualizations of postconcussion syndrome are not actually correlated with whether someone has had a concussion...

Postconcussion syndrome is NOT caused by MTBI – concussion

PCS in the non-brain-injured claimant / plaintiff population

Larrabee. *Forensic Neuropsychology 2nd Ed. 2012.*
(Based on published scientific findings from various sources)

WARNING: the symptom reporting for the mTBI group in the next slide is artificially elevated due to self-selection, inclusion of claimants / litigants, and no utilization of validity testing.

Symptom	Percent Endorsing Complaint		
	Mild Traumatic Brain Injury ^a	Medical Outpatients ^b	Non-neurologic Litigants ^b
Headache	59.1	62	88
Anxiety	58.3	54	93
Depression	63.2	32	89
Poor Concentration	70.5	26	78
Dizziness	52.0	26	44
Visual Problems	45.4	22	32
Irritability	65.9	38	77
Fatigue	63.9	58	79
Trouble Thinking	57.6	16	59 ^c
Poor Memory	50.6 ^d	20	53

^aMittenberg et al. 1992; 100 persons with MTBI

PCS in the non-brain-injured claimant/plaintiff population

Bottom Line:

The historical conceptualizations of postconcussion syndrome are more strongly associated with filing a medical-legal claim, rather than being specific to a history of concussion.

Postconcussion syndrome

What are the typical causes of a claim of persistent postconcussion syndrome?

What are the typical causes of a claim of prolonged postconcussion syndrome?

The World Health Organization's Collaborating Center Task Force on Mild Traumatic Brain Injury

Carroll L.J, Cassidy J.D. PROGNOSIS FOR MILD TRAUMATIC BRAIN INJURY: RESULTS OF THE WHO COLLABORATING CENTRE TASK FORCE ON MILD TRAUMATIC BRAIN INJURY. J Rehabil Med 2004; Suppl. 43: 84-105.

(continued)

The World Health Organization's Collaborating Center Task Force on Mild Traumatic Brain Injury

"The most consistent predictors of delayed recovery after mild traumatic brain injury are compensation and litigation factors, independent of mild traumatic brain injury severity."

The World Health Organization's Collaborating Center Task Force on Mild Traumatic Brain Injury

"...the question of whether pre-morbid personality is an important predictor of persistent symptoms after mild traumatic brain injury."

"One study that addresses this issue in a unique and highly selected sample of individuals who had been administered psychological tests prior to their injury found that post-mild traumatic brain injury psychological problems reflected pre-morbid personality, rather than the effects of the injury."

What are the typical causes of a claim of persistent postconcussion syndrome?

Iverson G.L. Outcome from mild traumatic brain injury. Current Opinion In Psychiatry, 2005, May, 18 (3), 301-17.

All of the following have a stronger effect than does MTBI...

All of the following have a stronger effect than does MTBI...

Claims context
Mood disorders
ADHD
Exaggeration/malingering
Benzodiazepines
Marijuana
Symptomatic HIV

>>>

What are the typical causes of a claim of prolonged postconcussion syndrome?

- **Remember that we already saw that hypertension has a stronger effect than does MTBI.**
- **We have only talked about the issues that have been shown, in head to head comparison, to have a stronger effect than MTBI. Note that there are many other neuropsychological risk factors that we have not yet talked about, which also need to be considered.**

What are the typical causes of a claim of prolonged postconcussion syndrome?
Mittenberg W., et al. (1992). Symptoms Following Mild Head Injury: Expectation As Etiology. Journal of Neurology, Neurosurgery, and Psychiatry, 55, pp. 200-204.

- **PCS is dependent upon the extent to which the postconcussive individual attributes non-injury-related shortcomings to the injury (example, they overlook any history of pre-existing headache, and attribute all current headaches to the MTBI).**
- **catastrophizing, avoidance, maladaptive coping, creating distress, stress, and disability.**

Persistent postconcussion syndrome

Are these people faking?

“These data show base rates of malingering that approach or exceed 50%...”

Larrabee G.J. Assessment of Malingered Neuropsychological Deficits. Oxford, 2007.

Persistent postconcussional syndrome

What can we do for someone with prolonged postconcussive complaints?

Credible treatment for claims of prolonged PCS

1. **Reassurance:** teaching patients about the excellent prognosis
2. **Cognitive behavior psychotherapy** focused on:
 - Teaching patients to re-evaluate “symptoms” as possibly normal shortcomings
 - Teaching patients to avoid over-reacting to such perceived symptoms
 - Teaching patients to avoid becoming stressed by such perceived symptoms

NOTE: This psychotherapy approach is the ONLY scientifically validated specific treatment for PCS.

Mittenberg W, et al. Cognitive-behavioral prevention of postconcussion syndrome. Archives of Clinical Neuropsychology, 1996, 11, 139-145.

Credible treatment for claims of prolonged PCS

AMA Guides to the Evaluation of Permanent Impairment

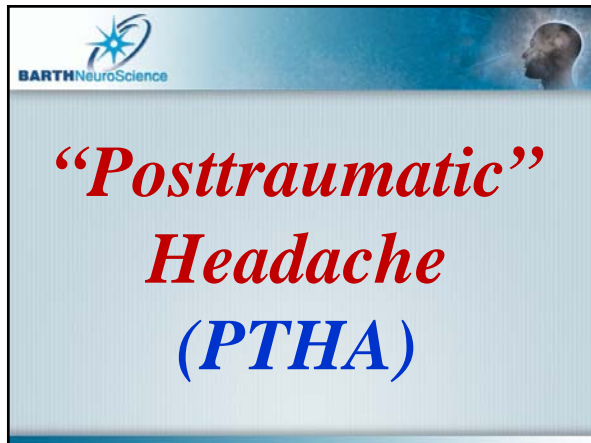
Both of the references chosen for this *Guides*' discussion of mTBI emphasize such reassurance and (if necessary) cognitive behavioral psychotherapy

World Health Organization

"Volume 2": 2001-2012

Nygren-de Boussard, et. al. Nonsurgical Interventions After Mild Traumatic Brain Injury: A Systematic Review. Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Archives of Physical Medicine and Rehab, 2014; 95(3 Suppl 2):S257-64.

- **Some support for**
- **"early, reassuring educational information"**
- **No support for any other treatments**



Does trauma cause prolonged headaches?

NO...

Barth R.J. Obstacles to Claiming Permanence and Injury-Relatedness for "Posttraumatic" Headache. *The Guides Newsletter*, May/June, 2009. American Medical Association.

Trauma is not a cause of prolonged headaches

Berry H. Chronic whiplash syndrome as a functional disorder. *Arch Neurol.* 2000 Apr;57(4):592-4.

- **Study of Demolition Derby Drivers**
- **Average collision experience per driver:**
 - 1900 collisions/driver**
 - **How many have clinically significant headache problems:**

0

Trauma is not a cause of prolonged headaches

Couch JR, Bearss C.

Chronic daily headache in the posttrauma syndrome: **relation to extent of head injury.** *Headache.* 2001 Jun;41(6):559-64.

"...the risk of developing posttraumatic chronic daily headache is greater for less severe head injury..."

Trauma is not a cause of prolonged headaches

In other words:

- In terms of both incidence and severity, **trauma is not correlated with headache.**
- All of this is **the opposite of a causative connection** between trauma and the headaches, according to health causation standards.

Trauma is not a cause of prolonged headaches

Obelieniene D, et al. *J Neurol Neurosurg Psychiatry*. 1999 Mar;66(3):279-83.

Headache is common immediately following head trauma, but such headache is associated with an overwhelmingly positive prognosis (maximum duration outside of a compensation context = 20 days).

Outside of a legal claims context, the percentage of trauma patients who continue to complain of headache is essentially the same as the percentage of non-injured people who complain of persistent headaches.

Trauma is not a cause of prolonged headaches

Schrader H, et al. *Lancet*. 1996 May 4;347(9010):1207-11.

the vast majority (85%) of people who complain of frequent headaches following a trauma, but who are removed from litigation/compensation contingencies, acknowledge that they also had frequent headaches prior to the trauma.

Trauma is not a cause of prolonged headaches

Warner, J. S. and Fenichel, GM (1996). Chronic posttraumatic headache often a myth? *Neurology*, 46, pp. 915-916.

- In research focused on claims of persistent posttraumatic headache, more than 80% of the sample of such patients were found to actually have a non-injury-related headache syndrome.
- In most cases, the true diagnosis was medication-induced headache.
- For those cases, a treatment plan focused on medication elimination led to the headache going away.

Trauma is not a cause of prolonged headaches

Such scientific findings are supportive of textbook conclusions that medication (e.g. narcotics, ergotamine derivatives, nsaid, etc.) is the necessary and sufficient cause of chronic daily headache complaints.

Levenson JL. *Textbook of Psychosomatic Medicine*. American Psychiatric Publishing; 2005.

Trauma is not a cause of prolonged headaches

Mathew NT. Chronic refractory headache. *Neurology*. 1993 Jun;43(6 Suppl 3):S26-33.

- "630 patients with chronic daily headache... 73% overused symptomatic medication, particularly analgesics and ergotamine, and as a result, suffered from drug-induced headache or rebound headache."
- The medication over-utilizers also commonly reported:
 - Fatigue
 - Irritability
 - Depression
 - Memory difficulties
 - Headache worsening with small amounts of effort (mental or physical)...

Trauma is not a cause of prolonged headaches

Mathew NT. Chronic refractory headache. Neurology. 1993 Jun;43(6 Suppl 3):S26-33.

- The medication over-utilizers also commonly reported:
 - Chronic headache
 - Fatigue
 - Irritability
 - Depression
 - Memory difficulties
 - Headache worsening with small amounts of effort (mental or physical)...

➤ **Is it just me???**

Or does this medication over-utilization syndrome appear to be awfully similar to the failed concepts of PCS?

Trauma is not a cause of prolonged headaches

In the absence of a claims context and medications, the most common correlate of persistent headaches is chronic depression or anxiety (found in the majority of cases).

Ropper AH, and Samuels MA(2009). Adams and Victor's Principles of Neurology, Ninth Edition. McGraw-Hill.



What about military mTBI?

World Health Organization

"Volume 2": 2001-2012

Boyle E, et. al. Systematic Review of Prognosis After Mild Traumatic Brain Injury in the Military: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Archives of Physical Medicine and Rehab, 2014; 95(3 Suppl 2):S230-7.

"Although the prognosis of injuries sustained in combat may differ from injuries sustained elsewhere, the results of this review are similar to those reported in the past by the World Health Organization Collaborating Centre Task Force on Mild Traumatic Brain Injury. The task force found ...consistent evidence that these deficits resolve within 3 months postinjury."

Military mTBI

Belanger HG, et al. Symptom complaints following combat-related traumatic brain injury: relationship to traumatic brain injury severity and posttraumatic stress disorder. J Int Neuropsychol Soc. 2010 Jan;16(1):194-9.

- **More PCS sx endorsed by mTBI survivors than by moderate-severe TBI survivors (the opposite of a causative dose-response relationship)**
- **Difference disappeared when emotional distress was controlled for**
- **Bottom line: PCS sx attributable to emotional distress rather than mTBI**

Military mTBI

O'Neil ME, et al. (2012). Complications of Mild Traumatic Brain Injury in Veterans and Military Personnel: A Systematic Review. VA-ESP Project #05-225.

"Though the overall strength of evidence evaluating outcomes following mTBI in Veteran or military populations is low, it is noteworthy that the findings are remarkably consistent with higher quality civilian literature. Both bodies of research suggest that many health consequences resolve within the first few months following injury, if not sooner."

Military mTBI

Shandera-Ochsner AL, et al. Neuropsychological effects of self-reported deployment-related mild TBI and current PTSD in OIF/OEF veterans. Clin Neuropsychol. 2013;27(6):881-907.

- “comprehensive neuropsychological testing”
- “Consistent with literature on civilian mTBI, the current study did not find evidence that combat-related mTBI in and of itself contributes to objective cognitive impairment in the late stage of injury.”
- Test results WERE significantly worse for participants endorsing elevated emotional distress.

Military mTBI

Lange RT, et al. Risk factors for postconcussion symptom reporting after traumatic brain injury in U.S. military service members. J Neurotrauma. 2013 Feb 15;30(4):237-46.

- “Many factors unrelated to brain injury were influential in self-reported postconcussion symptoms in this sample.”
- “PCD symptom reporting was most strongly associated with possible symptom exaggeration, poor effort, depression, and traumatic stress.”
- “PCD rarely occurred in the absence of depression, traumatic stress, possible symptom exaggeration, or poor effort.”

Military mTBI

Armistead-Jehle P. Symptom validity test performance in U.S. veterans referred for evaluation of mild TBI. Appl Neuropsychol. 2010 Jan;17(1):52-9.

“Fifty-eight percent of the sample scored below the MSVT cut scores on subtests more sensitive to effort than to neurological insult.”

Military mTBI

Blast Injuries?

Military mTBI: Blast Injuries

Belanger HG, et al. Cognitive sequelae of blast-related versus other mechanisms of brain trauma. J Int Neuropsychol Soc. 2009 Jan;15(1):1-8.

“Overall, the results do not provide any strong evidence that blast is categorically different from other TBI mechanisms, at least with regard to cognitive sequelae on select measures.”

Military mTBI: Blast Injuries

Lippa SM, et al. Postconcussive symptoms after blast and nonblast-related mild traumatic brain injuries in Afghanistan and Iraq war veterans. J Int Neuropsychol Soc. 2010 Sep;16(5):856-66.

- No difference in sx severity or pattern of sx
- No difference between one and multiple blast injuries (or proximity to blast).

Military mTBI: Blast Injuries

Belanger HG, et al. Symptom complaints following reports of blast versus non-blast mild TBI: does mechanism of injury matter? Clin Neuropsychol. 2011 Jul;25(5):702-15.

- “Mechanism of injury did not account for a significant amount of variance in post-concussion symptom reporting”
- “Symptom reporting was greater in those injured more than 1 month ago compared to those injured less than 1 month ago” (the opposite of a causative relationship)
- “Findings suggest that greater symptom reporting is most strongly related to emotional distress.”

Military mTBI: Blast Injuries

Nelson NW, et al. Neuropsychological outcomes of U.S. Veterans with report of remote blast-related concussion and current psychopathology. J Int Neuropsychol Soc. 2012 Sep;18(5):845-55.

- **No difference between blast-mTBI veterans and veterans who had not experienced mTBI, in terms of neuropsychological outcomes.**
- **Emotional disturbance was the strongest predictor of neuropsychological outcome.**

Military mTBI: Blast Injuries

Cooper et al. (2012). Relationship between mechanism of injury and neurocognitive functioning in OEF/OIF service members with mild traumatic brain injuries. Military Medicine, 177, 1157-1160.

“The current study supports previous research suggesting that mechanism of injury may not be a variable of significance with regards to neurocognitive outcome or treatment planning.”

Military mTBI: Blast Injuries

Verfaellie M, et al. Neuropsychological Outcomes in OEF/OIF Veterans With Self-Report of Blast Exposure: Associations With Mental Health, but not mTBI. Neuropsychology. 2013 Nov 18. [Epub ahead of print]

“Conclusions: A history of mTBI with or without LOC during deployment does not contribute to objective cognitive impairment in the chronic phase post injury. In contrast, PTSD and depression symptoms are associated with cognitive performance decrements.”

Military mTBI: Blast Injuries

Mac Donald CL et al. Prospectively assessed clinical outcomes in concussive blast vs nonblast traumatic brain injury among evacuated US military personnel. JAMA Neurol. 2014 Aug;71(8):994-1002.

“Results: Global outcomes, headache severity, neuropsychological performance, and surprisingly even PTSD severity and depression were indistinguishable between the two TBI groups, independent of mechanism of injury.”



What about mTBI from sports?

mTBI from sports

Belanger HG, Vanderploeg RD. The neuropsychological impact of sports-related concussion: a meta-analysis. J Int Neuropsychol Soc. 2005 Jul;11(4):345-57.


“However, no residual neuropsychological impairments were found when testing was completed beyond 7 days postinjury.”

World Health Organization

“Volume 2”: 2001-2012

Cancelliere C, et. al. Systematic Review of Prognosis and Return to Play After Sport Concussion: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Archives of Physical Medicine and Rehab, 2014; 95(3 Suppl 2):S210-29.

“It generally appears that cognitive function is not significantly impaired, or if impaired resolves within a few days to a few weeks for most high school, collegiate, and professional athletes after concussion.”



What about the NFL and “chronic traumatic encephalopathy”?




What about the NFL and “chronic traumatic encephalopathy”?

British Journal of Sports Med 2013

Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

What about the NFL and “chronic traumatic encephalopathy”?



2013 Consensus Statement International Conference on Concussion in Sport

“...it is not possible to determine the causality or risk factors with any certainty. As such, the speculation that repeated concussion or subconcussive impacts cause CTE remains unproven.”

World Health Organization

“Volume 2”: 2001-2012

Cancelliere C, et. al. Systematic Review of Prognosis and Return to Play After Sport Concussion: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Archives of Physical Medicine and Rehab, 2014; 95(3 Suppl 2):S210-29.

“Debates still exist about whether there is a link between repetitive concussion in athletes and late-life depression and mild cognitive impairment (MCI), chronic traumatic encephalopathy, and other dementia-related neurodegenerative disorders. There is insufficient high-quality evidence at this time to suggest these associations.”



Body mass index, playing position, race, and the cardiovascular mortality of retired professional football players.

Baron SL, et al.

National Institute for Occupational Safety and Health

Am J Cardiol. 2012 Mar 15;109(6):889-96.

National Institute for Occupational Safety and Health, 2012



- 3,439 National Football League players with ≥ 5 seasons from 1959 to 1988
- compared player mortality through 2007 to the United States population of men stratified by age, race, and calendar year
- **Overall player mortality was significantly decreased**

National Institute for Occupational Safety and Health, 2012



Cause of death: Mental, psychoneurotic, and personality disorders (e.g. suicide)

NFL: 4

Expected number based on matched controls (non-NFL): 11.7

NFL experience is PROTECTIVE against the effects of death associated with mental disturbance (e.g. suicide)?



**Mayo Clinic Proceedings. 2012
Apr;87(4):335-40**

High school football and risk of neurodegeneration: a community-based study.

Savica R, et al.

Mayo Clin Proc. 2012

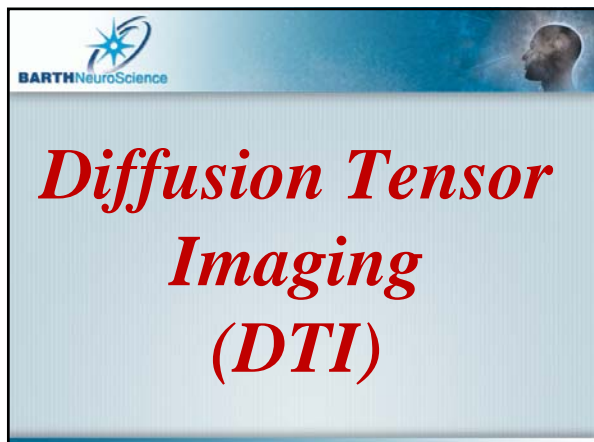


American football players from 1946 to 1956 did not have an increased risk of later developing dementia, Parkinson's Disease, or ALS (Lou Gehrig's Disease) compared with non-football-playing high school males, despite poorer equipment and less regard for concussions compared with today and no rules prohibiting head-first tackling (spearing).

Mayo Clin Proc. 2012



Indeed, the rate of PD and ALS was LOWER in the football group than in the glee club, choir, and marching band group.



Diffusion Tensor Imaging

Levin HS, et al. Diffusion tensor imaging of mild to moderate blast-related traumatic brain injury and its sequelae. *J Neurotrauma*. 2010 Apr;27(4):683-94.

- “Diffusion tensor imaging (DTI) ...disclosed no group differences” (between brain injured veterans and non-brain-injured veterans).
- “Correlations of DTI variables with symptom measures were non-significant and inconsistent.”

Diffusion Tensor Imaging

Wortzel HS, et al. Diffusion Tensor Imaging in Mild Traumatic Brain Injury Litigation. *J Am Acad Psychiatry Law* 39:511-23, 2011.

- “alterations in white matter integrity are not specific to TBI, and their presence does not necessarily confirm a diagnosis of mTBI.”
- “Guided by rules of evidence shaped by *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, we reviewed and analyzed the literature describing DTI findings in mTBI and related neuropsychiatric disorders. Based on this review, we suggest that expert testimony regarding DTI findings will seldom be appropriate in legal proceedings focused on mTBI.”

Diffusion Tensor Imaging

Lange RT, et al. Diffusion tensor imaging findings are not strongly associated with postconcussional disorder 2 months following mild traumatic brain injury. *J Head Trauma Rehabil*. 2012 May-Jun;27(3):188-98.

- “There were no significant differences between MTBI and *trauma control* groups on all DTI measures.”
- “In the MTBI sample, there were no significant differences on all DTI measures between those who did and did not meet the International Classification of Diseases, Tenth Revision research criteria for postconcussion disorder.”
- “These data do not support an association between white matter integrity in the corpus callosum and self-reported postconcussion syndrome 6 to 8 weeks post-MTBI.”

Diffusion Tensor Imaging

Sorg, SF, et al. White Matter Integrity in Veterans With Mild Traumatic Brain Injury: Associations With Executive Function and Loss of Consciousness. *J Head Trauma Rehabil* Vol. 29, No. 1, pp. 21-32, 2014.

“There were no significant overall group differences between control and mTBI participants on DTI measures.”

Diffusion Tensor Imaging

Wäljas M, et al. Biopsychosocial outcome after uncomplicated mild traumatic brain injury. *J Neurotrauma*. 2014 Jan 1;31(1):108-24.

mTBI subjects with multi-focal DTI abnormalities showed no evidence of worse symptoms, cognitive impairment, or slower RTW, compared to mTBI subjects with normal DTI

Diffusion Tensor Imaging

Yuh EL, et al.

Imaging concussion: a review.

Neurosurgery. 2014 Oct;75 Suppl 4:S50-63.

“no strong consensus yet exists on the best approach for utilizing DTI parameters for diagnosis and prognosis in the individual patient.”

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

Kraus MF, et al. White matter integrity and cognition in chronic traumatic brain injury: a diffusion tensor imaging study.

Brain. 2007 Oct;130(Pt 10):2508-19.

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

Kraus Brain. 2007

Control group:

“Eighteen healthy controls were recruited from the community.”

- No mention of injured controls
- No acknowledgement of this limitation

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

MacDonald CL, et al. Detection of blast-related traumatic brain injury in U.S. military personnel. N Engl J Med. 2011 Jun 2;364(22):2091-100.

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

MacDonald, 2011

Published comments (Xydakis):

- “Systematic differences between the scanners far exceed the differences between the two cohorts”
- “Until DTI metrics can be calibrated reproducibly within and across MRI scanners, *it is premature for the authors to suggest that quantitative DTI metrics be routinely used to assess individual patients with mTBI for the purpose of “diagnosis, triage, and treatment planning in clinical practice.”*”

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

MacDonald, 2011

Published comments (Hoge & Castro):

“The design is analogous to comparing persons with blast concussions to normal (non-injured) controls and then misattributing neuroimaging abnormalities to the mechanism instead of to the injury.”

Diffusion Tensor Imaging

Clarification of the problematic aspects of publications which provide superficial support

MacDonald, 2011

Author's response to published comments

- “We concur that our interpretation of the DTI abnormalities is but one of many possibilities.”
- “We do not suggest that DTI is at present ready for routine clinical use in TBI”
- “Improved calibration and standardization will be required before this potential is realized.”

Diffusion Tensor Imaging

A new project that brings many of today's themes together

Lange RT, et al.

Diffusion tensor imaging findings and postconcussion symptom reporting six weeks following mild traumatic brain injury.

Arch Clin Neuropsychol. 2015 Feb;30(1):7-25.

Diffusion Tensor Imaging

A new project that brings many of today's themes together

Lange RT, 2015

Considered four DTI measures and found no relationship to claimed impairment, six weeks post-injury

Diffusion Tensor Imaging

A new project that brings many of today's themes together

Lange RT, 2015

References similar findings for 3 weeks post-injury and 6-8 weeks post-injury (no relationship between claimed impairment and DTI measures)

Diffusion Tensor Imaging

A new project that brings many of today's themes together

Lange RT, 2015

DTI findings were NOT predicted by a history of mild traumatic brain injury

Diffusion Tensor Imaging

A new project that brings many of today's themes together

Lange RT, 2015

DTI findings were predicted by depression / anxiety

Diffusion Tensor Imaging


A new project that brings many of today's themes together
Lange RT, 2015

Replicating...

“Numerous studies have shown that depression and other affective disorders are associated with white-matter abnormalities as identified by DTI.”




More severe brain injuries
(the ones that are worse than mild)




Severe Brain Injury Scientific Findings

- **Recovery continues for at least ten years**
- **Return to a normal life is probable**



Severe Brain Injury Scientific Findings

- **Regaining the ability to work for a living is probable**
- **For those who do not RTW on their own, formal supportive employment programming reliably leads to a return to independent work**



Severe Brain Injury Scientific Findings

When a doctor predicts, within the first five years of the injury, a bleak prognosis, that doctor is probably wrong!

Severe Brain Injury **Scientific Findings**



- Dresser AC, et.al. Gainful employment following head injury. *Archives of Neurology*, August 1973, 111-116.
- Miller H, Stern G. The Long-Term Prognosis of Severe Head Injury. *Lancet*. 1965 Jan 30;1(7379):225-9.
- Sbordone RJ, et al. Recovery of function following severe traumatic brain injury: a retrospective 10-year follow-up. *Brain Injury*, 1995, 9, 3, 285-299.
- Wehman PH, et al. Return to work for persons with traumatic brain injury: A supported employment approach. *Arch Phys Med Rehab*, 1990; 71: 1047-52.
- Wood RL et al. Psychosocial adjustment 17 years after severe brain injury. *Journal of Neurology Neurosurgery Psychiatry* 2006; 77: 71-73.



Robert J. Barth, Ph.D.
Fellow, National Academy of Neuropsychology

*The American Medical Association's
Guides to the Evaluation of Permanent Impairment, 6th Edition
(the current edition)
specifies that mild traumatic brain injury
is NOT associated with any permanent impairment*

**Robert J. Barth, Ph.D.
Parkridge Hospital Plaza Two
2339 McCallie Ave.
Chattanooga, TN 37404
423/624-2000**

Background

The Sixth Edition of the American Medical Association's *Guides to the Evaluation of Permanent Impairment* (Rondinelli et. al.) is one of many publications which explains, based on the relevant scientific knowledge base, that there is no permanent impairment associated with mild traumatic brain injury (referred to as MTBI in the remainder of this paper) (a more detailed, and referenced, discussion is provided below). This article expands on the discussion that is provided by the *Guides*, specifically by providing details from the scientific literature which is referenced in the *Guides*' discussion of this issue.

MTBI Does Not Provide a Credible Basis for Claims of Permanent Impairment

The Sixth Edition of the American Medical Association's *Guides to the Evaluation of Permanent Impairment* (Rondinelli et al.) specifies that:

- MTBI leaves patients with no permanent impairment.

- Impairment from a MTBI generally resolves within days to weeks after the injury.

Scientific Publications Referenced By The Guides

The relevant passage from the *Guides* references two high-profile reviews of relevant scientific findings and healthcare recommendations.

The first of those reviews (Ropper and Gorson) has a high-profile status because it was published in the *New England Journal of Medicine*, and because the lead author is also the lead author of a best-selling neurology textbook (Ropper and Samuels) which has been independently reviewed as being of high quality (Lanska). Relevant key points from this review include:

- Research projects which have involved a high-quality scientific design have demonstrated that there is no persistent intellectual impairment associated with such injuries.
- Large-scale, extensive study of relevant cases has revealed that the prognosis involves a return to normal cognitive and motor functioning within a matter of weeks.
- The causes of persistent symptoms remain unclear.
- Scientific findings have established a link between eligibility for compensation, and persistent symptoms.
- Consequently, credible health care includes encouraging the patient to promptly resolve any legal entanglements.
- Established themes of treatment include reassuring the patient that the prognosis involves complete and rapid recovery (such reassurance has been scientifically demonstrated to reduce the incidence and duration of symptoms), and avoidance of narcotics.
- For cognitive complaints that persist for several weeks, the only recommendation for evaluation in response to such complaints is consultation with a neuropsychologist.

The second of the reviews that are referenced in the sixth edition of the *Guides* has a high profile status because it was created as part of a book series for the American Academy of Clinical Neuropsychology (McCrea). This review is voluminous: it involves an entire book, rather than simply involving a journal article. Relevant key points from this review include:

- The natural history of MTBI is characterized by gradual, full recovery in symptoms, cognition, and general functioning within several days to weeks of the injury.
- "The overwhelming majority of MTBI patients follow a favorable course of functional recovery by returning to normal occupational, social, and independent functioning within days to weeks after injury."
- "MTBI symptoms gradually resolve over a period of days to weeks in the overwhelming majority of cases."
- "MTBI is most often followed by a favorable course of cognitive recovery over days to weeks, with no indication of permanent impairment on neuropsychological testing by three months post-injury."
- Scientific findings have indicated that neurophysiologic effects of the injury follow a course of recovery consistent with the rapid resolution of symptoms and rapid demonstrations of recovery on neuropsychology testing, "as the brain returns to a normal physiologic state within days to weeks of injury".
- Most of the available scientific findings indicate that the physiologic abnormalities associated with mild traumatic brain injury resolve, and normal brain metabolic function returns, within days to weeks after the injury.
- Persistent symptoms and poor functional outcome are associated with non-injury-related variables.
- Scientific findings have indicated that the detrimental effect of financial incentives on outcome following MTBI is "quite significant".
- Scientific research which compared MTBI claimants to claimants who were not claiming to have experienced a brain injury (they were claiming to have experienced some sort of injury that did not involve the brain), revealed that the two groups endorsed similar levels of symptoms that are commonly attributed to MTBI. Such findings indicate that symptoms which are commonly attributed to MTBI are more strongly associated with a claims context of presentation, rather than actually being specific to claims of MTBI.
- Estimates that 15-20 percent of MTBI patients have persistent postconcussion symptoms are severely inflated.
- Symptoms which are commonly attributed to MTBI are not actually specifically associated with MTBI, and are commonly reported by healthy people.
- Scientifically validated treatment for symptoms that are commonly attributed to MTBI involves psychological and educational interventions (e.g., cognitive

behavior psychotherapy, focused on helping the patient to stop misattributing cognitive shortcomings to the history of MTBI).

References:

Lanska DJ. Adams and Victor's Principles of Neurology. *JAMA*. 2010; 303 (13): 1311 – 1312.

McCrea MA. *Mild Traumatic Brain Injury and Postconcussion Syndrome*. American Academy of Clinical Neuropsychology and Oxford University Press. 2008.

Rondinelli RD, Brigham CR, et al. (Editors). *Guides to the Evaluation of Permanent Impairment*, Sixth Edition, Reprint. American Medical Association. 2009.

Ropper AH & Gorson KC. Concussion. *The New England Journal of Medicine*, 2007; 356:166-72.

Ropper AH and Samuels MA. *Adams and Victor's Principles of Neurology, Ninth Edition*. McGraw-Hill, 2009.



Robert J. Barth, Ph.D.
Fellow, National Academy of Neuropsychology

SPECT is Not a Credible Tool for Evaluating Mild Traumatic Brain Injury

Robert J. Barth, Ph.D.

Background

The current edition of the American Medical Association's *Guides to the Evaluation of Permanent Impairment* (Rondinelli) is one of many publications which explain, based on the relevant scientific knowledge base, that there is no permanent impairment associated with mild traumatic brain injury.

There has been a growing trend for some imaging facilities, attorneys, and doctors to promote the use of single photon emission computed tomography (SPECT) as a mechanism for evading the relevant scientific knowledge base, in support of a legal claim that a MTBI has caused permanent impairment (Wortzel et al.; Granacher). This trend has been summarized in the following fashion: "The overselling of SPECT ...neuroimaging by lawyers is a serious potential evidentiary concern in the civil litigation of MTBI." (Granacher)

This trend raises a question of why SPECT, which involves a relative lack of scientific/engineering sophistication and anatomic resolution (compared to other imaging options) (Ropper & Samuals), would be so prominent in such efforts to evade the relevant scientific knowledge base. Published discussions of SPECT indicate that the reasons for this probably include the relative inexpensiveness and availability of SPECT, rather than SPECT providing any advantages in terms of scientific credibility or patient safety. The relative lack of expense, and relative accessibility of SPECT has been specified in multiple publications (e.g., Davalos & Bennett; Ropper & Samuals; Wortzel et al.).

The lack of any scientific or safety advantages for SPECT is clearly documented in the American College of Radiology's Appropriateness Criteria, which specify that other radiology options for head trauma are more appropriate in terms of stronger scientific support, and involve lower radiation exposure (references and details discussed later in this document).

This document is specifically being provided in response to this trend for SPECT to be used in an attempt to evade the relevant scientific knowledge base regarding MTBI. The

goal is to provide evaluators and adjudicators with the information that they will need in order to minimize any confusion that might be created by this trend.

Basic Health Science References Regarding SPECT and MTBI

Three high-profile resources regarding general health science of relevance to this issue are being offered for purposes of illuminating the relevant scientific knowledge base. A later section of this article will build on that foundation by reviewing health science publications which directly address the use of SPECT for forensic purposes (especially in cases of MTBI).

One such general health science resource is the neurology textbook, *Adam and Victor's Principles of Neurology, Ninth Edition* (Ropper and Samuels). This text is being referenced because independent reviews have specified that it is:

- "The definitive text on the full spectrum of neurology"; An "Essential Purchase" for medical school libraries; "This book should be an essential element in the library of both young and seasoned clinicians"; the highest rated general neurology book according to standardized rating system completed by 87 health science content specialists and 104 medical school librarians (Doody's Core Titles 2013 Edition)
- "This is one of the best neurology textbooks available"; "outstanding text"; "a key resource for neurologists and neurosurgeons"; "based on the best available studies"; "a comprehensive study guide" (Lanska)

Key points from this text include:

- Indexing for SPECT indicates that it is not mentioned in the craniocerebral trauma chapter (the chapter of most direct relevance to traumatic brain injury).
- Indexing for SPECT, and the associated text, indicates that traumatic brain injury is not included in the discussion of diagnostic issues for which SPECT might be a credible option (such discussions are limited to Alzheimer's dementia and localization of epileptic foci).
- The clinical usefulness of SPECT, in general, is limited, because of the relatively low quality anatomic resolution that it provides.

The American College of Radiology is the second source of general health science information that is being referenced for this discussion. Key points from this College include:

- The College's "White Paper on Radiation Dose in Medicine" warns that the "expanding use of imaging modalities using ionizing radiation may eventually result in an increased incidence of cancer in the exposed population" (Amis et al.)

- The white paper proposes minimizing the cancer risk by “preventing the inappropriate use of such imaging and by optimizing studies that are performed to obtain the best image quality with the lowest radiation dose”.
- This “White Paper” called for radiation dose information to be included in ACR considerations of imaging options, such as the Appropriateness Criteria reviewed below. The White Paper’s emphasis on preventing inappropriate imaging, optimizing studies that produce the best imaging quality, and optimizing studies that involve the lowest radiation dose, should be kept in mind as the following key points from the Appropriateness Criteria for “Head Trauma” are considered:
 - The June 21, 2012 update of the College’s Appropriateness Criteria for “Head Trauma” specifies that SPECT involves relatively high radiation dose (on a six point scale, the ACR criteria place SPECT at the second highest radiation dose level).
 - The June 21, 2012 update of the College’s Appropriateness Criteria for “Head Trauma” specifies that SPECT has extremely low to relatively low appropriateness for cases that might involve the issue of MTBI.
 - SPECT is rated as having the lowest level of appropriateness for “minor or mild acute closed head injury (GCS > 13), without risk factors or neurologic deficit”. This rating is at the lowest extreme (least appropriate) of a range that is labeled “usually not appropriate”. Seven other radiology options are listed as having a higher level of appropriateness, and all of those are listed as having a lower level of radiation exposure.
 - SPECT is also rated as having the lowest level of appropriateness for “minor or mild acute closed head injury, focal neurologic deficit, and/or risk factors”. This rating is at the lowest extreme (least appropriate) of a range that is labeled “usually not appropriate”. Seven other radiology options are listed as having a higher level of appropriateness, and all of those are listed as having a lower level of radiation exposure.
 - SPECT is also rated as being relatively low on the appropriateness scale for “subacute or chronic closed head injury with cognitive and/or neurologic deficits”. This rating is at the lowest extreme (least appropriate) of a range that is labeled “may be appropriate”, and is associated with the comment “For selected cases”. For the overall range of appropriateness ratings, this rating is in the lower half of the scale. Two other radiology options are listed as having higher levels of appropriateness and lower levels of radiation exposure, and three options are listed as having the same level of appropriateness as SPECT, but lower levels of radiation exposure.

- The low levels of appropriateness indicated for SPECT by the College’s ratings can be considered in conjunction with the textbook discussion that was provided above (e.g. the specification that the overall usefulness of SPECT is limited, due to the low quality of the anatomic resolution), and the forensic discussions that are referenced below (e.g., "Discrimination of neural or anatomic detail is not possible, even when SPECT is paired or fused with CT or MRI."; Granacher).
- The above considerations indicate that the use of SPECT for mild traumatic brain injury cases involves a mix of relatively low appropriateness, relatively low image quality, and relatively high radiation exposure. Consequently, such use of SPECT runs contrary to the College’s proposal of minimizing cancer risk by “preventing the inappropriate use of such imaging and by optimizing studies that are performed to obtain the best image quality with the lowest radiation dose”.
- Consequently, the College’s 2012 update of its “Appropriateness Criteria” for “Head Trauma” specifies that SPECT is “not considered routine clinical practice at this time”.
- The American College of radiology (ACR) also has a history of publishing "practice guidelines" regarding "SPECT brain perfusion" (these guidelines are published separately from the "appropriateness criteria" and "'White Paper on Radiation Dose in Medicine" that were discussed above).
 - The practice guideline entitled “ACR practice guideline for the performance of single photon emission computed tomography (SPECT) brain perfusion imaging" was retired/sunset it in 2007 (American College of Radiology – A). Such retirement/sunseting means "review of the literature indicates that a procedure or therapy is no longer considered effective are efficacious, or has been replaced by other technology or treatment" (American College of Radiology – B).
 - As a consequence of that retirement/sunseting, there is no practice guideline of relevance to brain SPECT in the ACR listing of Neuroradiology practice guidelines (American College of Radiology – C).
 - Another ACR practice guideline addresses "SPECT brain perfusion and brain death studies” (American College of Radiology – D). This guideline originated in 2007, and was updated in 2012. Both editions of this practice guideline have ventured slightly beyond the “brain death studies” that are focused on in their title. For example, each has listed a SPECT indication in the following vague fashion: “Evaluating symptomatic traumatic brain injury, especially in the absence of computed tomography (CT) and/or magnetic resonance imaging (MRI) findings". In the 2007 edition of this practice guideline, this "indication" was completely unexplained, and there was no referencing offered to justify it, or for purposes of developing an understanding of it. This lack of

explanation/referencing was corrected in the 2012 update. Specifically, the update offers two references that can be reviewed in order to develop a fuller understanding of this "indication".

- The older of the two references (Masdeu) provides the following elaboration of the potential indications for SPECT in cases of “mild head injury”:
 - “SPECT MAY (emphasis added) help in the ascertainment of more homogenous samples” of MTBI patients.
 - “Patients with EARLY (emphasis added) changes on SPECT COULD (emphasis added) be directed to cognitive rehabilitation programs and receive vocational guidance.”
 - “SPECT COULD (emphasis added) be used to detect cerebrospinal fistulas.”
- The more recent of the two references is a discussion of "ethical clinical practice" that was created by the Society of Nuclear Medicine Brain Imaging Counsel (Society of Nuclear Medicine Brain Imaging Counsel). Key points from that ethics discussion include:
 - mild traumatic brain injury is specified as an example of an issue for which there is not "adequate evidence to support the use of SPECT or PET in these instances to establish cause-and-effect relationships".
 - "mild head injury" is specified as an example of cases in which "the patterns are variable and not easily interpreted as being causally related to a particular disease entity".
 - "Head trauma" is specified as an example of "diseases where no well-defined metabolic or flow "signature" has been identified or where different subjects may have variable patterns of abnormalities".
 - The use of SPECT in personal injury and workers compensation cases is "especially controversial".
 - An introduction of SPECT "as objective evidence linking neurophysiological parameters (such as blood flow or metabolism) to" "an offer of proof of a traumatically caused...illness or injury" is specified an example of "unsupportable conclusions" within a forensic context.

- The referencing of this ethical discussion in the updated practice guideline provides a clear indication that the practice guideline's "indication" of the use of SPECT for symptoms that are attributed to a brain injury does not include mild traumatic brain injuries, especially within a forensic context. The older reference only provides guidance in terms of very limited potential uses of SPECT in mild brain injury cases (with those limited potential uses having no relevance to legal claims of persistent impairment being attributed to MTBI).

Forensic discussions

Several peer-reviewed health science publications have specifically addressed the attempts to utilize SPECT for forensic purposes in brain injury legal claims. The following text offers key points from several such publications. The publications are discussed in chronological order, for the sake of simplicity.

As was discussed above, the updated ACR "Brain death" practice guideline references the Society of Nuclear Medicine Brain Imaging Counsel's discussion of "ethical clinical practice" (Society of Nuclear Medicine Brain Imaging Counsel), which specifies that the use of SPECT for forensic purposes in a brain injury case is "unsupportable".

Readers are reminded that this ethics discussion was specifically selected for referencing in the 2012 update of the ACR practice guideline, thereby highlighting its continuing relevance as an indication of professional standards.

Two simultaneously published reviews of relevant literature focused on forensic applications of SPECT for MTBI cases (Wortzel et al.; Granacher) generated the following key points:

- Prior to the time of the publication of these reviews, "The medical literature (was) devoid of a rigorous review of the rules surrounding admission of evidence and the application of cerebral SPECT for forensic purposes."
- "The medical literature on functional neuroimaging (such as SPECT) and its applications to MTBI is weak scientifically, sparse in quality publications, lacking in well-designed controlled studies, and currently does not meet the complete standards of Daubert versus Merrill Dow Pharmaceuticals, Inc., for introduction of scientific evidence at trial."
- "The studies published to date on SPECT in TBI are sparse and inadequate. The studies have not been shown to correlate clearly with behavior changes or neuropsychological deficits at a level that one could testify to within reasonable medical probability or certainty."
- "This analysis of the suitability of cerebral SPECT imaging in mild TBI casts serious doubt on the evidentiary usefulness and appropriateness of this technique in this context at this time."

- "While clinicians and scientists are gaining experience with SPECT in mild TBI, the level of understanding surrounding the injured brain and this relatively new technology has not united to a degree sufficient to establish causal relationships between cerebral SPECT imaging findings and mild TBI or its neurobehavioral sequelae."
- "Officers of the court should be wary of any expert offering testimony involving definitive relationships between a SPECT image and an illness or symptom".
- "Experts should be discouraged from...making bold cause-and-effect claims between mild TBI and cerebral SPECT imaging findings. Based on the review of the literature presented in this article, testimony suggesting such relationships is neither justifiable nor appropriate. When misused and left unchallenged, cerebral SPECT imaging findings in mild TBI can be powerfully seductive and misleading"
- "the lack of a sufficient gold standard for detecting brain lesions after mild TBI makes calculations of sensitivity and specificity for SPECT impossible at this time."
- "the lack of the gold standard for the diagnosis of mild TBI makes any definitive determination of error rates (i.e., sensitivity, specificity, positive and negative predictive values of cerebral SPECT as a diagnostic assessment for mild TBI) impossible at present."
- "the direct causal relationship, if any, between such SPECT-identified rCBF abnormalities and mild TBI remains uncertain. Multiple potential confounding factors, including comorbidities, environmental influences, medications and substances of abuse, and patient activity, are usually operative in individual patients and are capable of generating rCBF patterns that are indistinguishable from those produced by mild TBI."
- "Collectively, these concerns suggest that considerable uncertainty remains regarding the sensitivity, specificity, positive and negative predictive values, and other possible sources of error when cerebral SPECT imaging is applied to the evaluation of both groups and individual patients with mild TBI. As a result, cerebral SPECT imaging and mild TBI does not appear to satisfy this aspect (known or potential error rate) of the third Daubert criterion."
- There is a "wide range of normal variability in cerebral SPECT imaging, both between and within subjects, which makes definitive identification of abnormalities challenging at best."
- Relevant ethical considerations emphasize "that patients will present with nonspecific perfusion patterns and that the implication of direct relationships

between the lesion and a particular etiology, behavior, or neuropsychiatric symptom is to be avoided."

- Relevant ethical considerations also note "the insufficient state of evidence surrounding cause-and-effect relationships between SPECT images of mild TBI".
- "Although patterns of abnormal SPECT imaging are commonly observed in the studies of persons with neurological or psychiatric conditions when compared with normal comparison subjects, these patterns are generally not specific to any individual neurological or psychiatric condition and instead demonstrate considerable overlap with one another."
- "metabolic changes"... "on cerebral SPECT imaging does not confirm a diagnosis of mild TBI"
- "extreme caution is merited before committing SPECT results to any single etiology such as mild TBI", because of:
 - the common occurrence of, and potential artifact caused by, comorbid conditions
 - the influence of pre-existing conditions on the SPECT results
 - "the dearth of information on how various medications, drugs of abuse, and dissimilarities in testing conditions may influence results".
- Scientific study of the ability of SPECT readers to distinguish mild TBI cases from other conditions revealed a 46% error rate (little better than flipping a coin).
- Scientific findings have revealed that "abnormal SPECT findings are not clearly useful in establishing clinically relevant and TBI-related cerebral dysfunction".
- "the prognostic utility of an abnormal SPECT study is unclear... SPECT imaging cannot be employed to forecast neuropsychological impairment"
- "The literature does not demonstrate consistent relationships between SPECT images and neuropsychological testing or neuropsychiatric symptoms."
- "The review of literature... confirms a lack of consistent relationships between SPECT neuroimaging and concurrent neuropsychological testing or the expression of neuropsychiatric symptoms in MTBI."
- Scientific findings have indicated that "there is no unique PET or SPECT profile that has been clinically validated with TBI".
- "In short, cerebral SPECT imaging, even with its relative abundance of research in mild TBI relative to PET and fMRI, is of uncertain clinical utility in the context of mild TBI."

- “The remaining Daubert inquiry asks if general acceptance of the theory and technique has been achieved in the relevant scientific community. In the case of SPECT imaging and mild TBI, the most accurate answer, based on the literature, appears to be no.”
- "Similarly, it is neither scientifically established nor generally accepted that cerebral SPECT can link patterns of abnormal rCBF to any specific etiology (i.e., mild TBI) or clinical neuropsychiatric condition."
- Because of several technical issues, SPECT may be especially inadequate for the study of brain injury (compared to its ability to study other health problems), and may be especially prone to producing unreliable data in brain injury cases.
- "At present, there are few consistent data regarding validity and reliability of SPECT techniques for clinical cases of TBI. In a review of the literature, almost all data that have been applied are single case studies or small group studies. No studies of a large nature with appropriate clinical controls exist."
- "There is no particular SPECT profile that is pathognomonic for any level of TBI or MTBI, and false-positive results are high."
- "For functional neuroimaging, and in particular for SPECT or PET, there are no published atlases demonstrating pathognomonic or characteristic lesions following TBI or MTBI. This should cause substantial concern in legal settings, particularly from the standpoint of applying Daubert criteria. For instance, with MRI or CT, it is very easy to find pathognomonic lesions in published brain atlases for traumatic-induced subarachnoid hemorrhage, subdural hematoma, parenchymal contusions, epidural hematoma, brainstem contusions, mass effects, intraventricular hemorrhage, and shift of intracranial contents. There are no SPECT or PET atlases with corresponding pathognomonic features of classic brain injury patterns."
- "Comorbidities, medications, substance abuse, pre-existing psychiatric illness, prior head trauma, and even mental activity can generate false positives in either SPECT or PET neuroimaging, which cannot be distinguished from those produced by mild TBI."
- "The last criterion in Daubert regards general acceptance of the theory and technique within the relevant scientific community. Analysis of the world literature on SPECT or Pet and the American College of Radiology guidelines, as well as the Society of Nuclear Medicine Procedure Guidelines for Single Photon Emission Computed Tomography, indicate the general acceptance has not been achieved."
- "At present, the availability of research studies and published data on both SPECT and PET is consistent with the conclusion that these imaging techniques do not

provide objective evidence of MTBI, and they will not meet, to a satisfactory degree, Daubert criteria when functional neuroimaging data are presented in the legal forum."

- "The evidentiary usefulness of functional neuroimaging (such as SPECT) to prove mild TBI in a court of law lacks a sufficient scientific database and lacks sufficient scientific standards."

The *Guides to the Evaluation of Permanent Impairment* (Rondinelli et al.) is itself a forensic document, in that impairment evaluation is uniquely associated with legal claims (as opposed to being associated with healthcare). Consistent with the *Guides* focus on scientific credibility, the current edition of the *Guides* does not incorporate brain SPECT into any impairment evaluation protocol. The *Guides* discussion of SPECT is limited to a brief mention in a listing of "clinical studies" that are not reliably associated with impairment (page 325). That brief discussion makes no mention of brain injury, focusing instead on "dementia and neurodegenerative diseases".

In 2012, two additional forensic-specific reviews were published (Ricker; Boone). The first of these (Ricker) specified the following key points:

- SPECT findings are not "evidence of compromised or nonfunctional brain tissue".
- "there is tremendous variability across individuals (i.e., no pathognomonic profile emerges)"
- "SPECT findings are usually not predictive of test performance".
- "In spite of advances in technology and data analysis, the utility of SPECT's characterizing specific illness and injury states or predicting outcome remains controversial".
- "Still lacking are prospective studies of SPECT in differential diagnosis, prognosis, and intervention."
- "there is no particular SPECT profile that is pathognomonic or reliable for brain injury".
- "Clinically, the literature does not support the routine use of SPECT for the evaluation of post-concussion syndrome in specific, or actually for brain injury in general."

The second of these very recent reviews (Boone) reiterates many of the key points from previous reviews, and detailed the following additional considerations:

- "findings obtained via (SPECT) generally do not correlate with long-term cognitive function"

- If SPECT, or any of the type of imaging, produces findings for health issues for which there are "no associated cognitive abnormalities" (as is specified in the *Guides* and other reviews of the scientific literature for MTBI), then the information from the imaging "has little bearing. The analogy would be that if one fractures a leg, complete recovery of function may in fact be achieved, despite the fact that evidence of the fracture remain on x-rays for the rest of the person's life."
- "A sizable percentage of normal individuals in fact are found to have imaging abnormalities".

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Robert J. Barth, Ph.D.
Fellow, National Academy of Neuropsychology

Author's draft of a project that was published by the American Medical Association in 2009

**Reference information for the published version:
Barth RJ. Obstacles to Claiming Permanence and Injury-
Relatedness for “Posttraumatic” Headache. *The Guides
Newsletter*, May/June, 2009. American Medical Association.**

Obstacles to Claiming Permanence and Injury-Relatedness for “Posttraumatic” Headache

Robert J. Barth, Ph.D.

Introduction:

There are two cases presented in the *Guides 6th Edition* which vaguely imply that mild head trauma can cause permanent impairment due to headache (Example 3-2, page 42; Example 13-16, page 342). These cases are highly problematic, and consequently warrant further discussion (which is provided in this article). This article reviews *Guides* principles and scientific considerations that should be noted by any evaluator faced with such cases. Additionally, in accordance with the overall goal of helping the *Guides* to be more scientifically sound (*Guides 6th*, Section 1.2b, Axiom 2) and internally consistent and (*Guides 6th*, Section 1.2b, Axiom 5), this article is offered as an aid for developing future editions of the *Guides* in a manner that will avoid such shortcomings.

Inconsistency with Guides Principles

Neither of the two *Guides 6th* examples (Example 3-2, page 42; Example 13-16, page 342) provides an explanation of how the fundamental principles of the *Guides* were satisfied for these cases. For example, there is no discussion of scientific findings which

link such scenarios to permanent impairment (fundamental principle #5, Table 2-1, page 20), there is no presentation of a treatment history which would allow evaluators to conclude that options have been exhausted and that a conclusion of maximum medical improvement can consequently be confidently endorsed (fundamental principle #5, Table 2-1, page 20), and there is no presentation of objective criteria in support of the evaluator's conclusions (fundamental principle #13, Table 2-1, page 20).

In regard to this last point, because one of these cases is presented in the Pain chapter, readers should note that the Pain chapter's exclusion from the *Guides* requirement for objective criteria, which was written into the original version of the *Guides* 6th, has now been eliminated, as documented in *Clarifications and Corrections*. Subsequently, use of the Pain Chapter is now held to the same standards as the rest of the *Guides*, including fundamental principle #13 as re-stated in *Clarifications and Corrections* (Table 2-1, page 2 of *Clarifications and Corrections*), "Subjective complaints alone are generally not ratable under the *Guides*."

Readers should also note that Example 3-2 from the Pain chapter actually violates the principles of that chapter (as well as violating the fundamental principles of the *Guides*, as was discussed above). Specifically, section 3.3d, page 40, notes that in order for the Pain chapter to be used, the complaint of pain must have been "determined to have a reasonable medical basis". The scientific findings that are discussed below create obstacles to credibly claiming that permanent "posttraumatic" headache complaints have been established as having a "reasonable medical basis", especially given the concussion/mild traumatic brain injury context that is specified for these examples.

Scientific findings which present obstacles to claiming that concussion/mild traumatic brain injury is a cause of permanent headache

The *Guides* 6th examples imply that permanent headache can be caused by concussion (Example 3-2 is labeled "Post-Concussive Headache"), or mild traumatic brain injury (the first sentence of Example 13-16 specifies a history of mild traumatic brain injury). Such implications have been scientifically tested in numerous ways, and have failed such tests (details discussed in this and subsequent sections).

For example, this issue was addressed by the World Health Organization in its effort to comprehensively review the scientific literature regarding the prognosis for mild traumatic brain injury.¹ Their conclusions included a favorable prognosis for posttraumatic headache, with complete recovery over a short period of time being the norm. The WHO review indicated that when symptoms persist, compensation and litigation are established risk factors, but there is little consistent scientific support for any other factors playing a predictive role (in other words, a lack of support for claims of injury-relatedness).

The broad scope of the WHO's review provides a compelling basis for concluding that a claim of concussion/mild traumatic brain injury causing permanent headache lacks

credibility. In contrast, neither case from the *Guides* 6th references any scientific support for such claims.

Scientific findings which present obstacles to claiming that more extensive trauma is a cause of permanent headache

Scientific tests of the premise that physical trauma can cause permanent headaches have repeatedly failed, not only for single cases of concussion/mild traumatic brain injury, but also in the study of more extensive trauma.

As one example of relevant scientific findings, Berry et al.'s study of demolition derby drivers can be noted.² The focus on this population was a very clever research design that captured the essence of this issue, because the average driver in their sample had been exposed to approximately 1900 collisions. Despite such extreme experience with head, neck, and generalized trauma, none of the drivers had clinically significant headache problems.

Additional relevant research findings were reported by Couch et al.³ In their sample of trauma patients, the risk of posttraumatic chronic daily headache was inversely correlated with the severity of head injury.

The two types of findings discussed above demonstrate a lack of dose-response correlation between trauma and prolonged headache complaints, both in terms of frequency of trauma, and in terms of severity of trauma. A dose-response correlation is a standard requirement for concluding that a causative relationship exists.⁴ A lack of dose-response relationship is always an obstacle to concluding a causative relationship. In this instance, the Couch et al results not only demonstrate a lack of dose response relationship, but actually demonstrate the extreme opposite of a dose-response relationship (a smaller dose of trauma being associated with a larger headache effect). This finding is severely contradictory of a causative relationship between physical trauma and prolonged headache, and indicates that some other factors must be playing a role in the development of the headache complaints. The research findings that are discussed in the remainder of this article provide clues in regard to the potential nature of such other factors.

The non-permanent nature of posttraumatic headache, when it presents outside of a compensation/litigation context

As was discussed above, the World Health Organization's effort to comprehensively review the scientific literature in regard to prognosis for mild traumatic brain injury concluded that compensation/litigation incentives was the most reliable risk factor for prolonged symptoms.¹ Given that finding, the discussion of headache complaints following all types of trauma requires a focus on cases which occur outside of a compensation/litigation context.

Relevant findings in this regard have been reported by Obelieniene et al.⁶ Their research indicated that headache is indeed common in the short-term immediately following head trauma. However, such headaches are associated with an overwhelmingly favorable prognosis, with the maximum duration of such complaints for any one individual in their sample of patients who were free from litigation/compensation incentives being 20 days.

Similarly, Schrader et al.⁶ also looked at this issue from outside of a legal context and found that the percentage of head trauma survivors who complained of persistent headaches was not significantly different from the percentage of non-injured people with such complaints. They additionally discovered that trauma patients who had persistent headache complaints, but who did not have compensation/litigation incentives, typically reported that they had experienced such problems even prior to their trauma.

Non-injury-related risk factors for persistent headache complaints

As has been discussed above, scientific findings have failed to support a causative relationship between trauma and permanent headaches (or even prolonged headaches). In contrast, non-trauma-related factors have been found to have strong associations with complaints of prolonged headache. Examples of relevant scientific findings are provided below.

The scientific findings that were discussed above indicate that the phenomenon of permanent “posttraumatic” headache is best predicted by compensation/litigation incentives, and does not apply to people who are free from those incentives. Therefore, compensation/litigation incentives, rather than trauma, are an established risk factor for persistent headache claims.

But compensation/litigation incentives do not appear to be the only cause of persistent headache complaints. Mathew et al.⁷ reported that the vast majority of their large sample of chronic refractory headache patients over-utilized the medications that had been prescribed to treat their headaches. They concluded that the majority of persistent headache sufferers were experiencing medication-induced headaches.

Warner and Fenichel⁸ tested the medication-induced headache explanation in a sample of patients who were not over-utilizing (note: this research project is additionally relevant because all of the research participants had originally been diagnosed as experiencing posttraumatic headache). They found that discontinuation of even appropriately used medications led to relief from the headaches for the vast majority of the sample.

Such scientific findings have led to textbook conclusions⁹ that medication (e.g. narcotics, ergotamine derivatives, nsaid, etc.) is the necessary and sufficient cause of chronic daily headache complaints, and that treatment will not be successful unless the patient is detoxified from such medications.

Scientific findings point toward one additional risk factor for persistent headache complaints - mental illness. Specifically, the review of relevant science prepared for the current edition of a standard neurology text¹⁰, led the authors to conclude that the most common cause of persistent headaches is various forms of depression or anxiety.

Implications for treatment, and for MMI determination

The findings discussed above have the following implications for treatment planning in regard to any claim of permanent posttraumatic headache:

- The examinee should be educated in regard to the reliable health benefits of removing themselves from a compensation/litigation context.

- Diagnostic efforts should move away from the claim of posttraumatic headache, and attempt to identify a more credible diagnosis. Any treatment implications of that more credible diagnosis should be implemented.

- If the examinee is medicated for the headache complaints, medication detoxification should be initiated.

- It can also be noted that textbook conclusions regarding treatment also involve an endorsement of cognitive-behavior psychotherapy as a standard option for the pain complaints.⁹

- Given the prominence of mental illness in such claims, a comprehensive psychological evaluation should be conducted, with the results serving as a basis for treatment recommendations.

An examinee should not be classified as having reached MMI until a treatment plan including all of the above elements has been attempted, complied with, and found to be unsuccessful.

Implications for impairment evaluation

Given the inconsistency of Example 3-2 (page 42, *Guides* 6th) and Example 13-16 (page 342, *Guides* 6th) with the principles of the *Guides*, and given the inconsistency of these cases with the broader scientific knowledge base, it is clear that they were provided as efficient (and therefore superficial and overly simplified) examples of using the *Guides*, rather than having been intended to be instructive of the relevant health science. The information that has been presented in this article serves to warn evaluators that they should not mistake such simplified examples as an indication of a credible general approach to any examinee who actually presents with a claim of permanent impairment from posttraumatic headaches.

The scientific findings discussed above highlight the lack of relationship between trauma and prolonged headache complaints. Such findings indicate that permanent headache problems (which, by definition, are the only type of headache complaints for which the *Guides* would be relevant), should not be labeled “posttraumatic”, labeled “postconcussive”, linked to mild traumatic brain injury, or linked to any other type of trauma. Such labeling and linking would create an unsupportable implication of a causative relationship between the headaches and trauma, and would thereby misdirect the evaluation, misdirect any associated treatment recommendations, and misdirect any administrative processes which are dependent on the results of the evaluation.

The issues that were discussed above create the following obstacles to creating an impairment rating:

1. The nonpermanent nature of postconcussive headache, posttraumatic headache, and all associated concepts indicates that they are not eligible for impairment evaluation.
2. Any convincing presentation of permanence for a claim of postconcussive headache, posttraumatic headache, or any similar concept indicates that the diagnosis is incorrect, and the case should be re-evaluated in an effort to identify an explanation for the permanence.
3. Permanent impairment cannot be credibly claimed until a credible diagnosis has been established which has been scientifically and convincingly linked to such permanence. The scientific evidence of permanence should be extremely convincing, because a conclusion of permanence would otherwise communicate an unjustified message of hopelessness to the headache sufferer.
4. Maximum medical improvement cannot be credibly endorsed until credible treatment options have been exhausted, specifically including medication detoxification, cognitive behavior psychotherapy for the pain complaints, and treatment for any mental illnesses that are identified through a comprehensive psychological evaluation.
5. When referral circumstances cause the impairment evaluation to be contingent upon issues of work-relatedness or injury-relatedness, the evaluator should warn the referral source of the non-work-related/non-injury-related nature of the established risk factors for persistent headaches.

Implications for future editions of the Guides

It would obviously be wise for future editions of the *Guides* to construct case examples in a manner that complies with all of the principles of the *Guides*. Consequently, examples such as those that were referenced at the beginning of this article should be avoided.

From a scientific perspective, given the multiple obstacles to concluding that permanent impairment is associated with posttraumatic headache, future editions of the *Guides* should avoid examples which are based on such claims. Additionally, the creators of future editions should consider including text which specifically identifies claims of posttraumatic headache as being ineligible for impairment evaluation. When the evaluation of any type of headache scenario is discussed in future editions of the *Guides*, the authors should consider incorporating, at a minimum, points 3 through 5 from the preceding section of this article.

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