

# The Military Acute Concussion Evaluation (MACE)

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## ABSTRACT

Traumatic brain injury (TBI), in both times of peace and times of war is a significant public health issue for the military. Even at its most mild, TBI (concussion) can degrade fighting effectiveness, put individuals at increased risk for another injury, and in some cases cause persistent difficulties in cognition, and aspects of physical and emotional functioning. Key to the appropriate treatment of those with TBI is the identification of those that have suffered TBI. This article describes one such tool for the identification of TBI in a military setting, the Military Acute Concussion Evaluation (MACE) including its history, administration, and interpretation.

## INTRODUCTION

In the current operational environment of OIF/OEF, blast injuries from devices such as improvised explosive devices (IEDs) produce a high number of mild traumatic brain injuries (mTBI). The continued use of IEDs against our forces suggests that mTBI will remain a focus of medical evaluation and treatment. The effects of mTBI or concussion can decrease individual or unit mission effectiveness, and potentially cause further risk to the safety of the individual or his peers. While TBI might be suspected after any injury that causes a significant blow to the head, there is also risk for brain injury related to the concussive force of explosive devices. In some cases, a blow to the head or blast exposure will cause no injury, while in other cases this external force will cause disruption in brain processes. This disruption may range from a brief, temporary period of being dazed or confused, to a lengthier period of loss of consciousness. In those circumstances, it is useful to have an instrument to assess potential cognitive or physical changes from this injury. Ideally, such an instrument is validated for its ability to serve in that role, has sensitivity to subtle cognitive changes that are perhaps not obvious in casual conversation, is brief, and does not require administration by a physician or psychologist.

This risk in wartime is in addition to that already substantial risk in young adulthood. In fact, young men, the group at greatest risk in the civilian population, has its rates largely matched by young women in the military, a figure that demonstrates the inherent risk in service.<sup>1</sup> From 1997 through 2006, there were 110,000 servicemembers who had at least one TBI-related medical encounter, with 11.6% being hospitalizations. As expected, the numbers of TBI associated with battle injuries and the war time ac-

tivity has increased since September 2001 relative to the period from 1997 to September 2001. In 2007; however, there was a marked increase in those that have two or more ambulatory visits at least seven days apart while deployed to/within 365 days of returning from Operation Enduring Freedom (OEF) or Operation Iraqi Freedom (OIF) with the rates more than doubling over the previous year.<sup>2</sup>

## DEFINITION OF TBI

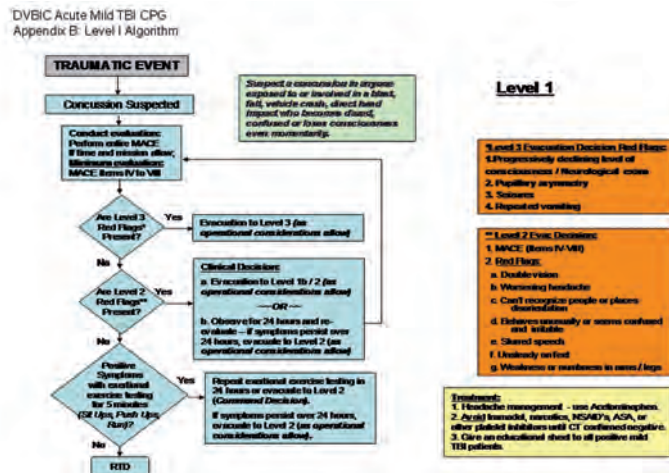
The Defense and Veterans Brain Injury Center (DVBIC) defines traumatic brain injury as an injury to the brain resulting from an external force and/or acceleration/deceleration mechanism from an event such as a blast, fall, direct impact, or motor vehicle accident, which causes an alteration in mental status, typically resulting in the temporally related onset of symptoms such as: headache, nausea, vomiting, dizziness/balance problems, fatigue, trouble sleeping/sleep disturbances, drowsiness, sensitivity to light/noise, blurred vision, difficulty remembering, and/or difficulty concentrating. This definition, developed for use in military settings, is consistent with other widely accepted definitions such as those by the CDC and WHO.

## HISTORY

The need for medical management of concussion (mTBI) is well recognized in the sports world. This involves two components.<sup>1</sup> One is the acute care management of the injured at the time of injury. This is to identify and treat any potential neurosurgical emergencies. The other is the monitoring of concussion symptoms over time to monitor progress in recovery and determine when an individual is fit to return to the playing field. McCrea and colleagues in a prospective cohort study of 1631 collegiate football players examined the course of recovery after a

subset of the players sustained a concussion.<sup>2</sup> These athletes showed the greatest number of physical and cognitive symptoms in the acute phase immediately after concussion, with a course of recovery over five to seven days, at which time most were again at their baseline. However, about 10% remained symptomatic at one week's time, and players demonstrated different patterns of recovery in their symptom reporting, cognition, and balance.

In November 2006, the DVbic assembled 32 military and civilian experts to create a literature-based clinical practice guideline with regard to the assessment and management of mTBI in a military operational setting. That group produced a set of guidelines (see [http://www.dvbic.org/pdfs/clinical\\_practice\\_guideline\\_recommendations.pdf](http://www.dvbic.org/pdfs/clinical_practice_guideline_recommendations.pdf) for the full document). For illustrative purposes, a graphical representation of the Level I practice guideline is shown below. As can be seen, this guide-



line relies on the use of the Military Acute Concussion Evaluation (MACE; see on page 71 for full instrument) a tool developed earlier that year by the Defense and Veterans Brain Injury Center. The MACE has both a history and evaluation component. The history component can confirm the diagnosis of mTBI after establishing that trauma has occurred and that during the course of this traumatic event, i.e. the service member having experienced an alteration in consciousness. The evaluation component, designed to be easily used by medics and corpsmen, can be administered within five minutes. It utilizes the Standardized Assessment of Concussion (SAC) to preliminarily document neurocognitive deficits in four cognitive domains: orientation, immediate memory, concentration and delayed recall.<sup>3</sup>

The SAC was developed in response to and in accordance with the recommendations of the Colorado and American Academy of Neurology Colorado Guidelines. The SAC was also designed to be consistent with the neuropsychological literature on those domains of function

thought to be most sensitive to the effects of mild traumatic brain injury/concussion, and the tests best suited to measuring those functions in brain injury patients.<sup>4,5</sup> The SAC has been shown in multiple studies to have validity in detecting and characterizing mental status abnormalities resulting from concussion.<sup>6,7</sup>

## MACE ADMINISTRATION

The MACE has full instructions in its administration. The MACE and instructions are available at [http://www.dvbic.org/cms.php?Medical\\_care](http://www.dvbic.org/cms.php?Medical_care). The MACE is designed for use fairly immediately post-injury. There are no data to support its use beyond the acute injury period, although it may have sensitivity to persistent cognitive deficits after the first week. The first eight parts of the MACE describes the incident that caused injury or concern for injury, determines whether a TBI actually occurred, based on the TBI definition, and asks about current symptoms. In practice, when possible, it is useful to determine whether the reported symptoms have a temporal relationship to the injury itself. That is, if tracking recovery from injury, one must be sure that the symptoms being examined did not antedate the injury. These first sections of the MACE are generally equivalent to the Brief Traumatic Brain Injury Screen (BTBIS and better known as the DVbic 3 Question Tool). The BTBIS<sup>10</sup> is a TBI screening that has had initial validation of its ability to determine the presence of a TBI when given as a questionnaire. While it has questions about TBI related symptoms, it provides only self report of cognition and other factors. The MACE is intended to be individually administered and can more carefully detect and characterize potential cognitive dysfunction as a result of the injury. Parts 9 through 13 of the MACE provide the formal cognitive examination and a neurological screening. This screening involves examination of the eyes for pupil reactivity; examination of verbal fluency and output; and motor changes such as gait disturbance or pronator drift. In the scored portion, one point is given for each correct response. However, there may not be equal clinical significance to each item. For example, if a service member were to lose a point for the month or year, it would be suggestive of more diffuse cognitive impairment than the inability to recall one of five learned words after a delay. There are alternate forms available for the words and digits, as there have been case reports of service members memorizing MACE word lists, so that they might remain deployable with their unit.

## INTERPRETATION

There is no definitive cutoff below which cognitive dysfunction is present. In studies of some non-concussed patients the mean score was 28. In the initial

validation studies of the SAC, a score of 25 provided the best combination of sensitivity and specificity to mental status changes. Therefore, in practice, a score below 25 may represent clinically relevant cognitive impairment.

The authors of the SAC provide several guidelines to be followed in the interpretation of the SAC performance in sports related concussion, but the guidelines and cautions for interpretation are equally useful in a military setting (p.47):

- The SAC provides a standardized, objective measure of mental status changes following concussion, but the examiner must not rely solely on the SAC or any other instrument as a stand-alone method of diagnosing concussion or determining a subject's recovery and readiness to return to play after injury. The SAC is intended to complement, not substitute for, the advice of a physician or other qualified healthcare provider. All aspects of the injury examination (e.g., mental status evaluation, physical exam, symptom survey, witness accounts, etc.) must be equally considered in the assessment and management of concussion.
- Concussion may manifest with signs other than mental status or neurocognitive abnormalities, such as physical signs or other post-concussion symptoms. Therefore, a comprehensive physical exam and survey of symptoms should accompany any mental status exam, including the SAC.
- Any unusual signs and symptoms reported or displayed by a subject following suspected concussion must be seriously considered by the examiner, regardless of performance on the SAC or any other assessment measure. The presence of any post-concussion signs or symptoms, on the SAC or otherwise, should preclude any subject from returning to competition and indicates the need for close monitoring of the subject's condition. Persistent symptoms indicate the need for further evaluation by a physician.



#### **Louis M. French, PsyD**

Dr. French received his doctorate in clinical psychology, focused on assessment, from the George Washington University. He completed fellowships in clinical and experimental neuropsychology at the National Institute of Mental Health and in neuropsychology, focusing on traumatic

brain injury, at the Defense and Veterans Brain Injury Center (DVBIC) at Walter Reed Army Medical Center. He is currently the TBI Service Chief at the hospital and site director for the DVBIC at Walter Reed, where he oversees operations related to the identification and treatment of individuals with traumatic brain injury. He serves or has served on a number of federal or DoD panels on issues in traumatic brain injury, including the Army Surgeon General's Taskforce on TBI.



#### **Michael McCrea, PhD, ABPP**

Dr. Michael McCrea is the Executive Director of the ProHealth Care Neuroscience Center based in suburban Milwaukee, Wisconsin. Dr. McCrea is a board-certified clinical neuropsychologist and has headed up the Neuropsychology Service at Waukesha Memorial Hospital since 1996. He earned his doctoral degree from the University of Wisconsin-Milwaukee, then completed his clinical training in neuropsychology at Vanderbilt

University School of Medicine, followed by a postdoctoral fellowship at Northwestern University Medical School. Dr. McCrea has been an active researcher in the neurosciences, with numerous scientific publications, book chapters, and national and international lectures on the topic of traumatic brain injury. Most recently, he authored the text *Mild Traumatic Brain Injury and Postconcussion Syndrome: The New Evidence Base for Diagnosis and Treatment* published by Oxford University Press.



#### **Mark R. Baggett, PhD**

LTC Mark Baggett is the Deputy Command Psychologist for the Directorate of Psychological Applications at the U.S. Army Special Operations Command. He holds a bachelor's in psychology from the University of California at Santa Cruz and a master's and Ph.D. in clinical psychology from Pacific Graduate School of Psychology, Palo Alto, CA. Prior to his current assignment, he served as the Command Psychologist for the JFK Special Warfare Center and School for two years; he served as an intern in clinical psychology, a neuropsychology fellow; chief of tele-health service at Walter Reed Army Medical Center; the division psychologist, 2nd Inf. Div.; chief of psychology service, Martin Army Hospital, Fort Benning, GA; command psychologist for the U.S. Army Infantry Center, Fort Benning; and chief of psychology service and chief of neuropsychology, Womack Army Medical Center, Fort Bragg.



## Military Acute Concussion Evaluation (MACE)

Defense and Veterans Brain Injury Center

Patient Name: \_\_\_\_\_

SS#: \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_ Unit: \_\_\_\_\_

Date of Injury: \_\_\_\_/\_\_\_\_/\_\_\_\_ Time of Injury: \_\_\_\_\_

Examiner: \_\_\_\_\_

Date of Evaluation: \_\_\_\_/\_\_\_\_/\_\_\_\_ Time of Evaluation: \_\_\_\_\_

### History: (I – VIII)

#### I. Description of Incident

Ask:

- a) What happened?
- b) Tell me what you remember.
- c) Were you dazed, confused, "saw stars"?  Yes  No
- d) Did you hit your head?  Yes  No

#### II. Cause of Injury (Circle all that apply):

- 1) Explosion/Blast
- 2) Blunt object
- 3) Motor Vehicle Crash
- 4) Fragment
- 5) Fall
- 6) Gunshot wound
- 7) Other \_\_\_\_\_

#### III. Was a helmet worn? Yes No Type \_\_\_\_\_

#### IV. Amnesia Before: Are there any events just BEFORE the injury that are not remembered? (Assess for continuous memory prior to injury)

Yes  No If yes, how long \_\_\_\_\_

#### V. Amnesia After: Are there any events just AFTER the injuries that are not remembered? (Assess time until continuous memory after the injury)

Yes  No If yes, how long \_\_\_\_\_

#### VI. Does the individual report loss of consciousness or "blacking out"? Yes No If yes, how long \_\_\_\_\_

#### VII. Did anyone observe a period of loss of consciousness or unresponsiveness? Yes No If yes, how long \_\_\_\_\_

#### VIII. Symptoms (circle all that apply)

- 1) Headache
- 2) Dizziness
- 3) Memory Problems
- 4) Balance problems
- 5) Nausea/Vomiting
- 6) Difficulty Concentrating
- 7) Irritability
- 8) Visual Disturbances
- 9) Ringing in the ears
- 10) Other \_\_\_\_\_

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## Military Acute Concussion Evaluation (MACE)

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### Examination: (IX – XIII)

Evaluate each domain. Total possible score is 30.

#### IX. **Orientation:** (1 point each)

Month:	0	1
Date:	0	1
Day of Week:	0	1
Year:	0	1
Time:	0	1

Orientation Total Score \_\_\_\_/5

#### X. **Immediate Memory:**

Read all 5 words and ask the patient to recall them in any order.  
Repeat two more times for a total of three trials. (1 point for each correct, total over 3 trials)

List	Trial 1	Trial 2	Trial 3
Elbow	0 1	0 1	0 1
Apple	0 1	0 1	0 1
Carpet	0 1	0 1	0 1
Saddle	0 1	0 1	0 1
Bubble	0 1	0 1	0 1
Trial Score			

Immediate Memory Total Score \_\_\_\_/15

#### XI. **Neurological Screening**

As the clinical condition permits, check

**Eyes:** pupillary response and tracking

**Verbal:** speech fluency and word finding

**Motor:** pronator drift, gait/coordination

Record any abnormalities. **No points are given for this.**

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Evaluation (MACE)**  
Defense and Veterans Brain Injury Center

**XII. Concentration**

Reverse Digits: (go to next string length if correct on first trial.  
Stop if incorrect on both trials.) 1 pt. for each string length.

4-9-3	6-2-9	0	1
3-8-1-4	3-2-7-9	0	1
6-2-9-7-1	1-5-2-8-5	0	1
7-1-8-4-6-2	5-3-9-1-4-8	0	1

Months in reverse order: (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sep-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan

0      1

Concentration Total Score \_\_\_\_/5

**XIII. Delayed Recall (1 pt. each)**

Ask the patient to recall the 5 words from the earlier memory test  
(Do NOT reread the word list.)

Elbow	0	1
Apple	0	1
Carpet	0	1
Saddle	0	1
Bubble	0	1

Delayed Recall Total Score \_\_\_\_/5

TOTAL SCORE \_\_\_\_/30

Notes: \_\_\_\_\_

**Diagnosis:** (circle one or write in diagnoses)

No concussion

850.0 Concussion without Loss of Consciousness (LOC)

850.1 Concussion with Loss of Consciousness (LOC)

Other diagnoses \_\_\_\_\_

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## Instruction Sheet

### Purpose and Use of the MACE

A concussion is a mild traumatic brain injury (TBI). The purpose of the MACE is to evaluate a person in whom a concussion is suspected. The MACE is used to confirm the diagnosis and assess the current clinical status.

### Tool Development

The MACE has been extensively reviewed by leading civilian and military experts in the field of concussion assessment and management. While the MACE is not, yet, a validated tool, the examination section is derived from the *Standardized Assessment of Concussion (SAC)* (McCrea, M., Kelly, J. & Randolph, C. (2000). *Standardized Assessment of Concussion (SAC): Manual for Administration, Scoring, and Interpretation.* (2nd ed.) Waukesa, WI: Authors.) which is a validated, widely used tool in sports medicine. Abnormalities on the SAC correlate with formal comprehensive neuropsychological testing during the first 48 hours following a concussion.

### Who to Evaluate

Any one who was dazed, confused, "saw stars" or lost consciousness, even momentarily, as a result of an explosion/blast, fall, motor vehicle crash, or other event involving abrupt head movement, a direct blow to the head, or other head injury is an appropriate person for evaluation using the MACE.

### Evaluation of Concussion

#### History: (I – VIII)

- I. Ask for a description of the incident that resulted in the injury; how the injury occurred, type of force. Ask questions A – D.
- II. Indicate the cause of injury
- III. Assess for helmet use. Military: Kevlar or ACH (Advanced Combat Helmet). Sports helmet, motorcycle helmet, etc.
- IV – V Determine whether and length of time that the person wasn't registering continuous memory both **prior** to injury and **after** the injury. Approximate the amount of time in seconds, minutes or hours, whichever time increment is most appropriate. For example, if the assessment of the patient yields a possible time of 20 minutes, then 20 minutes should be documented in the "how long?" section.
- VI – VII Determine whether and length of time of **self reported** loss of consciousness (LOC) or **witnessed/observed** LOC. Again, approximate the amount of time in second, minutes or hours, whichever time increment is most appropriate.
- VIII Ask the person to report their experience of each specific symptom since injury.

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## Military Acute Concussion Evaluation (MACE)

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### Examination: (IX – XIII)

#### Standardized Assessment of Concussion (SAC):

Total possible score = 30

Orientation = 5

Immediate Memory = 15

Concentration = 5

Memory Recall = 5

#### IX Orientation: Assess patients awareness of the accurate time

Ask: WHAT MONTH IS THIS?

WHAT IS THE DATE OR DAY OF THE MONTH?

WHAT DAY OF THE WEEK IS IT?

WHAT YEAR IS IT?

WHAT TIME DO YOU THINK IT IS?

**One** point for each correct response for a total of 5 possible points. It should be noted that a correct response on time of day must be within 1 hour of the actual time.

#### X Immediate memory is assessed using a brief repeated list learning test. Read the patient the list of 5 words once and then ask them to repeat it back to you, as many as they can recall in any order. Repeat this procedure 2 more times for a total of 3 trials, even if the patient scores perfectly on the first trial.

Trial 1: I'M GOING TO TEST YOUR MEMORY, I WILL READ YOU A LIST OF WORDS AND WHEN I AM DONE, REPEAT BACK AS MANY WORDS AS YOU CAN REMEMBER, IN ANY ORDER.

Trial 2 & 3: I AM GOING TO REPEAT THAT LIST AGAIN. AGAIN, REPEAT BACK AS MANY AS YOU CAN REMEMBER IN ANY ORDER, EVEN IF YOU SAID THEM BEFORE.

**One** point is given for each correct answer for a total of 15 possible points.

#### XI Neurological screening

Eyes: check pupil size and reactivity.

Verbal: notice speech fluency and word finding

Motor: pronator drift- ask patient to lift arms with palms up, ask patient to then close their eyes, assess for either arm to "drift" down. Assess gait and coordination if possible. Document any abnormalities.

**No points are given for this section.**

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## Military Acute Concussion Evaluation (MACE)

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### XII Concentration: Inform the patient:

I'M GOING TO READ YOU A STRING OF NUMBERS AND WHEN I AM FINISHED, REPEAT THEM BACK TO ME BACKWARDS, THAT IS, IN REVERSE ORDER OF HOW I READ THEM TO YOU. FOR EXAMPLE, IF I SAY 7-1-9, YOU WOULD SAY 9-1-7.

If the patient is correct on the first trial of each string length, proceed to the next string length. If incorrect, administer the 2nd trial of the same string length. Proceed to the next string length if correct on the second trial. Discontinue after failure on both trials of the same string length. Total of 4 different string lengths; 1 point for each string length for a total of 4 points.

NOW TELL ME THE MONTHS IN REVERSE ORDER, THAT IS, START WITH DECEMBER AND END IN JANUARY.

1 point if able to recite ALL months in reverse order.

0 points if not able to recite ALL of them in reverse order.

Total possible score for concentration portion: 5.

### XIII Delayed Recall

Assess the patient's ability to retain previously learned information by asking he/she to recall as many words as possible from the initial word list, without having the word list read again for this trial. DO YOU REMEMBER THAT LIST OF WORDS I READ A FEW MINUTES EARLIER? I WANT YOU TO TELL ME AS MANY WORDS FROM THE LIST AS YOU CAN REMEMBER IN ANY ORDER.

One point for each word remembered for a total of 5 possible points.

**Total score=** Add up from the 4 assessed domains: immediate memory, orientation, concentration and memory recall.

#### Significance of Scoring

In studies of non-concussed patients, the mean total score was 28. Therefore, a score less than 30 does not imply that a concussion has occurred. Definitive normative data for a "cut-off" score are not available. However, scores below 25 may represent clinically relevant neurocognitive impairment and require further evaluation for the possibility of a more serious brain injury. The scoring system also takes on particular clinical significance during serial assessment where it can be used to document either a decline or an improvement in cognitive functioning.

#### Diagnosis

Circle the ICD-9 code that corresponds to the evaluation. If loss of consciousness was present, then circle 850.1. If no LOC, then document 850.0. If another diagnosis is made, write it in.

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