



Mild Traumatic Brain Injury

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On the last day of a glorious two week vacation, MP a 20 year old male novice skier ended a great vacation in the wrong way. After several days of lessons, MP had become over confident with his marginal skills and decided he was ready for the back bowl, black diamonds. Unfortunately his instructors never emphasized the need to wear a helmet nor did they teach by example. At 40 mph, MP lost control on an ice patch and was launched head first into a tree. The impact was significant, the stars were bright, and MP lay unconscious for 1 to 3 minutes. By the time other skiers arrived to help, MP was awake and alert, and other than a “goose egg” on the top of his head, he claimed he was OK to ski down to the lodge. At the bottom of the mountain, MP felt well except for a moderate headache. When he said he had no appetite for lunch (which was unusual), his family insisted he be seen in the emergency department before embarking on the 12 hour trip home. In the ED, three hours after the accident, MP had a blood pressure of 118/80, a pulse of 64, a respiratory rate of 14, a temperature of 37, and an oxygen saturation of 100% on room air. His Glasgow coma scale score was 15, a small hematoma on his scalp without surrounding tenderness or deformity, and a completely normal neurologic examination. The examining physician determined that MP had not sustained a significant injury and discharged him a prescription for ibuprofen and a head injury sheet.

Key Clinical Questions

Is a single Glasgow coma scale (GCS) score predictive of the presence of a traumatic brain injury?

Are there historical or physical findings that predict the presence of a traumatic brain injury?

Is there a role for plain skull radiographs in the evaluation of patients with a MTBI?

Which patients with mild traumatic brain injury (MTBI) require neuroimaging?

Can patients with a GCS score of 15 and a normal head CT be safely discharged from the ED without admission to the hospital for observation?

In patients with a GCS of 15, what is the risk of developing the postconcussive syndrome?

Key Learning Points:

- A single Glasgow coma scale (GCS) score is not predictive of the presence of a traumatic brain injury thus patients who have sustained a head injury should have serial exams performed over the first several hours post-injury.
- Loss of consciousness and / or post-traumatic amnesia suggest the potential for a traumatic brain injury and drive the need for either a neuroimaging study or a prolonged period of observation. The presence of a focal neurologic deficit or signs of a basilar skull fracture are associated with a traumatic brain injury and thus their presence requires neuroimaging to assess the degree of injury.
- Normal plain skull radiographs do not decrease the possibility of a traumatic brain injury and therefore should not be used in risk stratifying patients with head injuries.
- A head CT is not indicated in head injury patients with a GCS score of 15 and no history of loss of consciousness or post-traumatic amnesia. In those patients with loss of consciousness or post traumatic amnesia, a head CT is **not** indicated if there is no headache, vomiting, age > 60, drug or ETOH intoxication, deficits in short-term memory, physical evidence of trauma above the clavicle, or seizure.
- There are no good predictors of which head injured patients with a GCS of 15 are at risk to develop the postconcussive syndrome thus all patients with a head injury should be given information regarding PCS.
- Patients with MTBI who are six hours post-injury, have a normal clinical examination, and who have a head CT that does not demonstrate acute injury can be safely discharged from the emergency department. Patients can be discharged after a shorter period of observation if under the care of a responsible third party.

Introduction

In the United States, approximately 1.6% of all emergency department (ED) visits are for a head injury. Approximately 90% of these visits are for mild traumatic brain injury (MTBI), and 10% for moderate or severe TBI. (1) TBI is the leading cause of death among people less than 24 years. (2) Approximately 50% of patients who die from TBI arrive to the hospital alive; a number which can potentially be decreased with early and aggressive interventions. (3)

Head injury and traumatic brain injury (TBI) are two distinct entities that are often, but not necessarily, related. A *head injury* is best defined as an injury that is clinically evident upon physical examination and is recognized by the presence of ecchymoses, lacerations, deformities, or cerebral spinal rhinorrhea or otorrhea. *Traumatic brain injury* refers to an injury to the brain itself and can occur without external signs of trauma.

Is a single Glasgow coma scale (GCS) score predictive of the presence of a traumatic brain injury?

Historically, the most often used system for grading severity of brain injury is the Glasgow Coma Scale (GCS) score which assesses eye opening, verbal function (mental status), and motor function; a modified scale exists for nonverbal children. (4) The GCS was developed in 1974 as a standardized clinical scale allowing for reliable interobserver neurologic assessments of TBI patients in coma. (5). The original studies applying the GCS score as a tool for assessing outcome required that coma be present for at least six hours. (5,6,7) The scale was not designed to diagnose patients with mild or even moderate TBI nor was it intended to supplant a neurological examination. Instead, the GCS was designed to provide an easy to use assessment tool for serial evaluations by relatively inexperienced care providers, and to facilitate communication between care providers on rotating shifts.

A single isolated GCS score is of limited value, is insufficient to determine the degree of parenchymal injury after trauma, and does not have prognostic value. On the other hand, serial GCS scores are a valuable clinical tool (when confounding factors such as drugs or alcohol are absent). A low GCS score that remains low, or a high GCS that decreases, predicts poorer outcomes than high GCS scores that remain high, or a low GCS score that progressively improves. In one of the original multi-center studies validating the score approximately 13% of patients who ultimately were in coma had a GCS of 15 (note that at the time these studies were done, CT was not available to aid in clinical decision making). (7)

The literature refers to “mild” TBI (MTBI) as those patients with a GCS score greater than 12. Some authors have suggested that patients with a GCS of 13 be excluded from the “mild” category and placed into the “moderate” risk group due to their high incidence lesions requiring neurosurgical intervention. (8,9) The key for the clinician is to not overly rely on a GCS score, but instead to use the GCS score in conjunction with a relevant neurologic exam to assess head injured patients for TBI.

Are there historical or physical findings that predict the presence of a traumatic brain injury?

On the initial encounter, it is not possible to accurately determine the degree of brain injury that a head injured patient has sustained. In patients with blunt trauma who appear to have sustained a minor head injury, the only historical parameters proven to be useful in identifying patients with lesions requiring neurosurgical intervention are loss of consciousness (LOC) and/or amnesia. (10, 11, 12) A history of headaches, seizures, nausea, vomiting, dizziness, age over 60, or evidence of trauma above the clavicle have not been found to be independent predictors of an intracranial lesion. However, the absence of all of the above has been reported to be 100% sensitive in excluding an injury requiring neurosurgical intervention even when LOC has occurred. (11) History of anti-coagulant therapy or hemophilia are additional historical findings that may be associated with an increased risk for an intracranial event.

The presence of focal neurologic findings or an altered mental status is predictive of significant lesions (13, 14), though conversely the absence of findings does not eliminate the possibility that an injury has occurred. (15) When performing the neurologic examination, particular attention must be paid to cranial nerves III, IV and VI. Papilledema is a late finding in increased intracranial pressure (ICP) and thus is not seen in acute head injury. The pupil exam consists of determining pupil size, symmetry, and reactivity to light. Mass effect from edema or an expanding lesion may result in a unilateral, fixed and dilated pupil. Bilaterally dilated and fixed pupils are consistent with brain stem injury. Hypoxemia, hypotension, and hypothermia are associated with dilated pupil size and abnormal reactivity, making it necessary to resuscitate and stabilize the patient before accurate pupillary assessment can occur. (16)

An assessment of cognitive function may be helpful in select cases in that it provides an important baseline in the patient's evaluation. Cognitive function is only superficially assessed in the GCS score through the patient's verbal response. In MTBI, it has not been shown to be predictive of parenchymal injury demonstrable on head CT. (9, 17)

Is there a role for plain skull radiographs in the evaluation of patients with a MTBI?

Hofman et al performed a meta-analysis of the literature examining the role of plain films in evaluating patients with TBI. (18) Two hundred studies were reviewed, and 20 were identified to have sufficient merit to be included in the meta-analysis. The authors reported that the sensitivity of skull fracture in detecting patients with an intracranial lesion ranged from .13 to .75, with a specificity from .91 to .995. They discussed their concern about both selection bias and verification bias contributing to the high specificity reported by the studies, i.e., patients were more likely to receive a CT if their GCS was less than 15 or if they had a positive plain film. Using the combined results for sensitivity, specificity, and prevalence the authors reported the positive predictive value of a skull fracture for the diagnosis of an intracranial lesion as .41 and the negative predictive value as .94. These findings suggest that the presence of a skull fracture increases the probability of an intracranial lesion fivefold. However, the meta-analysis concluded that though a fracture demonstrated on plain film increased the likelihood of an intracranial lesion, its low sensitivity precluded its use to rule out the diagnosis of an intracranial hemorrhage and thus is of limited clinical value in risk stratification for brain injury.

Which patients with mild traumatic brain injury (MTBI) require neuroimaging?

Patients with blunt head injury who do not sustain LOC or post traumatic amnesia are at almost no risk of significant intracranial injury requiring a diagnosis in the ED and do not need neuroimaging in the ED. On the other hand, approximately 10% of patients with a history of LOC and a GCS score of 15 will have an acute lesion on noncontrast head CT; less than one per cent will have a lesion in need of a neurosurgical intervention. (11) The literature does not clearly state which patients with intracranial lesions deteriorate, nor is it clear about the predictive value of intracranial lesions in predicting the development of postconcussive syndrome.

Well designed studies and evidence based practice guidelines recommend that patients with blunt head trauma who experienced LOC or posttraumatic amnesia, with a GCS score of 15 and a normal neurologic exam do not need a head CT in the ED if they **do not have** headache, vomiting, age > 60, drug or ETOH intoxication, deficits in short-term memory, physical evidence of trauma above the clavicle, or seizure. (11, 19) Patients with any of the above findings, and those with a GCS score below 15, should be considered for a head CT.

In patients with a GCS of 15, what is the risk of developing postconcussive syndrome?

The postconcussive syndrome (PCS) refers to a symptom complex experienced by many patients after mild TBI. In general, PCS is comprised of somatic, cognitive, and affective symptoms. Common symptoms include headache, dizziness / vertigo, difficulty concentrating, and depression. Approximately 30% of patients with mild TBI will have symptoms at 3 months post-injury, and up to 15% will continue to be symptomatic at one year post injury. (20, 21) It appears that well motivated, young, male patients are at the lowest risk of developing the PCS and that females, those over 55 years of age, or patients that experienced prolonged posttraumatic amnesia are at a higher risk of developing the PCS. (22) Despite the emerging consensus that somatic and cognitive deficits result from mild TBI, physiogenesis versus psychogenesis of symptoms is debated especially when symptoms persist for more than three months.

When managing a patient with mild TBI, it is important to take the time to advise them of the potential sequelae of the injury in that it may significantly assuage their anxiety of permanent damage. A referral to a specialist with expertise in caring for these patients may be helpful for the patient's prognosis. Recovery appears to be linked not only to the underlying lesion but also to psychosocial issues in the patient's life. Consequently, access to a multidisciplinary resource may provide the patient with the most comprehensive support services to assist in recovery.

Can patients with a GCS score of 15 and a normal head CT be safely discharged from the ED without admission to the hospital for observation?

Over the past decade, access to neuroimaging has resulted in a decline in the number of MTBI patients admitted to the hospital for observation without a reported increase in adverse outcomes. (23) The question is, at what point in time from the injury is it safe to discharge the patient. Most of the literature addressing this question is limited by its methodology. For example, Lee and

colleagues prospectively followed 1812 patients who were discharged from the hospital with a GCS of 15 at 3, 7, 30, and 60 days. Twenty-eight patients deteriorated, 57% within the first 24 hours; 23 of the 28 who deteriorated required a neurosurgical intervention. Unfortunately, most of the patients did not have initial CTs. (24) Shackford et al reported on 933 patients with normal neurologic examinations and normal head CTs who were admitted to the hospital for observation. (25) They reported that 2% of this group required intubation, i.e., deteriorated, though none required neurosurgical intervention. Unfortunately, the authors do not provide the timing of the deterioration or other specific information related to the cases. Nagy et al prospectively studied 1170 trauma center patients all of whom had a CT and were admitted for 24 hours of observation. (26) Similar to the studies already described, 3% of the patients had a positive CT, and 0.3 % required neurosurgery. Despite the study design's spectrum bias favoring sicker patients, no patient deteriorated. Dunham analyzed data from 2587 trauma center patients; no patient with a negative CT deteriorated and all patients who did deteriorate did so within 4 hours of arrival at the trauma center. (27) Jeret prospectively studied 712 patients, 67 (9.4%) of whom had a positive CT. One patient who initially had a normal exam deteriorated within "several hours" of arriving in the ED, at which point a CT disclosed a left temporal contusion; by 6 hours he was lethargic and had a craniotomy. (28)

Based on the best available evidence, patients with a GCS score of 15 and a negative head CT can be safely discharged home with a reliable adult. Although the safety of home observation has been established in this subset of patients, patients with TBI may not remember their discharge instructions emphasizing the need to not only give patients written instructions, but also to provide important information that will impact the patient during the recovery period to a family member or friend.

References

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Patient Outcome

On the way to the airport, MP's headache become progressively worse; he became confused then lethargic; he vomited twice and then had a generalized tonic clonic seizure. He was rushed to the emergency department and arrived with a GCS score of 6: An emergent head CT showed a large frontal subdural, and a small occipital intraparenchymal hemorrhage. MP was taken to the operating room for evacuation of the subdural and recovered without significant sequelae; however, he frequently has headaches and his family claims that his personality "is different" though they are unable to characterize the change better.

MP always wears a helmet now when he skies.

Annotated Bibliography

1. Haydel, MJ, Preston, CA, Mills, TJ, et al. Indications for computed tomography in patients with minor head injury. N Engl J Med. 2000; 343:100-105.

A prospective study with two phases: Phase I had 520 patients and was used to develop a prediction rule for MTBI in patients with a GCS of 15 and a history of loss of consciousness or post traumatic amnesia. Phase II was a validation study with 909 patients. Overall, 6.5% of patients had a positive CT, .4% with a neurosurgical lesion. Seven predictors of abnormal CT were identified: headache, vomiting, age over 60, drug or ETOH intoxication, deficits in short-term memory, physical evidence of trauma above the clavicle, seizure. Absence of all 7 had 100% negative predictive value. The studies only weakness was that patients were not followed-up after discharge.

2. Hofman, PAM, Nelemans, P, Kemerink, GJ, et al. Value of radiological diagnosis of skull fracture in the management of mild head injury: meta-analysis. J Neurol Neurosurg Psych. 2000; 68:416-422.

A meta-analysis of 20 studies looking at the role of plain film radiographs in TBI. The outcome measure used was skull fracture and intracranial hemorrhage. Thirteen studies documented both outcome measures and reported as an aggregate that 44% of patients with an acute traumatic brain lesion has a skull fracture, i.e, 56% with an intracranial lesion did not have a fracture. The authors concluded that a skull fracture increases the predictive value of an intracranial hemorrhage but the absence of a fracture can not be used as a surrogate to exclude a traumatic lesion.

3. Jeret JS, Mandell, M, Anziska, B, et al. Clinical predictors of abnormality disclosed by computed tomography after mild head trauma. Neurosurg. 1993; 32:9-16.

A prospective study of 712 consecutive trauma patients with a GCS of 15. The outcome measure used was an abnormal CT. The authors found that 9.4% of patients had an acute traumatic brain lesion and that .3% required neurosurgery. They reported that neither the neuro exam, digit span, nor object recall predicted which patients would have a neurosurgical lesion.

4. Livingston D, Lavery R, Passannante M, et a. Emergency department discharge of patients with a negative cranial computed tomography scan after minimal head injury. Ann Surg 2000; 232:126-132

This paper had the right idea but unfortunately its methodology was flawed and therefore its results suspect. The study included 2152 consecutive patients with a GCS of 14-15. A standardized physical and neuro exam was performed. The authors report a negative predictive value of a normal head CT as 99.7%. This paper's weaknesses include: the timing from injury to CT was not recorded; group of patients who deteriorated was not well described though appears that clinical course was predicted early on (GCS 14, etc); the data analysis is not presented clearly; and a negative predictive value is the wrong test for reporting findings.

5. Masters SJ, McClean PM Arcarese JS et al. Skull x-ray examination after head trauma. N Engl J Med 1987; 316: 84-90.

This is a classic paper that has flawed methodology but stimulated tremendous interest in the diagnosis of TBI. The authors developed a management strategy based on the review of the literature and then applied it to 7035 patients. They categorized patients into low, medium, and high risk subsets and made recommendations that changed the way clinicians approached the head injured patient. The papers weaknesses include: 48% of patients were lost to follow-up; the GCS score was not reported; it did not address the significance of CT findings.

6. Nagurney, JT, Borczuk, P, Thomas, SH. Elder patients with closed head trauma: A comparison with nonelder patients. Acad Emerg Med. 1998; 5:678-684.

A retrospective review of 1649 patients. Reported that a focally abnormal neurologic exam imparted a risk ratio for an abnormal CT of 4.4 in the elderly (older than 60) and 7.75 in the young. The papers weaknesses include: GCS score was not reported and old neurologic lesions were not separated from new ones.

7. Nagy, KK, Joseph, KT, Krosner, SM, et al. The utility of head computed tomography after minimal head injury. J Trauma Injury Infect Crit Care. 1999; 46:268-273.

A retrospective review of 1170 patients all of whom had a CT and were admitted for 24 hours observation. No patient with a normal head CT deteriorated and therefore the authors recommended that these patients can be safely discharged without the need for admission and observation.

8. Rimel R, Giordani B, Barth J, et al: Disability caused by minor head injury. Neurosurg 9;221, 1981.

A classic study which obtained three month followed-up on mild TBI patients who had been hospitalized for observation. They reported that 79% complained of persisting headaches, 59% of memory dysfunction, and that 33% of patients had not returned to work. They did not find ongoing litigation to be a significant predictor of PCS, however, they did report that patients with unskilled jobs had a higher incidence of PCS at three months while patients with executive or managerial positions had a higher incidence of returning to work.

9. Stiell I, Wells G, Vandemheen K, et al. The Canadian CT head rule for patients with minor head injury. Lancet 2001; 357:1391-1396.

A derivation study of a prospective cohort of 3121 TBI patients with a GCS of 15; all patients had a positive LOC or post traumatic amnesia. 8% had a positive CT; 1% required a neurosurgical intervention. The authors derived a CT head rule with 5 high risk predictors: failure to reach GCS 15 within 2 hours, suspected open skull fracture, sign of basal skull fracture, vomiting more than once, age >64. The high risk factors were 100% sensitive for predicting the need for neurosurgery and their application would decrease the need for head CT by 68%. The study's weaknesses include: only 67% of patients were scanned; 33% had a structured assessment survey for clinically important lesion at 14 days post discharge; only 172 patients who did not have a CT were followed-up (randomly selected). Of note, solitary contusions <5mm, localized SAH <1mm, smear subdural < 4 mm thick, isolated pneumocephaly, closed depressed skull fracture not through the inner table were not considered clinically important (based on survey consensus).

Questions

- 1. A skier hits his head on a tree with loss of consciousness for one minute. When the ski patrol arrives 3 minutes after the accident, his GCS score is 8 (opens his eyes only to pain; mumbles with no comprehensible speech). Which of the following is correct?**
 - a. The patient has a severe brain injury
 - b. The patient has a bad prognosis
 - c. The presence of brain injury or prognosis can not be determined

- 2. Which of the following is the most commonly affected cranial nerve in traumatic brain injuries?**
 - a. II
 - b. III
 - c. IV
 - d. VI
 - e. VII

- 3. A patient with a head injury with loss of consciousness has a GCS score of 15 in the ED. Plain skull radiographs are obtained and are normal. What per cent of these patients will have an acute traumatic lesion visualized on head CT.**
 - a. 10%
 - b. 20%
 - c. 30%
 - d. 40%
 - e. 50%

- 4. A 28 year old patient sustains a head injury with loss of consciousness. In the ED, his GCS score is 15; there is no headache, vomiting, seizure, intoxication, altered mental status, or physical evidence of trauma. What is likelihood of this patient having an acute traumatic brain lesion visualized on CT?**
 - a. 0%
 - b. 3%
 - c. 5%
 - d. 10%
 - e. 20%

- 5. Which of the following is true of the postconcussive syndrome after a MTBI:**
 - a. It is more likely to develop if the patient is involved in accident related litigation
 - b. It is reported in up to 80% of patients in the first week post injury
 - c. It rarely involves problems with concentration
 - d. It frequently persists after three months

Answers

1. Answer c.

A single GCS score, particularly immediately after an the injury is neither predictive of the degree of injury nor of prognosis. The original studies on the GCS score were performed on patients with severe traumatic brain injuries who were at least six hours out from the trauma.

2. Answer d.

The sixth cranial nerve is the longest intracranial nerve and therefore at greatest risk for injury from either direct trauma or from mass occupying lesions / edema. The VI cranial nerve innervates the lateral rectus and therefore head trauma patients should be examined for diplopia, especially at far lateral gaze.

3. Answer a.

Plain skull films, when normal, are not helpful in predicting the presence of an underlying traumatic brain injury and therefore can not be used to risk stratify patients with head injury. Fifty percent of patients with a documented acute traumatic brain injury have a normal skull radiograph. Ten percent of MTBI patients with a GCS score of 15 have an acute traumatic brain injury on CT though less than 1% have a neurosurgical lesion. Of the 10% with an acute lesion, 50% have a normal skull radiograph; on the other hand, the presence of a skull fracture on plain film radiograph significantly increases the likelihood that there is a traumatic brain lesion.

4. Answer a.

A well designed prospective study with a validation phase has conclusively demonstrated that a head CT is not necessary in the MTBI patient who has a GCS of 15, is less than 60 years old, and does not have evidence of trauma above the clavicle, seizure, vomiting, deficits in short-term memory, intoxication, or headache. It is estimated that using these criteria would decrease the use of CT by at least 20% without imposing any risk to missing a significant traumatic brain lesion.

5. Answer a.

The postconcussive syndrome (PCS) refers to a symptom complex experienced by many patients after mild TBI. Common symptoms include headache, dizziness, difficulty concentrating, depression, peripheral vestibular system dysfunction. Approximately 30% of patients with mild TBI will have symptoms at 3 months post-injury; it is rare, but possible, for symptoms to persist longer. It appears that well motivated, young, male patients are at the lowest risk of developing the PCS, and recovery appears to be linked not only to the underlying lesion but also to psychosocial issues in the patient's life. Ongoing litigation has not been demonstrated to predict the development or persistence of PCS.