Mild traumatic brain injury

Part 1: Determining the need to scan

Zachary Levine MD CCFP(EM)

An 18-year-old man was brought to the emergency department (ED) by ambulance on a Thursday evening. While playing hockey he was checked against the boards. He fell to the ice and did not get up on his own. Medical personnel rushed to his aid and found him breathing easily but completely unresponsive. His vital signs were normal. His cervical spine was immobilized and he was put on a backboard. En route to the hospital he began to regain consciousness.

On examination his airway and breathing were normal. Measurement of his vital signs revealed the following: heart rate of 90 beats/min, blood pressure of 120/80 mm Hg, oxygen saturation of 98% on room air, and a temperature of 36.8°C. On initial neurologic examination, the patient's Glasgow Coma Scale (GCS) score was 13, because he was confused about the date and where he was, and he opened his eyes only on command. He was fully exposed but kept warm. A secondary physical survey revealed no injuries, including no obvious head injuries. An examination of his helmet revealed a crack in the back of it.

When the patient's parents arrived they immediately rushed to his side. His mother, a lawyer, urgently asked, "Doctor, aren't you going to scan him? He could have an intracranial bleed!"

His father, a hockey coach, interrupted, "Doctor, when can he get back on the ice? He's got a big game tomorrow!"

Mild traumatic brain injury (MTBI) is defined as injury to the head resulting in loss of consciousness for less than 30 minutes, alteration in mental status at the time of the accident, or memory loss. At the time of presentation for health care, MTBI patients have GCS scores of 13 to 15.[1]

Mild traumatic brain injury is extremely common. In North America there are between 1.5 million and 2 million patient visits to EDs each year for head trauma, with 70% to 90% of these visits being MTBI cases.[2] This does not include the many people who hit their heads and choose not to seek medical attention. The groups at highest risk of MTBI are teens and young adults, although older adults and young children also have substantial morbidity. Mild traumatic brain injury is more common in men than in women. The most common causes are motor vehicle accidents and falls.

Emergency physicians are frequently confronted with cases like the one described here. They have to decide which patients need urgent imaging, which patients need to be observed, and which patients can be sent home. Between the years 1992 and 2000 there was a 165% increase in the rate of computed tomography (CT) of the head in Canadian hospitals. Ninety percent of head CT scans have negative results for clinically important brain injury.[3] Only 1% of all cases of MTBI require neurosurgical intervention. So who needs to be scanned?

Guidelines

In the late 1990s there were no fewer than 10 different sets of guidelines for determining which patients with MTBI warranted CT scans of the head. More recently 2 groups have produced externally validated rules for which patients require CT scans. Most familiar to us in Canada is the Canadian CT Head Rule (CCTHR)* by Stiell et al (**Box 1**).[4] Two further studies have shown the CCTHR to have a sensitivity of 100% for intracranial lesions that require neurosurgical intervention.[5,6]

Haydel et al provided another externally validated rule for CT of the head: the New Orleans Criteria (NOC)

Box 1. Canadian CT Head Rule

CT scan is only required for patients with minor head injuries* who have any 1 of the following findings:

High risk (for neurologic intervention)
- GCS score <15 at 2 h after injury
- Suspected open or depressed skull fracture
- Any sign of basal skull fracture (eg, hemotympanum, raccoon eyes, cerebrospinal fluid [otorrhea or rhinorrhea], Battle sign)
- Vomiting ≥2 episodes
- Age ≥65 y

Medium risk (for brain injury on CT)
- Amnesia before impact ≥30 min
- Dangerous mechanism (ie, pedestrian struck by motor vehicle; occupant ejected from motor vehicle; fall from height ≥3 ft or 5 stairs)

CT—computed tomography, GCS—Glasgow Coma Scale.
**Minor head injury* is defined as witnessed loss of consciousness, definite amnesia, or witnessed disorientation in a patient with a GCS score of 13-15.
Data from Stiell et al.[4]

*In Canada we are fortunate enough to practise in an environment where we are not under constant threat of malpractice litigation. For this reason we can focus on patient welfare without being wasteful or exposing patients to unnecessary radiation. The Canadian CT Head Rule is a guide that has been shown to identify 100% of neurosurgically important intracranial injuries in cases of mild traumatic brain injury while substantially lowering our use of resources and patient exposure to radiation.

(**Box 2**).[7] This rule was also shown to be 100% sensitive for neurosurgical lesions. Differences between the NOC and the CCTHR include the age cutoff of 60 years in the NOC versus 65 in the CCTHR; headache, intoxication, and seizure are criteria only in the NOC; and trauma above the clavicle is a criterion of the NOC but not of the CCTHR (which includes evidence of skull fracture). Furthermore, the CCTHR includes mechanism of injury while the NOC does not. Two studies comparing the rules[5,6] also found that both rules were sensitive in predicting intracranial lesions not requiring neurosurgical intervention, although one study found the CCTHR less sensitive for these (83.4% vs 98.3%). Both studies showed the CCTHR to have greater specificity and hence more ability to decrease the number of CT scans done.

Box 2. New Orleans Criteria to determine if CT is indicated after minor head injury

CT scan is needed if a patient has 1 or more of the following criteria:

- Headache
- Vomiting (any)
- Age > 60 y
- Drug or alcohol intoxication
- Persistent anterograde amnesia (eg, deficits in short-term memory)
- Visible trauma above the clavicle
- Seizure

CT—computed tomography.
Data from Haydel et al.[7]

Several other prediction rules have been published since 2001, but they still require external validation, including the CT in Head Injury Patients (CHIP) rule, which divides criteria into major or minor risk of intracranial lesion.[8] The authors of the CHIP rule recognized coagulopathy as an important risk factor. (Coagulopathy was an exclusion criterion in the CCTHR, and there were not enough patients in the NOC to determine its effect.) The most sensitive predictors of intracranial hemorrhage found by the CHIP investigators were signs of skull fracture, high-risk mechanism of injury, posttraumatic amnesia for more than 4 hours, seizure, neurological deficit, vomiting, decrease in GCS score, and coagulopathy.

In December of 2008 a joint panel of the Centers for Disease Control and Prevention and the American College of Emergency Physicians[9] provided updated guidelines for CT scanning of the head in MTBI based on review and analysis of the medical literature until 2007; these guidelines mirror the findings of the previous studies. Similar guidelines have been published by the World Health Organization Taskforce on MTBI[10] and the Neurotraumatology Committee of the World Federation of Neurosurgical Societies.[11] Finally, in 2007 Saboori et al reviewed 16 studies and found that skull fracture, abnormal neurologic examination results, age older than 60 years, vomiting, seizure, and coagulopathy were important risk factors in predicting substantial intracranial hemorrhage.[12]

Indicators and considerations

All in all, the studies agree on several signs indicating the need for urgent CT scanning of the head (**Box 3**): evidence of basal, depressed, or open skull fracture, seizure, vomiting, high-risk mechanism (eg, ejection from a vehicle; pedestrian vs automobile), and decreasing or persistently decreased GCS score. The following are other important factors to consider: age older than 60 years, persistent anterograde amnesia, retrograde amnesia for longer than 30 minutes, coagulopathy (either due to medication or not), intoxication, loss of consciousness, and a fall greater than 5 stairs or 3 ft.

It is also worth noting that epidural hematomas, perhaps the most feared and time-sensitive traumatic intracranial lesions, are located in the temporoparietal region 75% of the time and associated with skull fracture 90% of the time. Only 20% of epidural hematomas actually present with the "classic" brief loss of consciousness then alert "honeymoon" period followed by rapid progression to herniation and coma. Prognosis is excellent if hematomas are treated aggressively—outcome of surgical decompression is related directly to preoperative neurologic condition.[13,14]

Other factors to consider are the social context of the patient (eg, might there be abuse involved and can the patient be adequately observed at home) and whether a language barrier precludes getting an accurate

Box 3. Factors to consider when determining need of CT in patients with head injury

Indications for urgent CT scan include the following:

- Evidence of skull fracture—basal, depressed, or open
- Abnormal results of neurologic examination
- Seizure
- Vomiting > 1 time
- High-risk mechanism (eg, ejection from vehicle; pedestrian or cyclist vs automobile)
- Decreasing GCS score or persistently decreased GCS score of < 15

Indications for lower threshold for CT scan include the following:

- Age > 60 y
- Persistent anterograde amnesia
- Retrograde amnesia > 30 min
- Coagulopathy
- Fall > 5 stairs or > 3 ft
- Intoxication (examination unreliable)
- LOC > 30 min
- Mechanism and location of injury
- Social factors (eg, abusive situation at home, language barriers preclude accurate history)

CT—computed tomography, GCS—Glasgow Coma Scale, LOC—loss of consciousness.

Author's note

This article focuses on the ≥ 16 y population, as the Canadian CT Head Rule and the New Orleans Criteria are externally validated for this population. It is worth noting that 2 recent publications provide evidence-based guidance for determining which children require CT scanning of the head after MTBI:

- Osmond MH, Klassen TP, Wells GA, Correll R, Jarvis A, Joubert G, et al. CATCH: a clinical decision tool for the use of computed tomography in children with minor head injury. *CMAJ* 2010;182(4):341-8.
- Kuppermann N, Holmes JF, Dayan PS, Hoyle JD Jr, Atabaki SM, Holubkov R, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet* 2009;374(9696):1160-70. Epub 2009 Sep 14.

history. When physicians have weighed the information available from history and physical examination, they must also consider the resources available. That is, if a patient is at high risk of an intracranial lesion and he or she presents to a very remote clinic, the threshold must be relatively low to arrange transfer to a centre capable of providing neurosurgical intervention. This is because neurosurgically amenable lesions are time-sensitive. Indeed review studies have shown that up to half of patients who develop intracranial hematomas requiring emergent decompression have lucid intervals before their subsequent deterioration.[15,16] These are the people for whom CT rules are developed.

Case reflection

The young man in this case had a loss of consciousness of less than 30 minutes and a GCS score of 13 on presentation. Using the CCTHR, the patient does not warrant CT scanning of the head unless his GCS score does not recover to 15 within 2 hours or he vomits 2 or more times. If his GCS returns to 15 but he has amnesia for 30 minutes or more before the impact, then he is at risk of a serious intracranial lesion but not one requiring neurosurgical intervention; the CCTHR would recommend either a CT scan or close observation. Using the NOC, the patient would need a CT scan of the head if he complained of headache, vomited, had a seizure, or had persistent anterograde amnesia.

Further resources

Canadian CT Head Rule poster: Ottawa Hospital Research Institute [website]. *Canadian CT Head Rule*. Ottawa, ON: OHRI; 2010. Available from: **www.ohri.ca/emerg/cdr/docs/cdr_cthead_poster.pdf.**

New Orleans CT Head Criteria information: Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. *N Engl J Med* 2000;343(2):100-5. Available from: **http://content.nejm.org/cgi/content/full/343/2/100.**

BOTTOM LINE

- Mild traumatic brain injury (MTBI) is a common presenting problem in emergency departments. Emergency physicians face the difficult decision of which patients need urgent computed tomography (CT) scanning, which should be observed, and which can be sent home.
- By using validated predictive tools such as the Canadian CT Head Rule and the New Orleans Criteria, emergency physicians can reduce the unnecessary use of CT scans in MTBI and select patients most likely to require neurosurgical intervention.

POINTS SAILLANTS

- Les traumatismes crâniens mineurs (TCM) sont des problèmes fréquemment observés dans les services d'urgence. Les urgentologues sont aux prises avec la décision difficile de déterminer quels sont les patients qui ont besoin d'une tomodensitométrie (TDM) assistée par ordinateur d'urgence, ceux devraient rester sous observation et ceux qui peuvent retourner à la maison.
- En utilisant des outils de prédiction validés comme la règle canadienne d'utilisation de la TDM chez les patients avec TCM (Canadian CT Head Rule) et les critères de la Nouvelle-Orléans, les urgentologues peuvent réduire le recours inutile aux TDM dans les cas de TCM et identifier les patients qui ont le plus probablement besoin d'une intervention neurochirurgicale.

The patient recovered to a GCS score of 15 within 2 hours and did not have any amnesia, vomiting, headache, or seizure. Thus, he did not receive CT scanning of the head. He was eventually discharged home with instructions about warning signs for when to return to the ED.

But what of his father's question? When can his son return to hockey? This question introduces the topic of concussion, which will be discussed in the July 2010 issue of *Canadian Family Physician*.

Conclusion

Since 2000 tremendous progress has been made in defining MTBI and determining which patients require brain imaging. Several rules are now available to guide us in this effort to not miss any important intracranial lesions while not wasting time and money, and avoiding patients' exposure to unnecessary radiation, which has been shown to increase cancer risk.[17,18] When we add to

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these guidelines a thoughtful consideration of social factors and available resources, we have the tools to make confident decisions about who truly warrants brain imaging after MTBI.

Dr Levine is an attending physician in the Department of Emergency Medicine at the McGill University Health Centre in Montreal, Que.

Competing interests
None declared

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