



**JONATHAN GLAUSER, MD**

Department of Emergency Medicine,  
The Cleveland Clinic Foundation

# Head injury: Which patients need imaging? Which test is best?

## ABSTRACT

Some patients with head injuries definitely need to undergo an imaging study—usually computed tomography (CT). Most, however, are in a category of “apparently mild” injury, and controversy continues about which of them need to undergo imaging studies to rule out intracranial injuries.

## KEY POINTS

The New Orleans criteria recommend CT if a patient has any of the following: headache, vomiting, age greater than 60 years, drug or alcohol intoxication, deficits in short-term memory, seizure, or evidence of injury above the clavicles.

The Canadian CT rule lists five factors that indicate a high risk that the patient will need neurosurgery: a score lower than a perfect 15 on the Glasgow Coma Scale 2 hours after the injury, a suspected open or depressed skull fracture, more than two episodes of vomiting, physical evidence of basal skull fracture, or age greater than 65 years.

Other possible indications for emergency CT are anticoagulation therapy, a shunt for hydrocephalus, coagulopathy, and very young age.

A patient may not need CT if he or she has had no loss of consciousness; no amnesia for the event; no evidence of drug or alcohol intoxication; no neurologic deficit; no history of headache, vomiting, or seizure; and, perhaps, no physical evidence of trauma above the clavicles.

**T**HERE IS OFTEN UNCERTAINTY about which patients with a head injury need an imaging test, especially if the injury appears to be minor. Short of ordering an imaging test, how can a physician be sure that a head injury is truly minor and does not harbor an intracranial hematoma? And once a decision is made to order an imaging test, which is best: plain films, computed tomography (CT), or magnetic resonance imaging (MRI)?

## WHO DEFINITELY NEEDS AN IMAGING TEST?

For some head injuries, there is little debate about which patients need an imaging test. The accepted high-risk indicators include:

- Loss of consciousness for more than 5 minutes
- Depressed or decreasing level of consciousness
- Focal neurological findings
- Seizure
- Failure of the mental status to improve over time in an alcohol-intoxicated patient
- Penetrating skull injuries
- Signs of a basal or depressed skull fracture<sup>1-4</sup>
- Confusion or aggression on examination.

Headache, dizziness, scalp hematomas, lacerations, contusions, and abrasions are not considered high-risk factors.<sup>5-8</sup>

## WHEN THE PHYSICIAN CANNOT BE SURE

In other situations, the decision whether to obtain an imaging study of the head may not be as clear-cut. In these cases, the injury may

TABLE 1

**Glasgow Coma Scale**

FINDING (CHOOSE ONE FROM EACH GROUP)	SCORE
<b>Eye-opening</b>	
Does not open eyes	1
Opens eyes with pain	2
Opens eyes with loud verbal command	3
Opens eyes on own	4
<b>Speech</b>	
Makes no noise	1
Moans, makes unintelligible sounds	2
Talks, but nonsensical	3
Seems confused, disoriented	4
Alert and oriented	5
<b>Motor response</b>	
No motor response to pain	1
Extensor response (decerebrate)	2
Flexor response (decorticate)	3
Moves part of body, but does not remove noxious stimulus	4
Pushes away noxious stimulus	5
Follows simple motor commands	6
<b>Total</b>	

BASED ON DATA FROM TEASDALE G, JENNETT B. ASSESSMENT OF COMA AND IMPAIRED CONSCIOUSNESS. A PRACTICAL SCALE. LANCET 1974; 2:81-84.

appear minor, but the physician cannot be absolutely sure that the patient does not have an occult intracranial injury. Indeed, cases have been documented in which patients did not lose consciousness, could remember everything, and presented awake and alert, yet required intensive care and neurosurgical intervention after CT scans revealed traumatic injury.<sup>9,10</sup>

Traditionally, a physician who was in doubt about whether a patient had an intracranial injury would admit him or her to the hospital for observation. That tactic, however, can be risky: if not detected, intracranial hematomas can be devastating, and mental status often deteriorates abruptly. Hospitalization is also labor-intensive and expensive.<sup>11</sup>

Therefore, it may be desirable to obtain an imaging study to ensure a rapid and accurate diagnosis, even if a head injury appears minor. But imaging studies are also expensive, and

most patients with head injury fall into this "apparently minor" category. Is there any way to further distinguish patients who do or do not need an imaging test?

### No agreement on separating truly minor from apparently minor injury

A precise definition of who has a truly minor head injury and does not require an imaging test has never been agreed upon.

**Normal findings on a brief neurologic examination** are used as a loose definition of a truly minor injury by some experts, even if the patient may have briefly lost consciousness or had post-traumatic amnesia.

**The Glasgow Coma Scale** is used by others. Scores on this scale range from 3 (worst) to 15 (best) and are based on the patient's ability to open his or her eyes, talk, and move (TABLE 1).<sup>12</sup> But what cut-off score should be used? Some say that an injury is truly minor if the Glasgow Coma Scale score is 13 or higher,<sup>13-15</sup> while others say that any score lower than a perfect 15 indicates a depressed level of consciousness and clearly warrants an imaging study on an emergency basis.<sup>16</sup> In fact, 40% of patients with a score of 13 have an abnormal CT scan.<sup>17</sup>

Nagy et al<sup>18</sup> propose that patients do not need to undergo imaging and can be sent home in the care of a relative if they have:

- No loss of consciousness
- No vomiting
- No amnesia
- Minimal if any subgaleal swelling.

### STUDIES OF CRITERIA FOR IMAGING

Needed is a prospectively validated clinical decision rule that would help physicians decide which patients with head injuries need to undergo imaging.<sup>19</sup> Two such rules have been developed, and they are very sensitive—they identify all patients who truly have intracranial injuries. On the other hand, to date, there is no agreement on any set of clinical or historical data that will identify every patient who will have a negative CT scan.

### The New Orleans criteria

The New Orleans criteria consist of seven clinical or historical findings,<sup>20</sup> any of which



calls for CT after a minor head injury:

- Headache
- Vomiting
- Age over 60 years
- Drug or alcohol intoxication
- Deficits in short-term memory
- Seizure
- Evidence of injury above the clavicles.

In a series of more than 1,400 patients,<sup>20</sup> the presence of any of these seven findings was 100% sensitive; however, patients on anticoagulation therapy were underrepresented.

A prospective study evaluated the New Orleans criteria in 1,733 patients and correctly classified all 8 patients who required neurosurgical intervention, all 87 patients with “important” brain injuries, and 46 of 48 patients with “unimportant” brain injuries (these categories were not explicitly defined in the report).<sup>21</sup>

### The Canadian CT head rule

The Canadian CT head rule<sup>22</sup> is a list of factors that, if present, indicate that a patient with a “minor” head injury should have a CT scan. (Minor head injury is defined as witnessed loss of consciousness, definite amnesia, or witnessed disorientation in patients with Glasgow Coma Scores of 13 to 15).

There are five “high-risk” factors, which indicate a high risk that the patient will need neurosurgical intervention:

- A score of less than 15 on the Glasgow Coma Scale at 2 hours after the injury
- A suspected open or depressed skull fracture
- More than two episodes of vomiting
- Physical evidence of basal skull fracture
- Age > 65 years.

In addition, there are two “medium-risk” factors for predicting brain injury on CT:

- Amnesia for events that happened more than 30 minutes before the impact
- A dangerous mechanism of injury (pedestrian struck by motor vehicle, occupant ejected from motor vehicle, fall from higher than 3 feet or five stairs).

In a series of 3,121 patients,<sup>22</sup> the five high-risk criteria were 100% sensitive for predicting the need for neurologic intervention. Nevertheless, an “ultrasensitive” ver-

sion has been proposed in an attempt to devise a clinical examination acceptable to US practitioners for screening patients for head CT—who presumably demand that the criteria predict absolutely all patients requiring neurosurgical intervention. The ultrasensitive version incorporates an object recall test.

### ■ OTHER INDICATIONS FOR IMAGING STUDIES

**Ethanol-intoxicated patients** with minor head injuries have a prevalence of intracerebral injury seen on CT scans of between 2.4% and 8.4%,<sup>18,23</sup> a level high enough to justify early scanning.

**Patients with coagulopathies** or who are taking warfarin should be worked up aggressively, perhaps including overnight observation and repeat scanning. One report investigating the use of CT in 39 anticoagulated patients with minor head trauma (lacerations, contusions, and abrasions but no loss of consciousness or abnormal neurologic examination) found no significant abnormalities.<sup>23</sup> However, another study found that abnormal clotting studies at admission helped predict delayed brain injury seen on CT.<sup>24</sup>

**Patients with shunt-treated hydrocephalus** also warrant an aggressive diagnostic workup after a mild head injury.<sup>25</sup>

**Infants** have been reported to develop intracranial hematomas despite normal initial examinations and CT scans, and symptoms such as vomiting and seizures also have been shown to be poorly specific and sensitive. One retrospective study found that 19 of 101 infants admitted to the hospital with intracranial injury had no signs or symptoms of brain injury.<sup>26</sup> A number of studies report that between 0.4% and 1.5% of children with minor head injuries require neurosurgical intervention.

No single set of clinical criteria to detect all pediatric patients with radiographic lesions has been identified. Liberal use of CT scanning may be advisable despite the likely need for sedation and its associated risks, including hypoxia, apnea, prolonged depressed level of consciousness, and aspiration.<sup>27</sup>

**Which patients need CT after minor head trauma is controversial**

If the infant is younger than 2 or 3 months, the clinician may consider CT scanning after any nontrivial injury.<sup>27</sup> The risk for asymptomatic brain injury appears to be highest under the age of 6 months. Age younger than 2 years has been recognized since 1987 as an independent risk factor for significant head injury,<sup>28</sup> and any children of this age with any significant scalp findings such as hematoma may be candidates for scanning.

When head injury is suspected to be caused by abuse, MRI gives superior detail for many lesions, although it does not affect surgical decisions.<sup>29,30</sup>

**Age greater than 60 years** is another independent risk factor for intracranial injury<sup>31</sup> because of higher rates of intracranial hemorrhage and the poorer reliability of clinical signs and symptoms in this age group.

#### ■ CT IS THE PREFERRED IMAGING TEST

CT is the preferred method for detecting intracranial lesions that require surgery, at least in the United States, where high sensitivity is of paramount concern and where it is widely available. As of 1986, every level I and level II trauma center is required to have 24-hour CT capability.<sup>32</sup>

In Europe and Canada, CT is used more selectively because it is costly and less available and because fear of litigation is not as high.

#### Plain radiographs are inadequate

In general, plain radiographs of the skull are of no use in evaluating a blunt head injury. Although skull fractures are present in approximately 5% of mild head injuries,<sup>33</sup> if a fracture is detected on a plain film, a CT scan is needed anyway, and obtaining plain radiographs of the head can only delay the diagnosis of intracranial lesions.

As early as the 1980s, some experts recommended abandoning plain radiographs of the head.<sup>34,35</sup> A study by the Royal College of Radiologists concluded that if CT scans are used judiciously, obtaining plain radiographs of the head has a very low diagnostic yield and does not give any additional information that would lead to management changes.<sup>36</sup>

#### MRI is less available

Although magnetic resonance imaging (MRI) is better than CT in detecting axonal injury, small areas of contusion, and subtle neuronal damage, MRI and CT are equivalent for diagnosing surgically correctable lesions in the acute setting.

In one study, six (10%) of 58 patients discharged from the emergency department after minor head injury had abnormalities detected by MRI; however, this information did not affect their management.<sup>37</sup> MRI is not yet widely available on a 24-hour basis; as it becomes more so, it may play a greater role in evaluating minor head injuries.

#### ■ CRITERIA FOR A POSITIVE CT SCAN

From a practical standpoint, a CT scan is positive if it reveals an acute traumatic intracranial lesion that requires either intervention or observation,<sup>31</sup> eg:

- A subdural, epidural, or parenchymal hematoma
- A subarachnoid hemorrhage
- A cerebral contusion
- A depressed skull fracture.

#### ■ COST-EFFECTIVENESS OF CT IMAGING

Every year, between 800,000 and 1,000,000 Americans seek emergency care for head injuries.<sup>19,38,39</sup> More than 80% of these injuries are considered minor.

Fewer than 10% of patients with minor head injury have positive findings on CT scanning, however, and fewer than 1% require neurosurgical intervention,<sup>1,40</sup> leading some to question whether CT is cost-effective. Reinus et al<sup>41</sup> estimated that a 10% reduction in the number of CT scans performed on patients with minor head injury could save more than \$20 million per year.

However, because it can obviate the need for hospital admission or prolonged observation in the emergency department, obtaining a CT scan promptly may actually save money.<sup>40</sup>

Another issue is that of optimal care. Patients sent home are not always reliably observed for signs of deterioration,<sup>42</sup> underlining the need for accurate and prompt diagnosis.

**Fewer than 10% of patients with minor head injury have positive findings on CT**



## REFERENCES

1. Jeret JS, Mandell M, Anziska B, et al. Clinical predictors of abnormality disclosed by computed tomography after mild head trauma. *Neurosurgery* 1993; 32:9–15.
2. Moran SG, McCarthy MC, Uddin DE, Poelstra RJ. Predictors of positive CT scans in the trauma patient with minor head injury. *Am Surg* 1994; 60:533–536.
3. Duus BR, Lind B, Christensen H, Nielsen OA. The role of neuroimaging in the initial management of patients with minor head injury. *Ann Emerg Med* 1994; 23:1279–1283.
4. Cummins RO, LoGerfo JP, Inui TS, Weiss NS. High-yield referral criteria for posttraumatic skull roentgenography. Response of physicians and accuracy of criteria. *JAMA* 1980; 244:673–676.
5. Thornbury JR, Campbell JA, Masters SJ, Fryback DG. Skull fracture and the low risk of intracranial sequelae in minor head trauma. *AJR Am J Roentgenol* 1984; 143:161–164.
6. Vydaireny KH, Harle TS, Potchen EJ. An algorithmic approach to the roentgenographic evaluation of head trauma: medical and financial implications. *Invest Radiol* 1983; 18:390–395.
7. Ingebrigtsen T, Romner B. Management of minor head injuries in hospitals in Norway. *Acta Neurol Scand* 1997; 95:51–55.
8. Schunk JE, Rodgerson JD, Woodward GA. The utility of head computed tomographic scanning in pediatric patients with normal neurologic examination in the emergency department. *Pediatr Emerg Care* 1996; 12:160–165.
9. Stiell IG, Dreyer JF, Worthington JR, et al. An “ultra-sensitive” version of the Canadian CT Head Rule for U.S. physicians [abstract]. *Acad Emerg Med* 2001; 8:109–110.
10. Levitt MA, Petersen PL. Loss of consciousness and post-traumatic amnesia are not accurate predictors of need for CT scanning and intensive care/neurosurgical intervention in minor head trauma patients [abstract]. *Acad Emerg Med* 2001; 8:455.
11. Chan KH, Mann KS, Yue CP, Fan YW, Cheung M. The significance of skull fracture in acute traumatic intracranial hematomas in adolescents: a prospective study. *J Neurosurg* 1990; 72:189–194.
12. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. *Lancet* 1974; 2:81–84.
13. Shackford SR, Wald SL, Ross SE, et al. The clinical utility of computed tomography scanning and neurologic examination in the management of patients with minor head injuries. *J Trauma* 1992; 33:385–394.
14. Stein SC, O'Malley KF, Ross SE. Is routine computed tomography scanning too expensive for mild head injury? *Ann Emerg Med* 1991; 20:1286–1289.
15. Feuerman T, Wackym PA, Gade GF, Becker DP. Value of skull radiography, head computed tomographic scanning, and admission for observation in cases of minor head injury. *Neurosurgery* 1988; 22:449–453.
16. Ingebrigtsen T, Romner B, Kock-Jensen C. Scandinavian guidelines for initial management of minimal, mild, and moderate head injuries. The Scandinavian Neurotrauma Committee. *J Trauma* 2000; 48:760–766.
17. Stein SC, Ross SE. The value of computed tomographic scans in patients with low-risk head injuries. *Neurosurgery* 1990; 26:638–640.
18. Nagy KK, Joseph KT, Krosner SM, et al. The utility of head computed tomography after minimal head injury. *J Trauma* 1999; 46:268–270.
19. Stiell IG, Lesiuk H, Wells GA, et al. Canadian CT head rule study for patients with minor head injury: methodology for phase II (validation and economic analysis). *Ann Emerg Med* 2001; 38:317–322.
20. Haydel MJ, Preston CA, Mills TJ, Lubner S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. *N Engl J Med* 2000; 343:100–105.
21. Stiell IG, Clement C, Rowe BH, et al. Multicenter prospective validation of the New Orleans criteria for CT in minor head injury [abstract]. *Acad Emerg Med* 2003; 10:477.
22. Stiell IG, Wells GA, Vandemheen K, et al. The Canadian CT Head Rule for patients with minor head injury. *Lancet* 2001; 357:1391–1396.
23. Cook LS, Levitt MA, Simon B, Williams VL. Identification of ethanol-intoxicated patients with minor head trauma requiring computed tomography scans. *Acad Emerg Med* 1994; 1:227–234.
24. Reinus WR, Zwemer FL Jr. Clinical prediction of emergency cranial computed tomography results. *Ann Emerg Med* 1994; 23:1271–1278.
25. Stein SC, Young GS, Talucci RC, Greenbaum BH, Ross SE. Delayed brain injury after head trauma: significance of coagulopathy. *Neurosurgery* 1992; 30:160–165.
26. Schutzman SA, Greenes DS. Pediatric minor head trauma. *Ann Emerg Med* 2001; 37:65–74.
27. Kraus JF, Fife D, Cox P, Ramstein K, Conroy C. Incidence, severity, and external causes of pediatric brain injury. *Am J Dis Child* 1986; 140:687–693.
28. Greenes DS, Schutzman SA. Occult intracranial injury in infants. *Ann Emerg Med* 1998; 32:680–686.
29. Masters S, McClean P, Arcarese J, et al. Skull x-ray examinations after head trauma: recommendations by a multidisciplinary panel and validation study. *N Engl J Med* 1987; 316:84–91.
30. Levitt C, Smith W, Alexander R. Abusive head trauma. In: Reece R, editor. *Child Abuse: Medical Diagnosis and Management*. Philadelphia: Lea & Febiger; 1994.
31. Arienta C, Caroli M, Balbi S. Management of head-injured patients in the emergency department: a practical protocol. *Surg Neurol* 1997; 48:213–219.
32. Cooper PR, Ho V. Role of emergency skull x-ray films in the evaluation of the head-injured patient: a retrospective study. *Neurosurgery* 1983; 13:136–140.
33. Dunham CM, Coates S, Cooper C. Compelling evidence for discretionary brain computed tomographic imaging in those patients with mild cognitive impairment after blunt trauma. *J Trauma* 1996; 41:679–686.
34. Dacey RG Jr, Alves WM, Rimel RW, Winn HR, Jane JA. Neurosurgical complications after apparently minor head injury. Assessment of risk in a series of 610 patients. *J Neurosurg* 1986; 65:203–210.
35. Thornbury JR, Masters SJ, Campbell JA. Imaging recommendations for head trauma: a new comprehensive strategy. *AJR Am J Roentgenol* 1987; 149:781–783.
36. Costs and benefits of skull radiography for head injury. A national study by the Royal College of Radiologists. *Lancet* 1981; 2:791–795.
37. Pitts LH. The role of neuroimaging in minor head trauma. *Ann Emerg Med* 1991; 20:1387–1388.
38. Becker DP, Gade GF, Young HF, et al. Diagnoses and treatment of head injury in adults. In: Youmans JR, ed. *Neurological Surgery: a Comprehensive Reference Guide to the Diagnosis and Management of Neurosurgical Problems*. 3rd ed. Philadelphia: Saunders; 1990:2017–2148.
39. McCaig LF, Ly N. National Hospital Ambulatory Medical Care Survey: 2000 Emergency Department Summary. *Advance Data* 2000; 326:1–31.
40. Miller EC, Holmes JF, Derlet RW. Utilizing clinical factors to reduce head CT scan ordering for minor head trauma patients. *J Emerg Med* 1997; 15:453–457.
41. Reinus WR, Wippold FJ 2nd, Erickson KK. Practical selection criteria for noncontrast cranial computed tomography in patients with head trauma. *Ann Emerg Med* 1993; 22:1148–1155.
42. Saunders CE, Cota R, Barton CA. Reliability of home observation for victims of mild closed-head injury. *Ann Emerg Med* 1986; 15:160–163.

ADDRESS: Jonathan Glauser, MD, Department of Emergency Medicine, E19, The Cleveland Clinic Foundation, 9500 Euclid Avenue, Cleveland, OH 44195; e-mail [glauserj@ccf.org](mailto:glauserj@ccf.org).