High-risk mild head injury

JOHN N. K. HSIANG, M.D., PH.D., THERESA YEUNG, R.N., ASHLEY L. M. YU, M.SC.,
AND WAI S. POON, F.R.C.S.

Division of Neurological Surgery, and Center for Clinical Trials and Epidemiological Research, Prince
of Wales Hospital, The Chinese University of Hong Kong, Shatin, Hong Kong

ILD head injury is a common presentation in
emergency departments and doctors' offices. However, the definition of mild head injury in
the medical literature has been confusing. Some studies
define mild head injury as a brief loss of consciousness
after a blow to the head, whereas other studies grade the
degree of injury by the length of posttraumatic amnesia.6
The generally accepted definition of mild head injury is
currently based on Glasgow Coma Scale (GCS) scores. 17
A patient with a GCS score of 13 to 15, regardless of oth-
er clinical features, is classified as having mild head
injury. The presence of postinjury vomiting did not correlate
with findings of acute radiographic abnormalities.
Based on the results of this study, the authors divided all head-injured patients with GCS scores ranging from 13 to 15
into mild head injury and high-risk mild head injury groups. Mild head injury is defined as a GCS score of 15 without acute
radiographic abnormalities, whereas high-risk mild head injury is defined as GCS scores of 13 or 14, or a GCS score of
15 with acute radiographic abnormalities. This more precise definition of mild head injury is simple to use and may help
avoid the confusion caused by the current classification.

KEY WORDS • high-risk mild head injury • skull fracture • classification •
Glasgow Coma Scale score • outcome • radiographic finding

M ILD head injury is a common presentation in
emergency departments and doctors' offices. However, the definition of mild head injury in
the medical literature has been confusing. Some studies
define mild head injury as a brief loss of consciousness
after a blow to the head, whereas other studies grade the
degree of injury by the length of posttraumatic amnesia.6
The generally accepted definition of mild head injury is
currently based on Glasgow Coma Scale (GCS) scores.17
A patient with a GCS score of 13 to 15, regardless of oth-
er clinical features, is classified as having mild head
injury.6,13,14 Although this definition is convenient and re-
producible, it is arbitrary and may be misleading.
The term “mild head injury” should mean minor injury
with no significant consequences or long-term sequelae.
Nevertheless, it is not uncommon to see patients with mild
head injury, according to the GCS definition, suffering
from significant sequelae from a minor blow to the head. Rimel, et al.,19 reported that 79% of their patients had per-
sistent headache, 59% had memory problems, and 34% were not able to return to work even 3 months after the
mild head injury. Although this study provided convincing evidence that a considerable amount of disability occurs
after a so-called “minor head injury,” it did not distinguish
the outcome according to the GCS score of the patients.
Moreover, computerized tomography (CT) scans were ob-
tained in only 6% of the patients with mild head injury.
Therefore, the outcomes in these patients could not be cor-
related with the severity of intracranial lesions.
More recently, Williams and colleagues18 divided mild
head injury into uncomplicated and complicated injury
according to GCS scores and radiographic findings. Pa-
tients with uncomplicated mild head injury were those
with an initial GCS score between 13 and 15, a normal CT
scan, and either a normal skull x-ray film or an abnormal-
ity limited to a linear or basilar skull fracture. On the other
hand, patients with complicated mild head injury were
those with an initial GCS score of 13 or 14, or a GCS score of
15 with acute radiographic abnormalities. This more precise definition of mild head injury is simple to use and may help
avoid the confusion caused by the current classification.
indicates that there is heterogeneity in pathophysiology among patients with GCS scores ranging from 13 to 15, implying that the presently accepted definition of mild head injury is inappropriate.

Most recently, Culotta, et al., examined the relationship of individual GCS scores of 13, 14, or 15 on admission and the severity of injury in a large series of patients with mild head injury. The results clearly demonstrated that the degree of brain damage and the probability that a patient will require neurosurgical intervention increases significantly as the GCS score decreases from 15 to 13. Again this indicates the existence of heterogeneous pathophysiology among patients with GCS scores ranging from 13 to 15 and that not all of these patients should be categorized as having mild head injury.

The results of these studies call for a more precise definition of mild head injury. The outcome for patients with GCS scores of 13 and 15, even if both scores are categorized as mild head injury according to the present classification, can be very different. Moreover, the term “mild head injury” is misleading because these patients can experience severe sequelae from a “minor” blow to the head.

The present study investigated the outcome for patients with mild head injury according to their GCS score and acute radiographic findings. Based on the results, we divided these patients into two categories, which we labeled “mild head injury” and “high-risk mild head injury.”

Clinical Material and Methods

Patient Population

Data were prospectively collected from 1360 consecutive patients with mild head injury who were admitted to the neurosurgery service of the Prince of Wales Hospital during 1994 and 1995. Mild head injury was defined as a GCS score of 13 to 15 with or without documented loss of consciousness. Initial GCS scores were assigned by the neurosurgical resident at the time of admission. Patients who were treated in the emergency room but not admitted and patients younger than 11 years of age were excluded from this study.

Skull x-ray films and/or CT scans were obtained in all patients in this study. Skull x-ray films were obtained during admission and CT scans were acquired within 1 hour of admission in patients with impaired consciousness (GCS score 13 or 14) and a skull fracture. Otherwise, the CT scans were obtained within 8 hours after admission, and the decision to order the scan was left to the discretion of the admitting neurosurgeon.

Demographic and descriptive data such as the GCS score, skull x-ray film and CT findings, neurosurgical intervention, and the 6-month outcome postinjury were recorded. Abnormal radiographic findings were defined as the following: 1) skull fracture (including depressed skull fracture); 2) intracranial hematoma or contusion; and 3) traumatic subarachnoid hemorrhage. Neurosurgical interventions were defined as placement of an intracranial pressure monitor or craniotomy for evacuation of a clot. Patient outcome was assessed 6 months postinjury using the Glasgow Outcomes Scale. For all patients admitted in 1995, the presence of vomiting after head injury was also documented.

Statistical Analysis

Data were analyzed using commercially available software (Statistical Package for Social Science [SPSS]; SPSS, Inc., Chicago, IL). The chi-square and Mantel–Haenszel tests were used for the analysis. The Mantel–Haenszel test is a generalization of the test for trend in proportions. A two-tailed statistical significance level at 5% was used (α = 0.05) and compared to probability values computed by the SPSS. If the probability value was greater than or equal to 0.05, no trend effect existed between the GCS scores and the variable being tested. Conversely, if the probability was less than 0.05, a trend effect existed between the GCS scores and the variable being tested.

Results

During 1994 and 1995, 1360 patients were recruited into this study. More than 72% of the patients were male. Table 1 lists the number of patients and their gender and mean age by GCS score.

Table 2 shows the percentages of patients studied using x-ray films or CT scanning and relates the findings to their GCS scores. Head CT scans were obtained in 842 patients. Almost all patients (96%) with GCS scores of 13 underwent CT scanning. The percentage of patients undergoing CT scanning was inversely proportional to the GCS scores. This trend was reversed in patients in whom skull x-ray films were obtained. Almost all patients (94%) with GCS scores of 15 underwent x-ray films on admission. Chi-square analysis revealed statistically significant
(p < 0.0001) differences in the frequency of abnormal radiographic findings in relation to GCS scores. Patients with higher GCS scores were less likely to have positive radiographic findings, and there was a statistically significant linear trend across GCS scores. The same linear trend was seen in different radiographically identified pathology (p < 0.001), except in the case of epidural hematoma, in which patients with GCS scores of 14 had the highest percentage (p = 0.15).

The number of patients who underwent neurosurgical interventions in the first 48 hours after admission was as follows: GCS 13, nine (20%) of 45; GCS 14, seven (5.1%) of 138; GCS 15, 26 (2.2%) of 1177. These data show that patients with a lower GCS score were more likely to require neurosurgical procedures. Again, a statistically significant linear trend was demonstrated across the GCS levels (p < 0.0001).

The 6-month outcomes are summarized in Table 3. Four patients died in this study, which showed the highest percentage of mortality in patients with GCS scores of 13, with mortality rates decreasing as the GCS scores increased. Chi-square analysis revealed statistically significant differences (p < 0.0001) between the three GCS groups. A similar trend was noted in the moderately and severely disabled groups. As expected, patients with GCS scores of 15 had the highest percentage of good outcomes. This observation became even more striking when we separated the patients into two groups according to the presence or absence of acute radiographic abnormalities. Of 957 patients with GCS scores of 15 and negative radiographic findings, all except one with moderate disability (0.1%) had good outcome. Of the 108 patients with GCS scores of 13 or 14 and with no acute radiographic abnormalities, three (2.8%) did not have a good outcome.

All the deaths in this study occurred in elderly patients (> 65 years of age). For the two deaths in patients with GCS scores of 13, both died of progressive expanding subdural hematoma.

The relationship of postinjury vomiting to the presence of acute radiographic abnormalities was also investigated in the patients admitted in 1995. In these 736 patients, 28 had GCS scores of 13, 73 had scores of 14, and 635 had scores of 15. Our results did not demonstrate any relation-

(p < 0.0001) between the three GCS groups. A similar trend was noted in the moderately and severely disabled groups. As expected, patients with GCS scores of 15 had the highest percentage of good outcomes. This observation became even more striking when we separated the patients into two groups according to the presence or absence of acute radiographic abnormalities. Of 957 patients with GCS scores of 15 and negative radiographic findings, all except one with moderate disability (0.1%) had good outcome. Of the 108 patients with GCS scores of 13 or 14 and with no acute radiographic abnormalities, three (2.8%) did not have a good outcome.

All the deaths in this study occurred in elderly patients (> 65 years of age). For the two deaths in patients with GCS scores of 13, both died of progressive expanding subdural hematoma.

The relationship of postinjury vomiting to the presence of acute radiographic abnormalities was also investigated in the patients admitted in 1995. In these 736 patients, 28 had GCS scores of 13, 73 had scores of 14, and 635 had scores of 15. Our results did not demonstrate any relation-ship between vomiting and positive radiographic findings (Table 4).

**Discussion**

Mild head injury, as the name implies, should not cause any severe sequelae. Delayed complications secondary to undetected intracranial pathologies should be avoided. However, it is not practical or desirable to obtain head CT scans in all patients who suffer these injuries. Various investigators have tried to identify patients with mild head injury for whom the CT can be safely omitted. Thus far, no combination of clinical features has been identified that will allow clinicians to discharge confidently all patients with mild head injury without obtaining a CT scan.

We specifically studied vomiting as a clinical sign. However, our results showed that vomiting after head injury has no relationship to acute radiographic abnormalities. Headache is a subjective and common complaint and is therefore an unreliable clinical feature to investigate. Loss of consciousness indicates a significant concussion, although it has been shown that there is no relationship between loss of consciousness and positive CT scans. We did not investigate this symptom as one of the clinical features of mild head injury because a significant number of our patients were not able to tell us reliably about the presence and duration of loss of consciousness. Moreover, some of them could not distinguish posttraumatic amnesia from impaired consciousness.

The GCS score was a strong predictor of outcome, and our study also showed that the severity of injury was correlated with the GCS score. Nonetheless, the term “mild head injury” applied to head-injured patients with GCS scores higher than 12 is misleading because some of them may have significant sequelae. Because it is neurosurgeons who will deal with the potentially avoidable catastrophic complications of mild head injury, we strongly suggest that they devise a more detailed definition for it. Besides GCS scores, skull fracture is another clinical feature that has been shown to be an important correlation with outcome.

**Table 3**

<table>
<thead>
<tr>
<th>GCS Score</th>
<th>No. of Patients</th>
<th>Acnoma-</th>
<th>Outcome (no. of patients)†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>larity</td>
<td>Good</td>
</tr>
<tr>
<td>13</td>
<td>45</td>
<td>+</td>
<td>16</td>
</tr>
<tr>
<td>14</td>
<td>138</td>
<td>+</td>
<td>41</td>
</tr>
<tr>
<td>15</td>
<td>1177</td>
<td></td>
<td>290</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>586</td>
</tr>
</tbody>
</table>

† MD = moderate disability; SD = severe disability; + = present; − = absent.

† Significant at p < 0.0001.

**Table 4**

<table>
<thead>
<tr>
<th>GCS Score/ Vomiting W/ Symptom</th>
<th>No. of Patients W/ Acute Radiographic Findings</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>157</td>
<td>0.924</td>
</tr>
<tr>
<td>no</td>
<td>478</td>
<td>0.93</td>
</tr>
</tbody>
</table>

J. Neurosurg. / Volume 87 / August, 1997
High-risk mild head injury

![Diagram](image)

FIG. 1. Chart depicting criteria for new classification of mild head injury and high-risk mild head injury.

much less expensive than cranial CT scans, can be performed readily in the emergency department, and are very useful triage tools. A study by Mendelow, et al., showed that a patient with a skull fracture and impaired consciousness has a 25% chance of developing intracranial hematoma, whereas the risk is one in 6000 for patients with no skull fracture or impairment of consciousness.

In the present study, the incidence of abnormal radiographic findings in each GCS group was higher than that reported by other investigators. This is most likely caused by the higher percentage of falls and assaults in our predominantly urban population. However, other factors such as patient selection bias may exist because patients with skull fractures tend to be admitted to the hospital. This selection bias probably would not result in any significant changes in the findings of this study, but a similar study for all patients with mild head injury presenting to emergency rooms is certainly indicated.

The results of our study are in agreement with previous findings that patients admitted with a GCS score of 13, which is considered to be a mild head injury under the conventional classification, are more severely injured and tend to have a poorer outcome compared with patients having higher GCS scores. It is misleading to label all of these patients as mildly head injured because the word "mild" means not serious. The current definition using GCS scores 13 to 15 obviously lacks sensitivity in delineating the mild range of impaired consciousness; therefore, additional criteria are necessary to establish a more appropriate definition.

We propose that this definition should be divided into mild head injury and high-risk mild head injury. A classification of high-risk mild head injury implies that the patient is at risk for developing complications that may need neurosurgical intervention. Obviously, intracranial hemorrhage, no matter how small, should be considered serious. Equally, patients with persistent GCS scores of 13 and 14 should not be considered "totally normal," even though their CT scans are normal. Therefore, those patients with GCS scores of 13 or 14 and those patients with scores of 15 who exhibit acute radiographic abnormalities should be classified with high-risk mild head injury. Those patients with GCS scores of 15 and no abnormal radiographic findings should be classified with mild head injury because their injury is genuinely mild, that is, not serious (Fig. 1).

Using this new classification, our study demonstrated that no patient with mild head injury required neurosurgical intervention, whereas more than 10% of the patients in the high-risk mild head injury group received such neurosurgical intervention (Table 5). All except two (99.8%) of the patients with mild head injury achieved good outcome, and mild head injury was not the cause of severe disability in these two patients. One of the two patients was a 47-year-old man with residual hemiplegia caused by a stroke that had occurred previously and the other was a 66-year-old man who had also suffered a spinal cord injury. In the high-risk mild head injury group, 90% of the patients had good outcomes, 6.5% had moderate disability, 2.5% had severe disability, and 1% died. Using this new classification as a triage tool, most of the 959 patients with mild head injury could have been safely discharged from the emergency department, and tremendous amounts of resources could have been saved.

Similar to the classification of complicated and uncomplicated mild injuries proposed by Williams, et al., our new classification relies on radiographic findings. However, there are two major differences between their classification scheme and ours. First, we put patients with GCS scores of 13 and 14 into the high-risk mild head injury group because it has been reported that patients with a GCS score of 14 but normal skull x-ray films or CT scans developed epidural hematoma. Second, we put all patients with skull fracture, regardless of their initial GCS scores, into the high-risk mild head injury group because skull fracture was a strong risk factor for patients who developed delayed epidural hematoma, even if their initial CT scans were normal.

The goal in the care of mild head injury should be to detect and treat patients who deteriorate neurologically after a lucid period. The current classification of mild head injury determined by the GCS score alone has the drawback of misleading the treating physician and the patients and their family, because the term "mild" may give them a false sense of security. The new classification of mild head injury proposed here retains the GCS system and is therefore simple to use. More importantly, it allows...
patients with high-risk mild head injury to be identified while they are still asymptomatic. It also allows patients with genuinely mild head injuries to be safely discharged home.

References


Manuscript received November 26, 1996. Accepted in final form March 10, 1997.
Address reprint requests to: John N. K. Hsiang, M.D., Ph.D., Section of Neurosurgery, Virginia Mason Medical Center, 1100 Ninth Avenue, P.O. Box 900 X7-NS, Seattle, Washington 98111-0900.