

## Experimental and clinical studies

# Value of Skull Radiography, Head Computed Tomographic Scanning, and Admission for Observation in Cases of Minor Head Injury

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A retrospective review of 373 adult patients admitted to Harbor General Hospital between 1980 and 1984 for minor closed head injury (Glasgow coma scale 13–15) was performed to determine the benefits of skull radiography, computed tomographic (CT) scanning of the head, and admission for observation. Variables reviewed were mental status, neurological examination, presence or absence of loss of consciousness, clinical evidence of basilar skull fracture, and fracture on skull radiography. The neurological examination (including mental status and Glasgow coma scale) in the emergency room was the best predictor of subsequent deterioration or the presence of an operative hematoma. The only patients with Glasgow coma scale scores of 15 who required surgical evacuation of an extraaxial hematoma had focal neurological deficits referable to hemispheric compression, with or without an abnormal mental status. A Glasgow coma scale score of 13 or 14 places the patient at risk either of having a hematoma requiring surgery or of deteriorating. We recommend that a head CT scan be obtained on all patients with Glasgow coma scale scores of less than 15, abnormal mental status, or hemispheric neurological deficits. If no operative lesion is found on the CT scan, the patient should be admitted for observation because there is still a risk of deterioration. Those with a Glasgow coma scale score of 15, a normal mental status, and no hemispheric neurological deficit may be discharged to be observed at home by a competent observer despite basilar or calvarial skull fracture, loss of consciousness, or cranial nerve deficit. No benefit was gained from skull radiography in any group. (*Neurosurgery* 22:449–453, 1988)

**Key words:** Computed tomography, Glasgow coma scale, Head injury, Skull fracture, Skull radiography

Head injury is common in the United States. For the approximately 70% (5) of head-injured patients with apparently minor head injury (Glasgow coma scale 13–15) (4), the predictive value of skull radiography, head computed tomographic (CT) scanning, and admission for observation in identifying those patients at risk for neurological deterioration has been unclear. Several recent studies (1–4, 6–10) have documented conflicting views regarding the importance of these variables in managing patients with a Glasgow coma scale (GCS) score of 13, 14, or 15. Consequently, we performed a retrospective review of 373 patients to determine the benefits of skull radiography, head CT scanning, and hospital admission for observation.

### METHODS

This study was based on a retrospective review of 373 adult patients admitted to Harbor General Hospital between 1980 and 1984 for minor head injury (GCS 13 to 15) (Table 1). Demographic, historical, physical examination, and radiological data, operative and medical therapies, and sequelae, outcome, and discharge diagnoses were reviewed.

Demographic data collected included age, sex, dates of hospitalization, and time period between injury and presentation. To be included in the study, the patient must have been 16 years of age or older and must have presented to the emergency room within 24 hours of the time of injury.

Historical data included whether consciousness was lost and the presence of other injuries associated with the cause of head injury. Physical examination data included neurological examination including GCS score and the mental status (a normal mental status was defined as a clear indication in the patient's medical record that he or she was alert with no abnormality in the level of consciousness, oriented to person, time, and place, and had no dysphasia or dyspraxia); presence and type of skull fracture (depressed/nondepressed, open/closed); and evidence of basilar skull fracture, including hemotympanum, Battle's sign, periorbital ecchymosis, cerebrospinal fluid otorrhea, or rhinorrhea.

Radiological studies reviewed included skull radiograms, head CT scans, and cerebral angiograms. These studies were obtained as thought necessary by the emergency room physicians and neurosurgical consultants. No standard protocol was followed in the decision to obtain radiographic studies.

Operative therapy (type, response to, and time from injury to operation) was examined. Medical therapies utilized included hyperventilation, hyperosmolar agent, pentobarbital coma, steroids, and intracranial pressure (ICP) monitoring.

### RESULTS

#### *GCS 13*

Thirty-four patients each had a GCS score of 13. Of the 34 patients, 31 were male and 3 were female. Men ranged in age

TABLE 1  
Total Patients Reviewed

	No. Patients with:		
	GCS 15	GCS 14	GCS 13
Total number	236	103	34
Loss of consciousness (by history)	160	61	27
Basilar skull fracture	86	27	13
Skull fracture/skull x-ray film	72/201	28/88	14/30
Hemispheric deficit	5	4	2
Operative hematoma	2	3	0
Deteriorated	0	1	2

from 18 to 80 years (mean = 28), and women ranged in age from 22 to 30 years (mean = 23).

Twenty-seven (79%) had a history of loss of consciousness. Twelve patients (35%) had severe associated injuries.

Thirteen patients (38%) had basilar skull fractures. Seven patients (21%) had focal neurological deficits: dysphasia (1 case), upgoing plantar response (1 case), 3rd cranial nerve palsy (1 case), 6th nerve palsy (1 case), central 7th nerve palsy (2 cases), peripheral 7th nerve palsy (1 case), and 8th nerve dysfunction by bedside examination (1 case).

Thirty patients (88%) underwent skull radiography, and 21 patients (62%) had head CT scans. Fourteen patients (41% of those who had skull radiographs) had skull fractures. Positive CT findings in 13 of the 21 patients (62%) who had head CT scans were: pneumocephalus (2 cases), diffuse cerebral edema (1 case), cerebral contusion (8 cases), subdural hematoma (2 cases), and subarachnoid hemorrhage (1 case).

#### GCS 14

One hundred three patients each had a GCS score of 14. Of the 103 patients, 90 were male and 13 were female. Men ranged in age from 19 to 79 years (mean = 31), and women ranged in age from 18 to 78 years (mean = 34).

Sixty patients (59%) had histories of loss of consciousness. Thirty-four patients (33%) had severe associated injuries.

Twenty-seven patients (26%) had basilar skull fractures. Twelve patients (12%) had focal neurological deficits: 3rd cranial nerve palsy (2 cases), bilateral 4th nerve palsies (1 case), 6th nerve palsy (1 case), central 7th nerve palsy (2 cases), peripheral 7th nerve palsy (1 case), diminished 8th nerve function by bedside examination (4 cases), aphasia (1 case), frontal lobe syndrome (1 case), and hemiparesis (1 case).

Eighty-eight patients (85%) underwent skull radiography, and 49 patients (48%) had head CT scans. Twenty-eight patients (27% of those who had skull radiographs) had skull fractures. Positive CT findings in 20 of the 49 patients (41%) who had head CT scans were: pneumocephalus (1 case), diffuse cerebral edema (4 cases), cerebral contusion (8 cases), subdural hematoma (4 cases), epidural hematoma (3 cases), intracerebral hematoma (1 case), and subarachnoid hemorrhage (1 case).

#### GCS 15

Two hundred thirty-six patients each had a GCS score of 15. Of the 236 patients, 182 were male and 54 were female. Men ranged in age from 18 to 64 years (mean = 31), and women ranged in age from 19 to 80 years (mean = 36).

One hundred forty patients (68%) had histories of loss of

consciousness. Sixty-four patients (27%) had severe associated injuries.

Eighty-six patients (36%) had basilar skull fracture. Twenty-eight patients (12%) had focal neurological deficits: 1st cranial nerve dysfunction (3 cases), 2nd nerve dysfunction (3 cases), 3rd nerve palsy (2 cases), 4th nerve palsy (1 case), 6th nerve palsy (1 unilateral, 1 bilateral), central 7th nerve palsy (3 cases), peripheral 7th nerve palsy (6 cases), 8th nerve dysfunction by bedside testing (16 unilateral, 1 bilateral), and aphasia (3 cases).

Two hundred one patients (85%) had skull radiographs, and 59 patients (25%) had head CT scans. Seventy-two patients (31% of those who had skull radiographs) were found to have skull fractures. Positive CT findings in 20 of the 59 patients (34%) who had head CT scans were: pneumocephalus (4 cases), diffuse cerebral edema (1 case), cerebral contusion (11 cases), epidural hematoma (4 cases), subdural hematoma (2 cases), intracerebral hematoma (2 cases), and subarachnoid hemorrhage (3 cases).

#### Case summaries of patients who deteriorated or had hematomas

These eight cases are summarized in Table 2.

*Case 1.* A 34-year-old man came to the emergency department 72 hours after being struck on the head with a pool cue. He complained of headache, poor memory, and difficulty with speech. Neurological examination revealed bilateral periorbital ecchymoses and a GCS score of 15, with an expressive aphasia. Skull radiographs showed a linear fracture, and a CT scan of the head showed a left frontal acute epidural hematoma with an underlying contusion. A craniotomy confirmed the acute epidural hematoma, which was evacuated. The patient made a complete recovery.

*Case 2.* A 46-year-old man was involved in a motor vehicle accident and was brought immediately to the hospital. Examination showed a left hemotympanum, a GCS score of 15, a normal mental status, and an upgoing plantar response on the right. Skull radiographs showed a linear fracture, and a head CT scan showed an acute epidural hematoma on the left. The patient had a slight deterioration in mental status and was taken to the operating room for evacuation of the hematoma. He subsequently made a full recovery.

*Case 3.* A 40-year-old woman with a history of alcoholism was brought to the hospital after a fall. She was disoriented, with a GCS score of 14. Neurological examination was significant for right 3rd and 4th cranial nerve palsies, right hemiparesis, and an upgoing plantar response on the left. A head CT scan showed a right-sided acute subdural hematoma. Skull roentgenography was not performed. A craniotomy was performed and the acute subdural hematoma was evacuated. The patient had a moderate long term disability.

*Case 4.* A 65-year-old man who had apparently been beaten was found in an alley. He initially had a GCS score of 14, but his condition rapidly deteriorated in the emergency department to a GCS score of 4 with bilateral decerebrate posturing, midposition and fixed right pupil, diffusely hyperactive reflexes, and upgoing plantar responses. No skull radiographs were obtained. A head CT scan showed a right-sided acute subdural hematoma, which was evacuated after craniotomy. He recovered consciousness, but suffered a severe alteration of cognition.

*Case 5.* A 22-year-old man who was involved in a motor vehicle accident was brought immediately to the hospital by paramedics. Upon arrival, he was combative and disoriented, with a GCS score of 14. Right periorbital ecchymosis was present. Skull radiographs showed a linear fracture. A head

TABLE 2  
Summary of Clinical Data of Patients Who Deteriorated or Had Hematomas<sup>a</sup>

Case	Age	Sex	Cause of Injury	GCS	Focal Deficit	Skull Fracture	CT Findings	Treatment/Outcome
1	34	M	Blow	15	Expressive aphasia	+	Left EDH	Craniotomy for EDH; full recovery
2	46	M	MVA	15	Right upgoing plantar response	+	Left EDH	Craniotomy for EDH; full recovery
3	40	F	Fall	14	Right 3rd and 6th nerve palsies; right hemiparesis left upgoing plantar response	ND	Right SDH	Craniotomy for SDH; mild postoperative tetraparesis
4	65	M	Blow	14 → 4 <sup>b</sup>	Decerebrate bilaterally; fixed right pupil	ND	Right SDH	Craniotomy for SDH; severe memory deficit
5	22	M	MVA	14	None	+	Right EDH	Craniotomy for EDH; full recovery
6	36	M	MVA	14	None	+	Right ICH, contusion	Deteriorated 12 hr after injury; craniotomy for ICH; full recovery
7	21	M	MVA	13	None initially; 5 d after injury, right hemiparesis	ND	Initially normal; 5 d after injury, left SDH	Craniotomy for SDH; persistent right hemiparesis
8	41	M	Blow	13	None	+	Bifrontal contusions; bifrontal SAH	Deteriorated 24 hr after injury; medical therapy of increased ICP; died 12 d after injury

<sup>a</sup> Abbreviations: EDH, epidural hematoma; MVA, motor vehicle accident; GCS, Glasgow coma scale; SAH, subarachnoid hemorrhage; ICH, intracerebral hematoma; SDH, subdural hematoma; ND, not obtained.

<sup>b</sup> Arrival GCS deteriorated to 4 while in emergency department.

CT scan showed a right-sided acute epidural hematoma. A craniotomy was performed, and the hematoma was evacuated. The patient made a full recovery.

*Case 6.* A 36-year-old man was involved in a motor vehicle accident. He had a GCS score of 14. Neurological examination was nonlocalizing. Skull radiographs showed a linear skull fracture. A head CT scan showed a right temporal intracerebral hematoma and right parietal contusion with a right-to-left shift. The patient was observed in the hospital for 12 hours before his mental status deteriorated. He was taken to the operating room for evacuation of the intracerebral hematoma. He subsequently made an excellent recovery.

*Case 7.* A 21-year-old man was involved in a motor vehicle accident. Upon arrival at the emergency department, he was confused and somnolent, with a GCS score of 13. Neurological examination was nonlocalizing. Skull radiographs were not obtained. A head CT scan was unremarkable. He was taken to the operating room for repair of facial and oral injuries. On the 5th postoperative day, he was still disoriented and developed a right hemiparesis. Repeat head CT scanning revealed a left acute subdural hematoma, which was evacuated by craniotomy. Postoperatively, his mental status improved, but his right hemiparesis persisted.

*Case 8.* A 41-year-old man was brought to the hospital after suffering a blow to the head. He was disoriented, with a GCS score of 13. He had a right hemotympanum. Neurological examination was nonlocalizing. Skull radiographs showed two linear fractures. A head CT scan showed bifrontal contusions and a small bifrontal subarachnoid hemorrhage. Within the next 24 hours, he became comatose with a dilated

right pupil and decerebrate posturing. The findings of repeat CT scanning were unchanged. An ICP monitor was placed and showed an ICP elevated to 25 to 30 mm Hg. The patient was treated with hyperventilation, dexamethasone, mannitol, and barbiturate coma, but never regained consciousness. He died of pneumonia on the 12th day after his injury.

## DISCUSSION

In performing this study, we attempted to determine which criteria could predict the presence of an operative intracranial hematoma or a posttraumatic deterioration in neurological status. Either of these complications of head injury necessitates admission to the hospital. Patients with the predictive factors will need to be admitted to the hospital, and the remainder of the patients could be observed at home. Establishing these predictive factors is of medical, social, and economic value.

Of the 236 patients with a GCS score of 15, the only 2 who proved to have operative intracranial hematomas had focal deficits on their neurological examination referable to a hemispheric lesion. In addition, 1 of these patients had an abnormal mental status manifested by poor memory. None of the remaining 234 patients deteriorated while in the hospital under observation. Therefore, with a GCS score of 15, a normal mental status, and a normal neurological examination in the emergency room, the chance of a patient developing a serious complication from a minor head injury is exceedingly small. These patients may be observed at home by a competent observer. In the GCS 15 group, if either an abnormal

mental status or a focal neurological deficit is present, an emergency CT scan should be obtained. If no operative lesion is present, the patient should be admitted to the hospital for observation. We are not concluding that a normal neurological examination (including normal mental status) eliminates the possibility of a complication; there are many anecdotal stories of a patient being neurologically normal in the emergency room after a minor head injury only to deteriorate later. We are recommending that these patients be observed at home because the chance of this deterioration is so small.

If a patient's GCS is 13 or 14, we recommend that a CT scan of the head be obtained emergently. If this scan is unremarkable, the patient should be admitted for observation. This is based on the finding that 3 of the 137 patients with GCS scores of 13 or 14 had operative hematomas and another 3 had significant deterioration while in the hospital under observation.

Patients with skull fractures on radiography were at greater risk of having a hematoma or deteriorating. This information, however, does not improve upon the predictive value of the neurological examination. None of the patients with GCS 15, normal mental status, and normal neurological examination had operative hematomas or consciousness deterioration, so skull radiography may be superfluous. The two patients with GCS scores of 15 who had operative hematomas had focal neurological deficits referable to the location of the hematoma, and one had an abnormal mental status. The information gained by skull radiography would not have altered the management course of either of these patients. If a patient is found to have a GCS score of less than 15, he is at risk for a hematoma or deterioration regardless of the presence or absence of a skull fracture, and, therefore, a CT scan should be obtained. Data from skull radiography again would be superfluous.

There has been controversy in the recent neurosurgical literature about the indications for diagnostic tests and admission for observation in cases of minor head injury. The question of whether to admit patients to the hospital based on the presence or absence of a skull fracture has been addressed in several studies (2-4, 6, 8, 9). Most studies conclude that the presence of a skull fracture increases the probability that a patient will have an intracranial hematoma or deteriorate (3, 4, 6, 8, 9). This, however, is not an indication to obtain skull radiograms because patients both with and without skull fractures may be at serious risk for deterioration and, with clinical neurological examination, skull radiography is redundant. For example, Mendelow et al. demonstrated that the risk of a disoriented patient with a skull fracture having a hematoma was 18 times greater than the risk for a patient without a fracture (9). The disoriented patient without a fracture, however, was found to have a 1.5% chance of having an intracranial hematoma. A disoriented patient, therefore, will need a head CT scan regardless of the skull roentgenographic finding. If the CT scan is negative, the patient should be admitted for observation because of the risk of deterioration. Unfortunately, in discussing their subgroup of oriented patients, Mendelow et al. failed to describe either the GCS status or the neurological examination of their patients (9), data that are extremely important. A previous study by the same group also failed to discuss the details of the neurological examination in alert and oriented patients who developed intracranial hematomas, so it is not possible to determine whether skull radiography was indeed beneficial in that group of patients (8). Another study showed that the presence of a skull fracture increased the possibility of the patient having an intracranial hematoma, but it did not

differentiate between oriented and disoriented patients (4). Thus, the failure to consider carefully level of alertness, orientation, and neurological examination may have led to the conclusion that the presence or absence of a skull fracture would change management in minor head injury. We found that skull radiographs added nothing to the clinical data obtained from a careful neurological examination. This conclusion is supported by a study by Cooper et al., who found that, with judicious ordering of CT scans, no change in management was made based on skull radiographs (2).

Several other studies have demonstrated the safety of discharging patients with normal mental status and normal findings of neurological examination after minor head injury (1, 7, 10). They support our conclusion that these patients do not need skull radiographs or a head CT scan, but can be discharged home to be observed by a competent adult.

In a large prospective study on minor head injury by Dacey et al., several patients who presented with GCS scores of 15 either had intracranial hematomas or deteriorated while under observation in the hospital (3). Dacey et al. did not describe the details of the neurological examinations of these patients, however. Focal neurological deficits or mental status abnormalities may have been present, which would have been an indication that these patients had suffered more serious injuries than might have been suspected based on their mental status.

It cannot be overemphasized that a careful, detailed neurological examination must be done in the evaluation of minor head injury. This examination should include a GCS score and a mental status examination. The GCS is not the equivalent of the mental status examination. Indeed, a patient with a GCS score of 15 may be mildly lethargic or have a memory deficit. Findings as subtle as these or a mild paresis or reflex asymmetry may be the only clues to the presence of an operative extraaxial hematoma.

We conclude that the neurological examination (including GCS score and mental status) is the best predictor of serious complications of minor head injury. A patient with a GCS score of 15 with normal mental status and no focal hemispheric deficit may be discharged from the emergency room to be observed at home by a competent observer. Of the 234 patients in this category who were admitted to the hospital for observation, none deteriorated. In a patient with a GCS score of 15 and a focal hemispheric deficit or an abnormal mental status, a CT scan of the head should be obtained because an operative intracranial hematoma may be present. If the CT scan does not reveal an operative lesion, the patient should be admitted to the hospital for observation. If the patient has a GCS score of 13 or 14, a CT scan should be obtained. If the scan does not show an operative lesion, the patient should be admitted to the hospital for observation because a significant number of these patients are at risk of deterioration. Skull radiographs are unnecessary in the decision-making process in minor head injury because management decisions can be based on a careful neurological examination.

In proposing these guidelines to the management of minor head injury, we emphasize the importance of careful clinical evaluation of these patients. The physician should not allow a management algorithm to replace the exercise of clinical judgment. For example, if a patient with a GCS score of 15, normal mental status, and nonfocal neurological examination complains of severe headache or nausea and vomiting, a CT scan or admission for observation may be warranted. As in all aspects of medicine, a patient must be evaluated and



managed on an individual basis and algorithms should be used to guide rather than to dictate management.

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#### COMMENTS

Feuerman et al. have provided an interesting retrospective review of the clinical evaluation of a large number of adult patients presenting to the emergency room with minor closed head injuries. These data are important because the patients have been assessed with respect to their Glasgow coma scales,

which are currently commonly used in most emergency rooms. In addition, the sensitivity and specificity of the various diagnostic tests commonly used have been evaluated. Again, skull radiographs were found not to be of diagnostic benefit and mental status was found to be the best predictor of subsequent deterioration. The authors have thus provided the data supporting their guidelines for performing cranial CT scans on all patients with abnormal mental status or hemispheric neurological deficits. In addition, guidelines with respect to admission and overnight observation have also been provided. This report is important to all physicians who care for head-injured patients, especially those affiliated with emergency rooms.

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The authors have provided critical information in the evaluation and management of patients with minor head injury. Previous authors have commented on the association of skull fractures and intracranial hematomas without specifying the importance of the neurological examination. Patients have been categorized by Glasgow coma score (GCS) without further subdivision regarding degree of disorientation, lethargy, etc. Feuerman and colleagues have documented that patients with a GCS of 15 and with a "normal mental status" are at extremely low risk of developing complications after head injury. In contrast, patients with head injury characterized by GCS scores of 13 and 14, plus those patients oriented to time, person, and place, following commands, opening eyes spontaneously (i.e., GCS 15), but who are somewhat lethargic and not thinking clearly, are at risk for significant intracranial complications. The authors rightly recommend CT scanning and admission of these patients to minimize their risk of deterioration from significant intracranial lesions that might be treated appropriately by operation or active nonsurgical therapy. This report thus provides a basis for obtaining CT scans and admitting selected patients with "minor head injury;" it also suggests a rational basis for discharge home for some patients, avoiding unnecessary CT scanning and skull roentgenography.

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