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Computed Tomography and Magnetic Resonance Imaging of Mild Head Injury – Is it Appropriate to Classify Patients with Glasgow Coma Scale Score of 13 to 15 as "Mild Injury"?

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Summary

Objective. The purpose of this study is to examine the relation between Glasgow Coma Scale (GCS) score and findings on computed tomography (CT) and magnetic resonance (MR) imaging of patients with mild head injury presenting GCS scores between 13 and 15.

Methods. Data were collected from all consecutive patients with mild head injury who were referred to our hospital between July 1 and October 31, 1999. All patients were recommended to undergo CT and MR imaging examinations. Patients younger than 14 years of age were excluded.

Results. Ninety patients were recruited into this study. CT scans were obtained in 88 patients and MR imaging were obtained in 65 patients. Of these 90 patients, 2 patients scored 13 points, 5 scored 14 points and 83 (92.2%) 15 points. Patients with GCS score of 13 points demonstrated parenchymal lesions on both CT and MR imaging. Those with 14 points revealed absence of parenchymal abnormality on CT, but presence of parenchymal lesions on MR imaging. Patients in advanced age (chi square test, $p < 0.0001$), and those with amnesia ($p = 0005$, not significant), although scoring 15 points, revealed a tendency to abnormal intracranial lesions on CT scans.

Conclusion. It is doubtful whether patients with GCS score 13 should be included in the mild head injury category, due to obvious brain damage on CT scans. MR imaging should be performed on patients with GCS score 14, since the parenchymal lesions are not clearly demonstrated on CT scans. Even if patients scored GCS 15, patients with amnesia or of advanced age should undergo CT scans at minimum, and MR imaging when available.

Keywords: CT scans; Glasgow Coma Scale; mild head injury; MR imaging.

Introduction

Mild head injury is a common presentation in emergency departments with favorable prognosis [6]. However, especially in the aged patients, memory disturbance, progression of dementia, and deterioration of concentration may occur after mild head injury, which may cause difficulty in daily living [2]. Thornhill reported that the incidence of disability was higher than expected in young people and adults admitted to hospital with a mild head injury [8]. Historically, patients with Glasgow Coma Scale (GCS) 13 to 15 were first grouped together in the work of Rimel and colleagues and the term they used was "minor head injury" [7]. There has been quite a lot of variation since then. Although the definition of minor or mild head injury in the medical literature has been confusing, the current generally accepted definition of mild head injury is based on GCS scores of 13 to 15, regardless of clinical features [1, 3, 4]. Therefore, perpetuation of grouping by GCS 13 to 15 has the important merit of comparisons with most previous work. There is only one previous report of mild head injury with cohort study [8]. The purpose of our study is to investigate the relationship between GCS score and neuro-imaging studies in mild head injury. The presence or absence of transient amnesia was investigated in the patients with GCS scores 13 to 15 and compared with results of neuro-imagings (CT and MR imaging).

Clinical Material and Methods

Data were collected from all of the consecutive patients with mild head injury referred to the Department of Neurosurgery of Naruto Hospital, Chiba, Japan between July 1 and October 31, 1999. Naruto Hospital is the only neurosurgical center in the area serving a population of 180,000. Almost all the patients with head injury in this region are referred to this hospital. Patients younger than 14 years of age were excluded. GCS scoring, neurological examinations, and medical history inquiries were performed by the neurosurgeons. The patient's GCS and neurological examination were assessed at the time of arriving at the hospital. All patients were given a choice

Table 1. *Distribution of Age and GCS Score of 90 Consecutive Head Injury Patients with Glasgow Coma Scale (GCS) Scores of 13 to 15*

Age distribution (years)	GCS score			
	13	14	15	Total
~19	0	1	29	29
20–39	1	1	22	24
40–59	0	0	21	21
60–79	1	2	11	14
80~	0	1	0	1
Total	2	5	83	90

to undergo CT and MR imaging examinations at initial medical examination.

The CT scan used was GE9800 (General Electric Medical Systems), and MR imaging was performed on GE signa advantage 1.0T, using axial T1, T2 weighted, fluid-attenuated inversion recovery (FLAIR) images and coronal T2 weighted images within 2 weeks after head injury.

Results

During July 1 and October 31, 1999, the total number of patients with head injury were 116 cases. The number of patients over fourteen years and GCS score 13 to 15 was 90 and all were recruited into this study, including 45 males (50%) and 45 females (50%), with age range of 13 to 80 (mean 35.5 years). Table 1 categorizes the patients' gender and mean age by GCS score. CT scans of 88 patients (97.8%) were obtained within 24 hours from head injury. Two patients who refused CT scan and underwent only MR studies were included in this study. MR imaging were obtained within 14 days, mean 10.5 days after head injury in 65 patients (72.2%). Of the 90 patients, 2 (2.2%) patients scored 13 points, 5 (5.6%) scored 14 points and 83 (92.2%) scored 15 points.

GCS Score and Clinical Features of Patients

a) GCS score 13

Two patients scored GCS 13.

Case 1

A 61-year-old male fell down backwards while taking a walk and hit the occipital area. Upon arrival to the emergency room, his GCS score was 13 (E3, M6, V4), and there was no focal sign. A CT scan revealed bifrontal contusion and interhemispheric subarachnoid hemorrhage (Fig. 1a). MR imaging performed 3 days later confirmed the same findings (Fig. 1b).

Case 2

A 22-year-old female fell from her bicycle due to a traffic accident and hit her head. At the emergency room, her GCS score was 13 (E4, M6, V3). CT scan and MR imaging on admission demonstrated bifrontal contusion (Fig. 2a and 2b).

The two patients with GCS score 13, presented obvious parenchymal lesions on both CT scan and MR imaging.

b) GCS score 14

Five patients scored GCS 14 (Table 2).

CT findings were normal in one patient and abnormal in 4 patients. Abnormal CT findings revealed were intracranial air, subdural hematoma, subarachnoid hemorrhage and brain contusion in each respective patient (extraaxial lesion in 3, parenchymal lesion in 1).

Extra-axial lesions were common and contusions occasional in CT findings: however, all 5 patients revealed parenchymal lesions on MR imaging. Characteristic CT and MR imaging are presented.

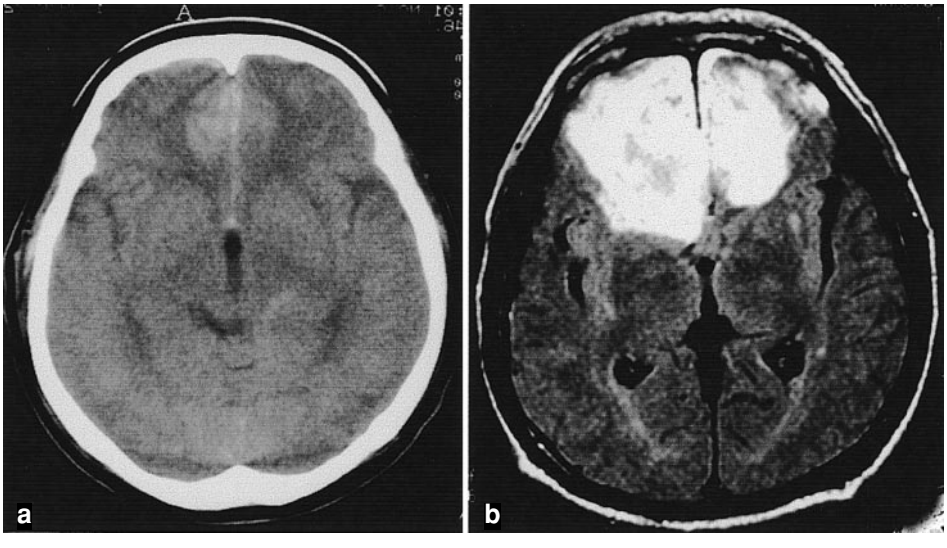

Fig. 1. Computed tomography (CT) scan revealed bifrontal contusion and interhemispheric subarachnoid hemorrhage (a). Magnetic resonance (MR) imaging was performed 3 days later, and showed the same finding as those of CT scan (b)

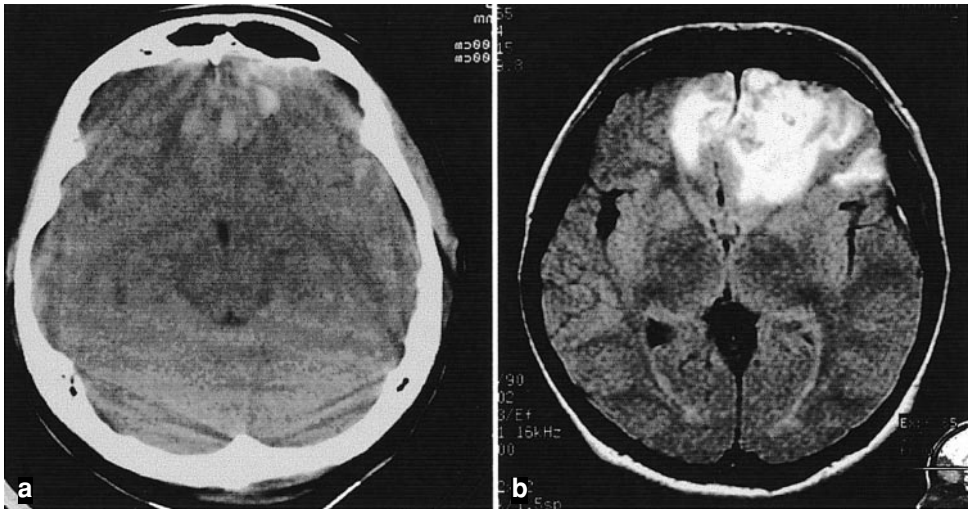

Fig. 2. Both CT scan (a) and MR imaging (b) on admission demonstrated bifrontal contusion

Table 2. *CT and MR Imaging Findings of the Patients with GCS Scores of 13 and 14*[a]

Case	CT	MRI
1	bifrontal contusion	bifrontal contusion
2	bifrontal contusion	bifrontal contusion
3	normal	lateral ventricule wall contusion
4	intracranial air	frontal lobe contusion
5	acute SDH	temporal lobe contusion
6	SAH	frontal lobe contusion
7	frontal lobe contusion	frontal lobe contusion

[a] *CT* Computed tomography; *MR imaging* magnetic resonance imaging; *SDH* subdural hematoma; *SAH* subarachnoid hemorrhage.

Case 3

A 62-year-old female pedestrian was hit by a car and hit her head when she fell. Upon arrival at the emergency room, her GCS score was 14 (E4, M6, V4), and she had post-traumatic amnesia for 3 hours. No other neurological signs were found. A CT scan showed no abnormal findings (Fig. 3a). FLAIR imaging at day 3 showed a small high signal lesion in the left lateral ventricle wall (Fig. 3b), although not clear on T2 weighted image (Fig. 3c), which had disappeared on day 30 (Fig. 3d).

Case 4

A 29-year-old female fell from her bicycle during a traffic accident and hit her head. At the emergency room, her GCS score was 14 (E4, M6, V4), and she had post-traumatic amnesia for 1 hour. A CT scan on admission revealed subarachnoid hemorrhage, but no obvious brain contusion (Fig. 4a). However, MR imaging at day 5 revealed bifrontal contusion (Fig. 4b).

c) GCS score 15

Of 83 patients, mean age was 36.2 years (range 15 to 78), with GCS score 15, eighteen patients presented with retrograde amnesia. Abnormal CT findings were revealed in 4 of the 18 patients with amnesia, but in only 2 of the 63 amnesia-free patients, total 6 patients with abnormal CT findings (Table 3). Between abnormal CT scan findings and presence of amnesia, patients with presence of amnesia had a tendency to abnormal CT findings, but statistical significance was not established ($\chi 2 = 7.7$, $p = 0.005$, chi square test). Looking at age and abnormal CT findings, 2 patients showed abnormal findings aged under 60 years, seventy cases were normal. Among the over 60 year olds (11 patients), age ranged from 45 to 78 years, four cases showed abnormal CT findings. Between abnormal CT findings and age (over 60 years old or under), statistical significance was established ($\chi 2 = 16.5$, $p < 0.0001$, chi square test). CT findings of these 6 cases were all extra-axially abnormal lesions: 3 subarachnoid hemorrhage and 3 subdural hematoma. Parenchymal lesions were revealed on MR imaging in 2 cases.

Characteristic CT and MR imaging are presented.

Case 11

A 75-year-old female pedestrian was involved in a traffic accident and suffered from loss of consciousness and transient amnesia. Upon arrival at the emergency room, her general neurological examination was normal. A CT scan revealed right subdural hematoma (Fig. 5a) and MR imaging on day 4 revealed a right temporal contusion (Fig. 5b).

Case 12

A 77-year-old female fell from her bicycle and hit her head without subsequent loss of consciousness or amnesia.

She was free of neurological deficits. A CT scan revealed thin right subdural hematoma (Fig. 6a) and MR imaging at day 5 revealed a right temporal contusion (Fig. 6b).

Patients with amnesia had tendency of abnormal findings on CT scan, but it was not statistically significant ($p = 0.005$). Patients of advanced age (over 60 years), even with a GCS score of 15, revealed statistically significant ($p < 0.0001$) incidence of abnormal findings on CT scans.

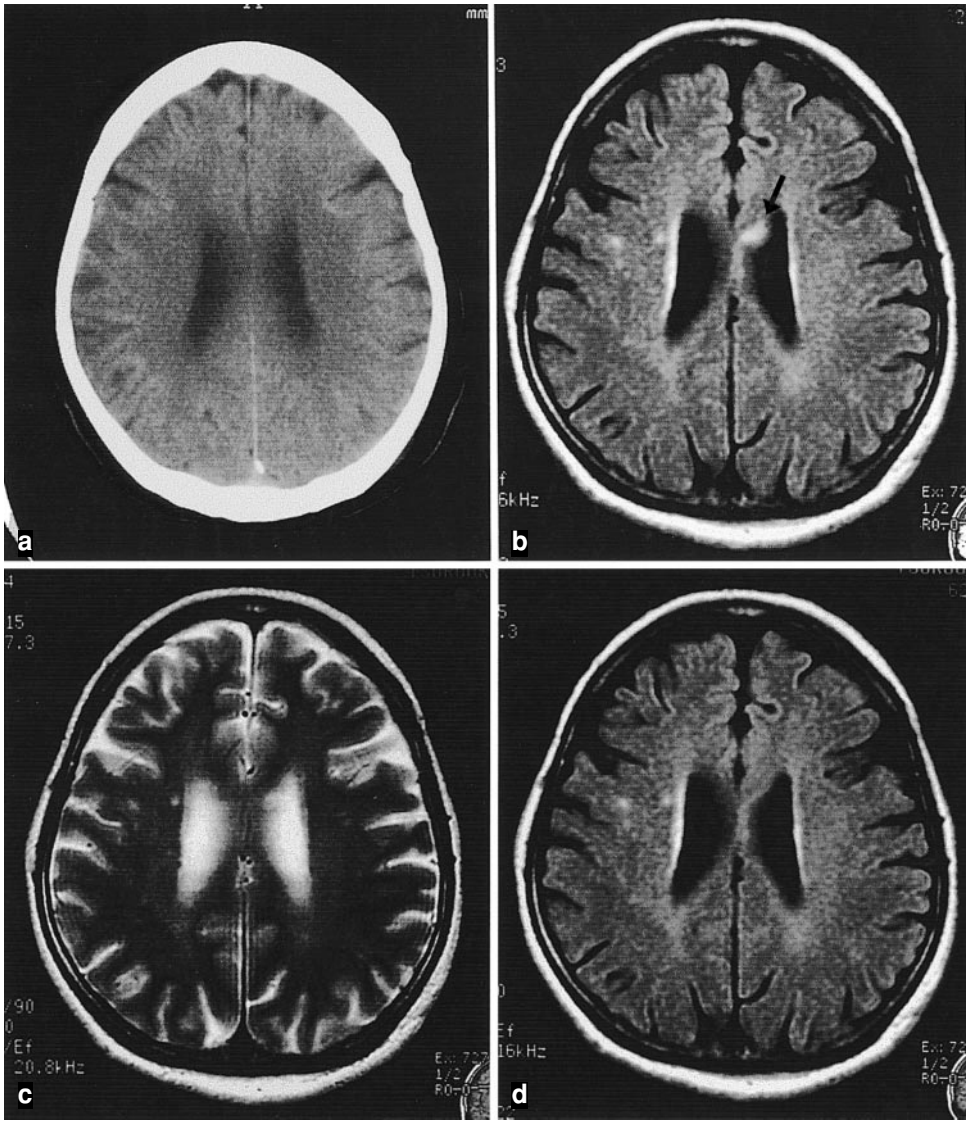

Fig. 3. CT scan showed no abnormal findings (a). MR (FLAIR) imaging on Day 3 showed a small high signal lesion in the left lateral ventricle wall (arrow) (b). This lesion was not clear on T2 weighted imaging (c). It disappeared on FLAIR imaging at Day 30 (d)

Summary of Results

In the two cases of patients with GCS score 13, parenchymal lesions were clearly demonstrated on CT and MR imaging. Those with GCS score 14 (five patients) revealed no clear parenchymal abnormality on CT scans, but demonstrated obvious parenchymal lesions on MR imaging. In the patients with GCS score 15, patients with amnesia had a tendency to abnormal CT findings. Patients of advanced age (over 60 years), even with a GCS score of 15, revealed a significant incidence of intracranial lesions on CT or MR imaging.

Discussion

The generally accepted definition of mild head injury is currently based on Glasgow Coma Scale (GCS) scores, in which scores of 13 to 15 are classified as mild head injury [1, 3, 4]. However, an increasing number of recent reports have highlighted sequelae, such as memory disturbance, progression of dementia, or deterioration of the power of concentration, resulting from minor head injury [2, 8]. Thornhill *et al.*, in a prospective cohort study, concluded that the incidence of disability in adults admitted with a head injury is

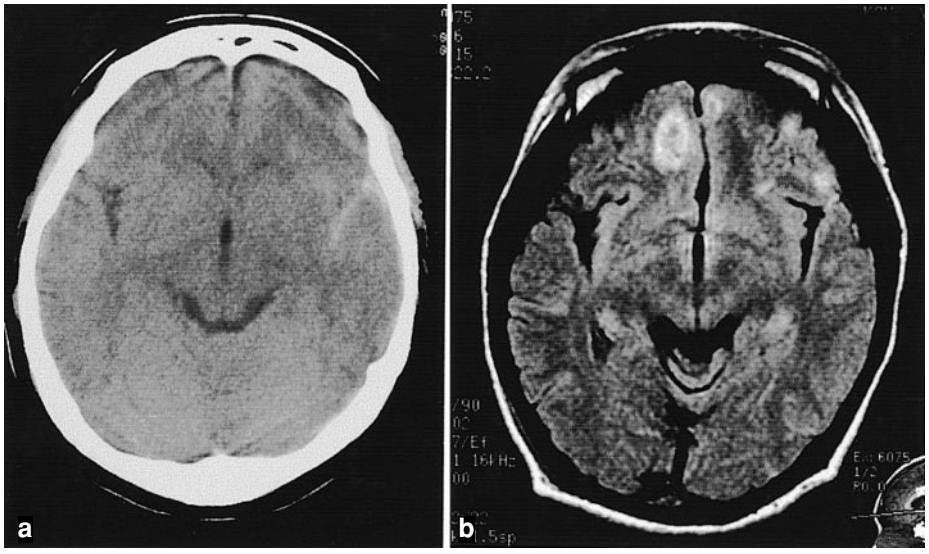

Fig. 4. CT scan on admission showed subarachnoid hemorrhage, but showed no obvious brain contusion (a). However, MR imaging of Day 5 showed bifrontal contusion (b)

Table 3. *Patients with GCS Score 15; 6 Patients Presented Abnormal CT Findings*[a]

Case	Age (yrs)	Amnesia	CT findings	MRI findings
8	45	−	SAH	not performed[b]
9	56	+	SAH	not performed[b]
10	72	+	SAH	normal
11	75	+	SDH	contusion
12	77	−	SDH	contusion
13	78	+	SDH	normal

[a] *GCS* Glasgow Coma Scale; *CT* computed tomography; *SAH* subarachnoid hemorrhage; *SDH* subdural hematoma.
[b] Not performed, Patients refused to take MR imaging examination.

higher than expected, and in the large number of patients admitted to hospital with mild head injury, that reflects the high rate of sequelae previously unrecognized [8]. The findings of an abnormality of imaging of this kind in a patient may be important in two different ways. The first of these is in the acute stage, when a lesion that is potentially surgically significant is detected allowing its early removal before clinical deterioration and leading to a potentially improved outcome. Second, other abnormalities which are of no surgical relevance may still be important in providing

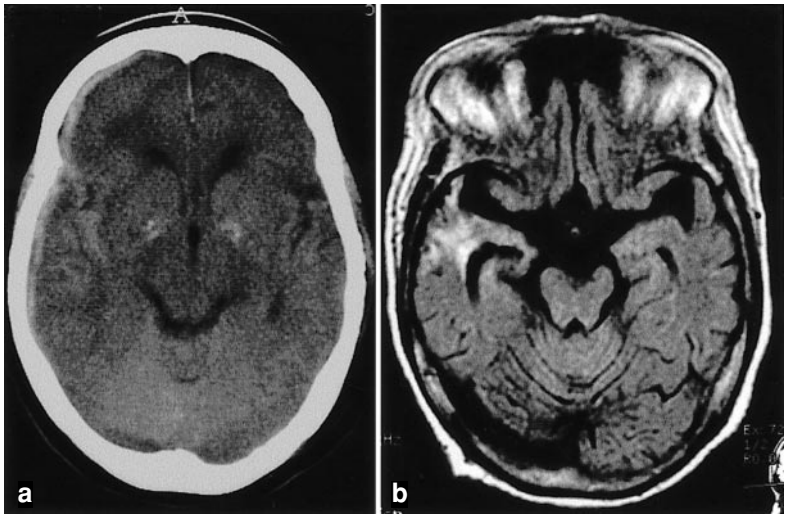

Fig. 5. CT scan revealed a right subdural hematoma (a), and MR imaging on Day 4 showed a right temporal contusion (b)

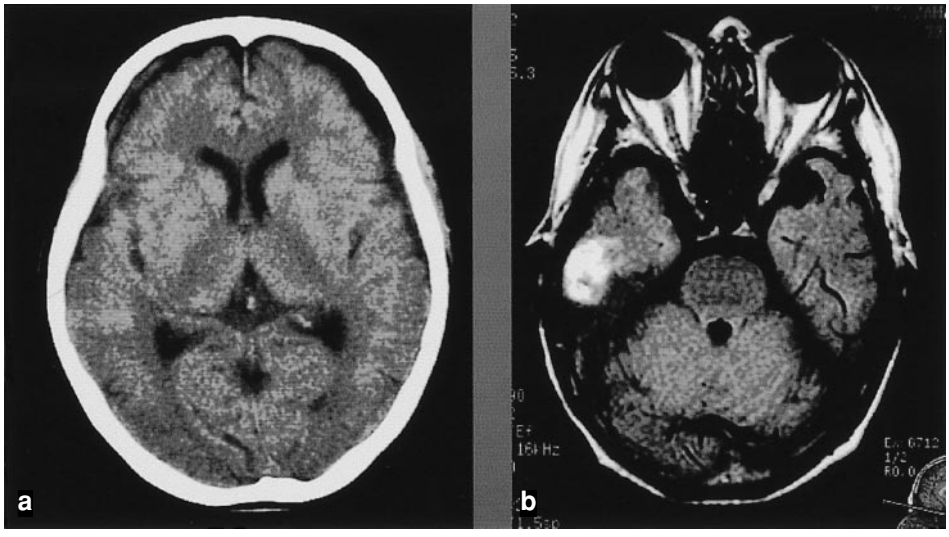

Fig. 6. A CT scan demonstrated a thin right subdural hematoma (a). MR imaging on Day 5 showed a right temporal contusion (b)

evidence of brain injury that significant at a later stage. A large number of retrospective studies on CT abnormality due to mild head injury has been reported in recent years [3, 4, 5]. Most previous reports of patients with mild head injury have focused on the finding of lesions of potential early significance [3, 5]. Gomez *et al.* [3] reported that patients with GCS 13 to 14 had increased incidence of abnormal CT findings and significantly higher incidence of delayed neurological deterioration. Patients with loss of consciousness or post-traumatic amnesia, even with a GCS score of 15, showed a high incidence of intracranial lesions. These findings coincided with our results. There was an unusually high population in our study of females (50%) who in most series account for only 20% of subjects [3, 5]. The reason was probably that our study was carried out as a prospective hospital based study. Jeret *et al.* [5], studied 712 patients who presented with amnesia or loss of consciousness after head trauma and who had a GCS score 15, and concluded that intracranial lesions cannot be excluded clinically. Such lesions are detected by CT scanning, from the point of acute stage management, MR imaging is not necessarily carried out on all patients with GCS 14. But from the point of view of late stage management, especially the cases with GCS 14, it was demonstrated that even when CT scans revealed no clear parenchymal abnormality, only MR imaging revealed obvious parenchymal lesions. Although further study will be needed to define the relationship between the lesions shown by MR imaging and sequelae at a later stage, according to our results, it seems preferable that MR imaging should be performed on patients with GCS score 14, to confirm parenchymal lesions. Reports of MR imaging of mild head injury are scarce. Van der Naalt *et al.* [6], who reported MR imaging and CT in mild to moderate head injury, concluded that abnormalities detected with MR imaging were associated with poor outcomes. We performed both CT scan and MR imaging in the majority of this group of patients limited to mild head injury. We have found that MR imagings were abnormal in patients with GCS 13 (2 cases) and 14 (5 cases), and were more likely to be so in elderly patients with GCS score 15.

Concerning with Case 3 who presented a transient abnormal finding on FLAIR imaging, Wakamoto *et al.* [9], examined cases of mild head trauma with transient amnesia by FLAIR imagings and detected parenchymal lesions, which were similar to MR findings in this Case. They reported that, they suspect those lesions to be brain edema or mild contusion without hemorrhage. Although undetectable on CT or conventional MR imaging, they were detectable on FLAIR imaging. Since those lesions often appear near the fornix, the existence of a relationship between this lesion and sequelae, such as memory disturbance after mild head injury, is suspected, although long term and further investigations are required.

Conclusion

It is doubtful that patients with GCS score 13 should be included in the so-called mild head injury group, due to obvious brain contusion on CT scans and MR imaging. MR imaging should be performed on patients with GCS score 14, since their parenchymal lesions are undetectable solely on CT scans. Even if GCS scores are 15, patients with advanced age should undergo CT scans at minimum and MR imaging, if available. Long term follow-up is necessary for patients with GCS scores 13 to 15 to clarify the relationship between abnormalities detected on CT and/or MR imaging and disability.

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Comments

This is an interesting study and contains useful information. It adds to the increasing recognition that patients with this category in head injury can have structural lesions in the brain in the early stage as well as significant sequelae at follow up.

A. Maas

Quite a few publications, reports and presentations over the past year have emphasized that so called mild TBI is not so mild, that many patients show abnormalities on CT and/or MRI and that outcome is not always so good as expected. Attempts have been made to identify risk factors for potentially more severe pathology and less favorable course of the disease. As such this manuscript high lights the authors experience in this regard, what they have done is add to the already growing evidence that this grouping and the term mild injury should not be interpreted as meaning negligible brain injury in either the acute or late stage. Their most important conclusion, if statistically supported, may be that amnesia and advanced age (either separately and independently or in combination?) are reliable indicators of an increased likelihood of an abnormal scan in the patient with a GCS of 15.

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