Microbleeds as a Prognostic Factor for Acute Subdural Hematoma

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Abstract

This study investigated the frequency of poor outcome at discharge of acute subdural hematoma (SDH) patients with and without microbleeds. We retrospectively examined the records of 37 patients with acute SDH who were surgically treated with hematoma removal and received magnetic resonance (MR) imaging within 2 weeks of head injury onset. MR images were used to determine the presence or absence of microbleeds and contusional hemorrhage (CH). Patient outcome was categorized as good (moderate disability or good recovery) or poor (severely disability, vegetative state, or dead) according to the Glasgow Outcome Scale at discharge. Microbleeds were found in 23 patients (62%) and CH was found in 26 patients (70%). Fifteen patients (41%) had both microbleeds and CH. Poor outcome at discharge was more common in SDH patients with both microbleeds and CH than in SDH patients with neither microbleeds nor CH (14/15, 93% vs. 14/22, 64%; $p = 0.04$). Poor outcome at discharge was more common in SDH patients under 60 years of age with microbleeds (6/8, 75%) than patients under 60 years of age without microbleeds (0/4, 0%; $p = 0.03$). The location of the microbleed was not related to the outcome at discharge. These results suggest that the presence of microbleeds and CH on MR images may indicate poor prognosis in patients with acute SDH.

Key words: acute subdural hematoma, microbleed, contusional hemorrhage, magnetic resonance imaging

Introduction

Acute subdural hematoma (SDH) complicates approximately 20% of severe traumatic brain injuries.^{4,12,13,18} The overall mortality rate in patients with acute SDH who require surgery is 40% to 60%.^{4,13} Prognostic indicators of acute SDH are age, Glasgow Coma Scale score, pupillary reactivity, SDH volume, and midline brain shift.^{4,6,9,14} Microbleeds identified on T₂*-weighted magnetic resonance (MR) images correlate with outcome in patients with diffuse axonal injury.^{7,16,20} However, the relationship between microbleeds and prognosis in patients with acute SDH is not known. The present study investigated the relationship between microbleeds and outcome in patients with acute SDH.

Materials and Methods

We retrospectively reviewed the medical records of all patients who were admitted to the University Hospital of Kawasaki Medical School between January 2005 and October 2011 with acute SDH and who were surgically treated with hematoma removal with or without decompressive craniectomy. Patients were included in this study if they underwent MR imaging within 2 weeks of the onset of head injury. Patients who underwent MR imaging more than 15 days after SDH onset, had conservative treatment, received burr hole surgery, or were diagnosed with acute SDH in the posterior cranial fossa were excluded. The institutional ethics committee of Kawasaki Medical School approved the study protocol.

MR imaging was performed using a 1.5 T Signa Horizon, Signa EXCITE (GE Healthcare, Chalfont St. Giles, Buckinghamshire, UK) or Excelart Vantage Atlas (Toshiba Medical Systems Corp., Otawara, Tochigi) scanner. Microbleeds were diagnosed on

Fig. 1 T₂*-weighted magnetic resonance images showing microbleeds (A: arrows) and contusional hemorrhage (B: arrowheads).

axial T₂*-weighted gradient echo images obtained with a repetition time of 600–700 msec and an echo time of 20 msec, and were defined as focal areas of very low signal intensity, smaller than 10 mm in size (Fig. 1A). Contusional hemorrhage (CH) was defined as areas of very low signal intensity larger than 10 mm in size (Fig. 1B).

Patient outcome was classified according to the Glasgow Outcome Scale at discharge. Patients with moderate disability or good recovery were defined as having a good outcome. Patients with severe disability and those in a vegetative state or dead were defined as having a poor outcome. The distribution of good and poor outcomes was compared across patients with and without microbleeds, and with and without CH, using Fisher's exact test. A value of $p < 0.05$ was considered significant.

Results

We reviewed the records of 81 patients diagnosed with acute SDH who received surgical treatment with hematoma removal. Of these, 37 patients received MR imaging within 2 weeks of head injury onset and formed the sample for the current study. Clinical and demographic characteristics of these patients are shown in Table 1. The mean age of the patients was 61.8 years. Age was similar in patients with microbleeds (61.6 years) and patients without microbleeds (62.2 years, $p = 0.936$).

Microbleeds were found in 23 patients (62%) and CH in 26 patients (70%). Both microbleeds and CH were found in 15 patients (41%). Although the proportion of patients with microbleeds who had poor outcome (83%) was larger than the proportion of patients without microbleeds who had poor outcome (64%), this difference was not significant ($p = 0.19$). Similarly, although the proportion of patients with CH who had poor outcome (85%) was larger

Table 1 Patients' clinical and demographic data (N = 37)

	Number (%)	Mean $\pm$ SD
Age (year)	17–86	61.8 $\pm$ 22.1
Sex, male/female	29/8	
GCS score before surgery		7.65 $\pm$ 3.20
3–8	25 (68%)	
9–13	10 (27%)	
14–15	2 (5%)	
Time of MR imaging from injury (day)		7.9 $\pm$ 3.8
0–1	7 (19%)	
2–4	4 (11%)	
5–9	8 (22%)	
10–14	18 (49%)	
Operation side, right:left:both	18:16:3	

GCS: Glasgow Coma Scale, MR: magnetic resonance, SD: standard deviation.

Fig. 2 Outcome at discharge in patients with and without microbleeds (MBs) and contusional hemorrhage (CH). Poor outcome at discharge was more common in patients with both MBs and CH than in patients with neither MBs nor CH (* $p = 0.04$). D: dead, GR: good recovery, MD: moderately disabled, SD: severely disabled, VS: vegetative state.

than the proportion of patients without CH who had poor outcome (55%), this difference was not significant ($p = 0.06$). Of the 15 patients with both microbleeds and CH, 14 (93%) had poor outcome at discharge. This is a significantly higher proportion than that observed in patients who had either microbleeds or CH, but not both (64%, $p = 0.04$, Fig. 2). Of 12 patients aged under 60 years, eight had microbleeds. Six of these (75%) had poor outcome at discharge, whereas none of the four patients without microbleeds had poor outcome (0%, $p = 0.03$, Fig. 3).

Microbleeds were located in lobar white matter or cerebellum only ($n = 12$), in corpus callosum ($n = 8$), or in the brainstem ($n = 5$) (Fig. 4). Two patients had microbleeds in both the corpus callosum and the brainstem. The location of the microbleed was not

Fig. 3 Outcome at discharge in patients under 60 years old with and without microbleeds (MBs). Poor outcome at discharge was more common in patients with MBs than in patients without MBs (**p* = 0.03). D: dead, GR: good recovery, MD: moderately disabled, SD: severely disabled, VS: vegetative state.

Fig. 4 T₂*-weighted magnetic resonance images showing microbleeds in the lobar white matter (A: arrow), corpus callosum (B: arrowhead), and brainstem (C: arrow).

Table 2 Relationships between the location of microbleeds, contusional hemorrhage, and outcome

	Location of microbleeds		
	Lobar white matter or cerebellum	Corpus callosum	Brainstem
Total	12	8	5
Contusional hemorrhage	7 (58%)	6 (75%)	3 (60%)
Outcome			
good	1 (8%)	2 (25%)	2 (40%)
poor	11 (92%)	6 (75%)	3 (60%)

related to the outcome at discharge (Table 2).

Illustrative Case 1, patient with microbleeds and CH: An 18-year-old man was admitted to our hospital after a traffic accident. On admission, Glasgow Coma Scale score was 6 with anisocoria, and head computed tomography (CT) revealed an acute SDH (Fig. 5A, B). Decompressive craniectomy was

Fig. 5 Illustrative Case 1, an 18-year-old man who was admitted to hospital after a traffic accident. A, B: Computed tomography scans on admission showing right acute subdural hematoma. C, D: T₂*-weighted magnetic resonance images obtained 8 days after admission showing microbleeds in the corpus callosum and lobar white matter, and contusional hemorrhage on both sides of the frontal lobe.

Fig. 6 Illustrative Case 2, a 50-year-old man who was admitted to hospital after a fall. A: Computed tomography scan on admission showing right acute subdural hematoma. B: T₂*-weighted magnetic resonance image obtained 8 days after admission showing neither microbleeds nor contusional hemorrhage.

urgently performed. MR imaging performed 8 days after surgery revealed microbleeds in the corpus callosum and lobar white matter, and CH in both sides of the frontal lobe (Fig. 5C, D). The patient was moved from our hospital in a vegetative state at 95 days after surgery.

Illustrative Case 2, patient without microbleeds and CH: A 50-year-old man was admitted to our hospital after a fall. On admission, Glasgow Coma Scale score was 6 with anisocoria, and head CT revealed an acute SDH (Fig. 6A). Decompressive craniectomy was urgently performed. MR imaging performed 8 days after surgery revealed neither microbleeds nor CH (Fig. 6B). The patient was discharged with good recovery at 10 days after surgery.

Discussion

This study showed that concurrent occurrence of microbleeds and CH was related to increased likelihood of poor outcome in patients with acute SDH. In addition, patients with only microbleeds or only CH tended to be more likely to have poor outcome than patients with neither microbleeds nor CH. Age, Glasgow Coma Scale score, and pupillary reactivity are known prognostic indicators in patients with acute SDH.^{4,6)} In some studies, SDH volume and midline brain shift have also been related to poor outcome.^{4,9,14)} This study is the first to report the effect of microbleeds on prognosis in patients with acute SDH. Our results support a previous study that reported a relationship between microbleeds and prognosis in patients with moderate and severe traumatic brain injury and diffuse axonal injury.^{3,19)}

The majority of SDH cases that require surgery are complicated by associated intracranial and extracranial injuries, of which contusions and intracerebral hematomas are the most frequent.⁴⁾ In this study, contusions and intracerebral hematomas were considered CH, whereas diffuse axonal injuries and microvascular injuries were considered microbleeds. In autopsy after head injury, axonal shear-strain deformations are induced by sudden traumatic acceleration or rotational forces on the brain. The resulting injuries tend to be diffuse and accompanied by petechial hemorrhages^{1,2)} that can be detected as microbleeds on T_2^* -weighted MR images. Brain parenchymal injury markedly increases the mortality associated with SDH: SDH associated with brain parenchymal injury had a mortality of 53%, compared to 9% for SDH without such injury.⁸⁾ We believe that, in the present study, patients with both microbleeds and CH frequently had poor outcome because they had complications that were caused by contusions, intracerebral hematomas, and diffuse axonal injuries.

The overall prevalence of microbleeds is high, and is reported to increase with age from 18% in persons aged 60–69 years to 38% in those over 80 years.¹⁷⁾ We found that, even in patients under 60 years of age, poor outcome at discharge was more common in

patients with microbleeds than in patients without microbleeds. Therefore, regardless of age, poor outcome at discharge tended to be more common in patients with microbleeds than in patients without microbleeds.

It has been reported that there is a correlation between poor outcome and lesion location in the brainstem or corpus callosum in patients with diffuse axonal injury.^{3,11)} In this study, there were no differences in outcome according to the location of microbleeds. However, the small number of patients with microbleeds in the corpus callosum and the brainstem limits this comparison, and more patients are needed to address this point.

The conclusions of this study may be limited by selection bias, because patients who were conservatively treated or did not receive MR imaging within 2 weeks of head injury onset were not considered. These patients were considered to be not severe enough to perform surgery or MR imaging. Thus, our study may have included many patients with poor outcome. Furthermore, the timing of MR imaging was not constant across subjects. Microbleeds are perivascular collections of hemosiderin deposits.⁵⁾ T_2^* -weighted MR imaging detects the paramagnetic effects of deoxyhemoglobin and methemoglobin,¹⁰⁾ but cannot detect the diamagnetic effects of oxyhemoglobin. Oxyhemoglobin changes to deoxyhemoglobin during the hyperacute phase. In this study, MR imaging was performed before surgery, i.e., during the hyperacute phase, in seven patients. It is possible that microbleeds increased with progress after surgery; however, we cannot evaluate this because MR imaging was performed on only one occasion. Considering the appearance of deoxyhemoglobin and methemoglobin, the appropriate time for MR imaging is 3–7 days after injury. In our study, eight patients underwent MR imaging during this period. Four of five patients (80%) with microbleeds had poor outcome, whereas one of three patients (33%) without microbleeds had poor outcome. Susceptibility-weighted MR imaging is a highly sensitive way of identifying microbleeds and diffusion tensor imaging is a sensitive way of evaluating white matter lesions.¹⁵⁾ Examination of prognosis using these methods is required in patients with acute SDH, as these methods can detect minute brain damages which cannot be detected by T_2^* -weighted MR imaging. To resolve these limitations, prospective studies should be performed to examine outcomes in SDH patients with and without microbleeds.

In conclusion, the results of this study demonstrate that poor outcome at discharge is more common in SDH patients with both microbleeds and CH

than in SDH patients with neither microbleeds nor CH, regardless of patient age and microbleed location. Therefore, the presence of microbleeds and CH on MR images may indicate poor prognosis in patients with acute SDH.

Conflicts of Interest Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices in the article. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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