症例報告

超急性期外傷性び慢性脳浮腫における reversal sign on CT

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The reversal sign on CT of hyper-acute diffuse traumatic brain swelling in an infant

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Abstract　We present the case of a 6-month-old boy who underwent brain CT and MR imaging within 90 minutes after traumatic injury. CT image obtained within 1 hour of trauma showed the so-called reversal sign on CT, with reversal of the relatively greater density of the cerebellum compared to that of the cerebrum. The diffusion weighted images (DWI) of MRI obtained 90 minutes after onset showed pan-cerebral restricted diffusion, whereas T2-weighted and FLAIR image findings were normal. In our case, the image finding of the reversal sign on CT was equally diagnostic as DWI of MRI for diffuse traumatic brain swelling in the hyper-acute state.

Keywords　*Reversal sign on CT, Diffusion weighted image on MRI, Infant, Traumatic diffuse brain swelling*

Introduction

Diffuse brain swelling (DBS) due to closed traumatic brain injury is a kind of malignant brain damage observed mostly in infants and children under five years old[1,2]. Early and accurate diagnosis, where imaging plays a primary role, is important.

We present a case of 6-month-old male infant with head trauma who underwent both CT and MRI within 90 minutes after the traumatic event. The so-called reversal sign on CT was equally diagnostic as hyper-intensity on a diffusion-weighted image (DWI) of MRI in this case.

Case report

A 6-month-old male infant with an unremarkable birth and medical history was brought to the hospital after a car accident. He was on his mother's lap without a seatbelt in the front seat of the car, which was hit by another car from behind. The car was pushed forwards and hit the car in front, and the infant was caught between his mother's chest and the air bag.　He exhibited generalized

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convulsions when the ambulance reached the hospital 15 minutes after the accident. He was intubated immediately and initial SaO_2 was 85%. During the transfer, there was no apnea attack or cardiac arrest.

He was presented to our hospital 30 minutes after the accident. At that time, SaO_2 was 100% but blood pressure was low (60/20mmHg) with a low heart rate of 70/min, and his Glasgow coma scale was 7 (E2V2M3). His anterior fontanelle exhibited swelling, suggesting elevated intracranial pressure.

CT scan was performed 1 hour after the accident. On CT images, a shallow subdural hematoma was observed in the left side. The entire cerebrum exhibited slightly lower attenuation than that of the cerebellum, which is the so-called reversal sign on CT[3] (Fig.1a, b). Cortical and white matter interface is slightly obscure.

MR scan was performed immediately after CT examination to confirm the area of brain damage. MR images (Philips, Intera, 1.5T unit) including T1-weighted images (not shown), fast spin-echo T2-weighted images, and FLAIR images reveal no signal changes in the cerebrum (Fig.2a, b). Fast spin-echo T2-weighted images showed motion artifacts (Fig.2a). On DWI (spin-echo echo-planner imaging with diffusion encoding in 6 axes, B=0, 1000s/㎟), the entire cerebrum, predominantly gray matter, exhibited marked hyper-intensity, except for the right insular cortex and both anterior medial temporal regions (Fig.2c). Thalamic regions were also spared (not shown). There was a faint hyper-intense area in the dorsal brainstem. The cerebellum exhibited normal signal intensity. The ADC map (not shown) exhibited restricted diffusion. MR angiography was also performed, but there were no remarkable findings (not shown).

Despite intensive care with low-temperature therapy and steroids, CT examination performed after 24 hours revealed pan-cerebral low attenuation with diffuse brain swelling (Fig.3).

His electro-encephalogram showed a flat pattern on the next day, and he died 12 days after the accident.

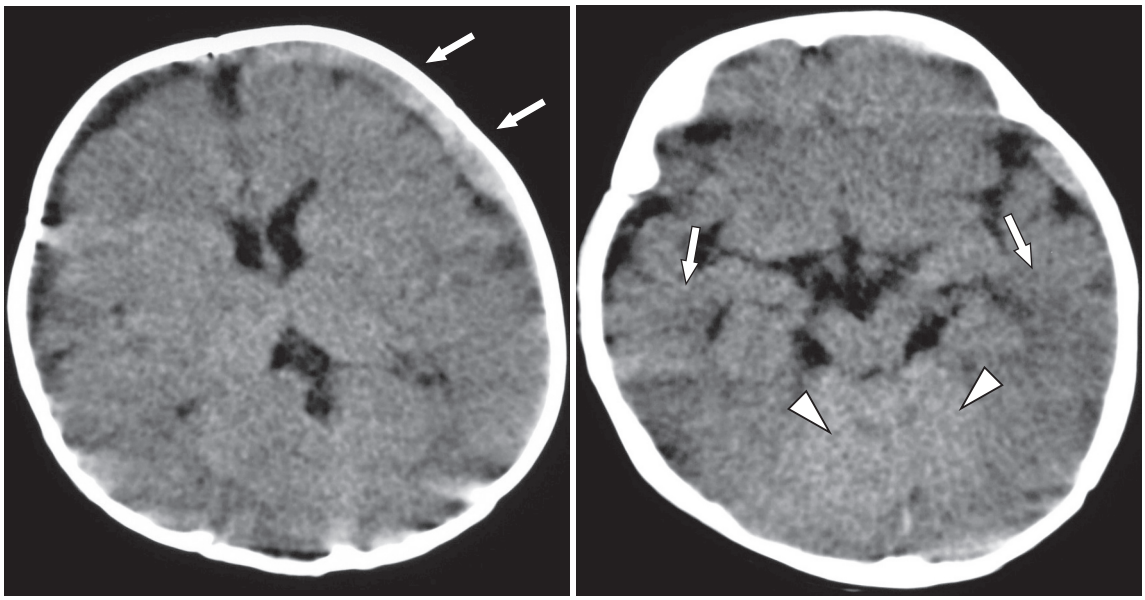
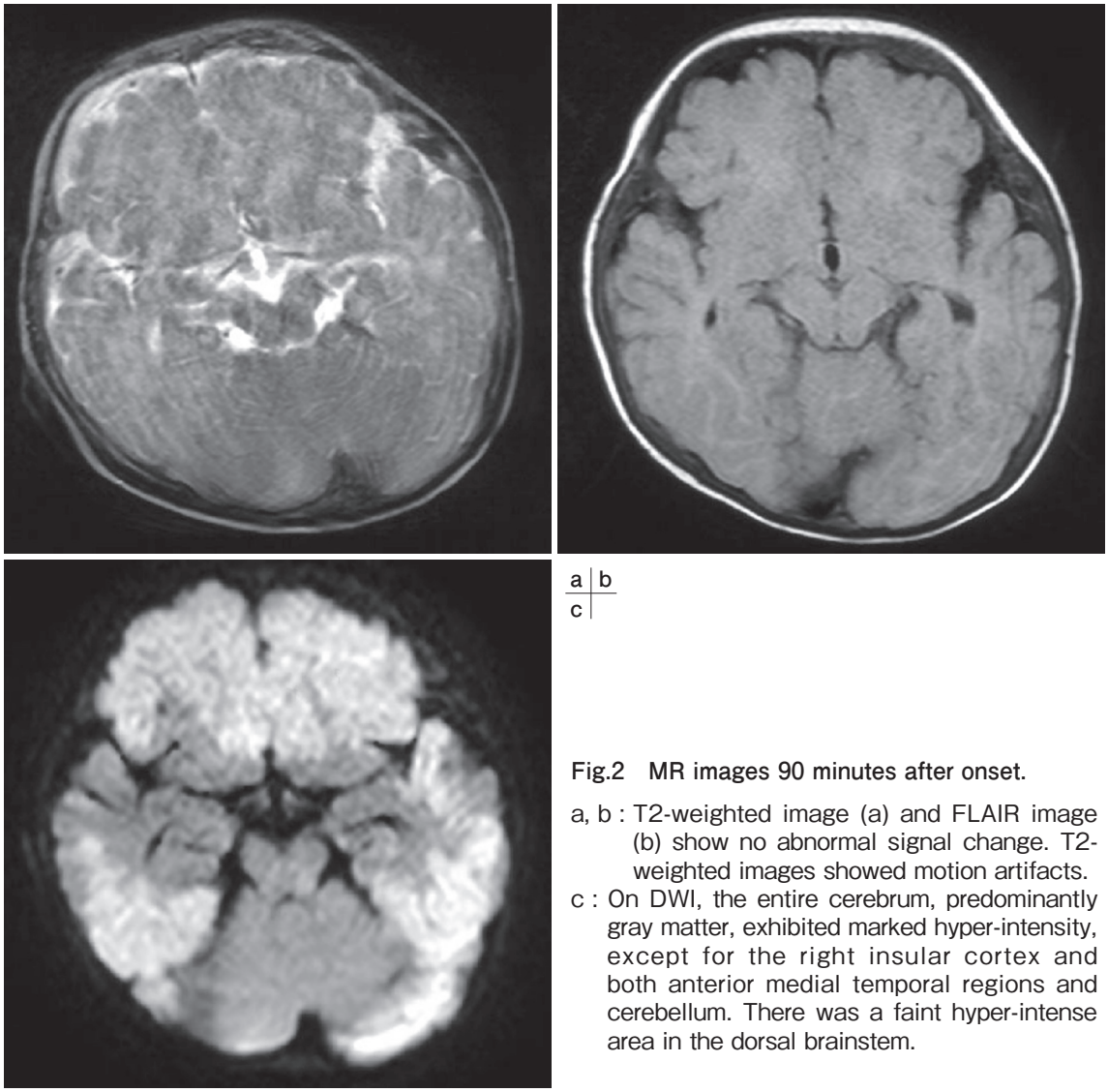


Fig.1　CT images 1 hour after onset
a : A shallow subdural hematoma was observed on the left side (arrows). Cortical and white matter interface is slightly obscure.
b : The entire cerebrum exhibited slightly lower attenuation (arrows) than that of the cerebellum (arrowheads), which is the so-called reversal sign on CT.



a | b
c

Fig.2 MR images 90 minutes after onset.

a, b : T2-weighted image (a) and FLAIR image (b) show no abnormal signal change. T2-weighted images showed motion artifacts.

c : On DWI, the entire cerebrum, predominantly gray matter, exhibited marked hyper-intensity, except for the right insular cortex and both anterior medial temporal regions and cerebellum. There was a faint hyper-intense area in the dorsal brainstem.

Discussion

DBS, generalized cerebral swelling, or traumatic cerebral edema is a malignant finding associated with traumatic brain damage or asphyxia which is often observed in infants and yound children under five years of age[1]. This generalized cerebral swelling probably results from a combination of extracellular and intracellular edema and decrease in vascular resistance, resulting in vasodilatation and increased cerebral blood volume[4]. Recent reports suggest, according to the DWI findings, the dominant contribution of intracellular edema in DBS[5,6]. In our case also, restricted diffusion suggested intracellular edema. DWI is well established as a sensitive MR technique in the detection of intracellular edema in acute brain ischemia.

The CT features of DBS are diffuse brain swelling and the so-called reversal sign on CT[1]. The reversal sign consists of a diffusely decreased density of cerebral cortical gray and white matter with a decreased or lost gray/white matter interface,

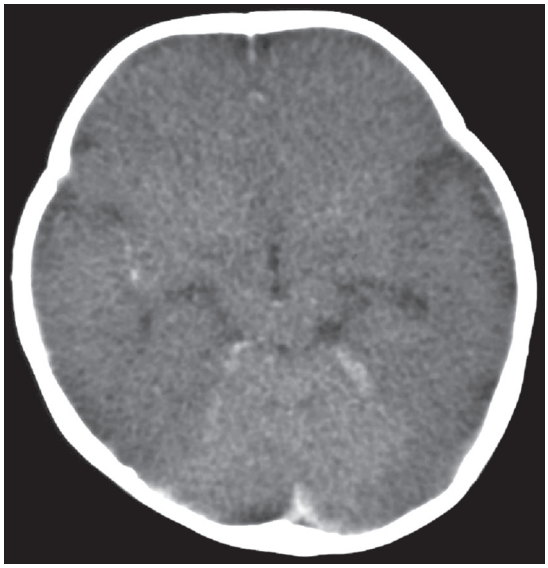


Fig.3 CT image obtained after 24 hours shows typical diffuse brain edema

or reversal of the gray/white matter densities and relatively greater density of the cerebellum, brainstem, and thalami. In other words, this finding is described as "white cerebellar sign" [1,3]. It probably represents a diffuse brain edema as a result of anoxic/ischemic cerebral injury[3,7,8].

It is noticeable that the reversal sign was observed on CT 1 hour after the injury in our case. To our knowledge, this is the first report of reversal sign on CT detected 1 hour after the traumatic event. In our case, the reversal sign on CT was observed only in the cerebellum, and thalami and brainstem were not white. On DWI, cerebral white matter and dorsal brainstem showed restricted diffusion, whereas deep white matter, thalami and cerebellum showed normal diffusion. From these findings, the reversal sign on CT in this case may reflect mainly the contrast between hypo-dense cerebral cortex with edema and normally dense cerebellar cortex. We suggest that this is why the reversal sign was not observed in thalami or brainstem in our case.

As shown in our case, the reversal sign on CT may be a subtle change in attenuation. We should therefore look carefully and may need to observe the images in narrow window width (under 60 H.U.).

Prognostic value of the reversal sign on CT in pediatric traumatic events has not been discussed fully. In anoxic/ischemic cerebral injury, Hans et al reported that patients with the reversal sign had a poorer prognosis than those without it[3]. On the other hand, Lang et al. evaluated the prognosis of DBS after head injury and reported a better outcome in children than in adults[11]. The reversal sign on CT in pediatric traumatic events may therefore suggest a poor prognosis, but not always.

Recent studies have suggested that MRI may be useful for blunt head trauma in the pediatric population. Sue et al reported that of 18 children with presumed non-accidental trauma who underwent MR imaging studies within 5 days of presentation, 16 (89%) demonstrated abnormalities on DWI/ADC[5]. Sigmund et al evaluated CT within 24 hours and MRI study 7 +/− 4 days after injury and concluded that CT is inconsistent in lesion detection and outcome prediction in pediatric traumatic brain injury[12]. However, they also suggested that CT has an advantage in that the information is quickly obtained and aids in the rapid treatment of neurosurgical emergencies. We suggest, too, that CT is the brain imaging modality of first choice evaluating pediatric trauma, but that if the finding is not clear or the patient's state is more severe than the imaging findings, MRI including diffusion-weighted images should be considered.

Conclusion

We present CT and MRI images of a case in the hyperacute stage of DBS. The reversal sign on CT was subtle but equally diagnostic of DWI as MRI in our case. We should not miss this sign on CT.

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