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Post-Traumatic West Syndrome due to Abusive Head Trauma in Two Infants with Different Brain Imaging Findings

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Abusive head trauma (AHT), commonly known as shaken baby syndrome, is a cranial injury of infants and young children. AHT is an important cause of morbidity and mortality in young children, particularly those younger than 12 months of age. We describe two patients who developed West syndrome, which is a severe epilepsy syndrome composed of the triad of infantile spasms, hypsarrhythmia on electroencephalography, and developmental arrest or regression, possibly attributable to AHT. Case 1 was a 5-month-old boy presented with generalized convulsive status epilepticus when a babysitter had cared for him. Brain magnetic resonance imaging (MRI) exhibited a subdural hemorrhage with diffuse brain edema and a midline shift highly suggestive of AHT. He developed West syndrome at the age of 10 months. Case 2 was a 6-month-old girl presented infantile spasms and diagnosed with West syndrome. Although she had poor weight gain due to inadequate care by her mother, there were no history of trauma, no cutaneous finding, and no developmental delay. Brain MRI performed when West syndrome was diagnosed revealed contusional tears highly suggestive of AHT. The MRI finding indicated that contusional tears had occurred 1~2 months before the development of West syndrome. There are no reports of West syndrome due to contusional tears. AHT may be an important risk factor for postnatal West syndrome. It is noteworthy that evidence of AHT was found only after West syndrome onset, as in Case 2. The onset of West syndrome may contribute to the finding that AHT had occurred earlier.

Keywords: abusive head trauma; contusional tears; diffuse brain injury; infantile spasms; West syndrome
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Introduction

Abusive head trauma (AHT) encompasses cerebral, spinal, or cranial injuries of infants and young children inflicted by shaking, impact trauma, or a combination commonly known as shaken baby syndrome, is a cranial injury of infants and young children (Christian et al. 2009). The diagnosis of abusive head trauma is aided by the presence of additional clinical features in children with intracranial injury, including a history that is inconsistent with the physical findings, retinal hemorrhages, fractures, unexplained bruises, apnea, and seizures (Piteau et al. 2012). However, early signs and symptoms of AHT in infants may be nonspecific, such as irritability, lethargy, or vomiting. AHT is an important cause of neurological morbidity and mortality in children, being most common in infants younger than 1 year of age (Palifka et al. 2016). West syndrome is an age-dependent epilepsy that most frequently presents in the first year of life, composed of the triad of infantile spasms, hypsarrhythmia on electroencephalography (EEG), and developmental arrest or regression. Although the etiology of West syndrome is heterogeneous, including infections, perinatal events, and congenital genetic disorders, the incidence of West syndrome attributable to postnatal etiologies, including cerebral injuries, is lower than that attributable to prenatal or perinatal etiologies (Osborne et al. 2010). Only a few reports on patients with West syndrome associated with AHT have appeared (Wang et al. 2014; Birca et al. 2014; Park and Chugani 2017). Here, we report on two infants who developed West syndrome, possibly attributable to AHT; they exhibited two different types of cerebral injury: diffuse brain injury with subdural hemorrhage and contusional tears. These cases offer important insights into the co-occurrence of, and relationship between, West syn-

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drome and brain injury.

Case Report

Case 1

The patient was a previously normal 5-month-old boy who had been born via normal vaginal delivery at full term, and who evidenced no complications during pregnancy. He presented with generalized, convulsive status epilepticus after a babysitter had cared for him while his mother was absent at the age of 5 months. Head computed tomography (CT) revealed a subdural hematoma and diffuse cerebral edema with a marked midline shift (Fig. 1); emergency surgery to remove the hematoma was performed. The blood test results, including the serum chemistry data, the complete blood count, and the coagulation test, were normal. Retinal hemorrhage was noted; thus, the presentation was highly suggestive of AHT. At 8 months of age, he presented with partial seizures that improved on treatment with carbamazepine. Infantile spasms with hypsarrhythmia were noted at 10 months, thus 5 months after the AHT (Fig. 1). Brain magnetic resonance imaging (MRI) revealed remarkable cerebral atrophy, predominantly in the left hemisphere (Fig. 1). Although intramuscular injections of synthetic adrenocorticotropic hormone (ACTH) therapy (daily 0.015 mg/kg for 3 weeks, 0.015 mg/kg every 2 days for 1 week) was effective in that the infantile spasms ceased, the spasms recommenced 3 months later. None of repeat ACTH treatments, or various anticonvulsants [valproate (VPA), zonisamide (ZNS), clonazepam, clobazam, nitrazepam, lamotrigine, levetiracetam, or topiramate] afforded remission of the spasms or hypsarrhythmia (Fig. 1). At 4 years of age, he exhibited severe developmental delay, was unable to sit unaided, could not walk, and could not speak. He exhibited predominant right-side spastic quadriparesis.

Case 2

A 6-month-old girl was admitted because of sudden symmetrical flexion of the upper and lower limbs that had occurred 3 days prior. She was born at 37 weeks of gestation and her birth weight was 2,442 g; no complication had

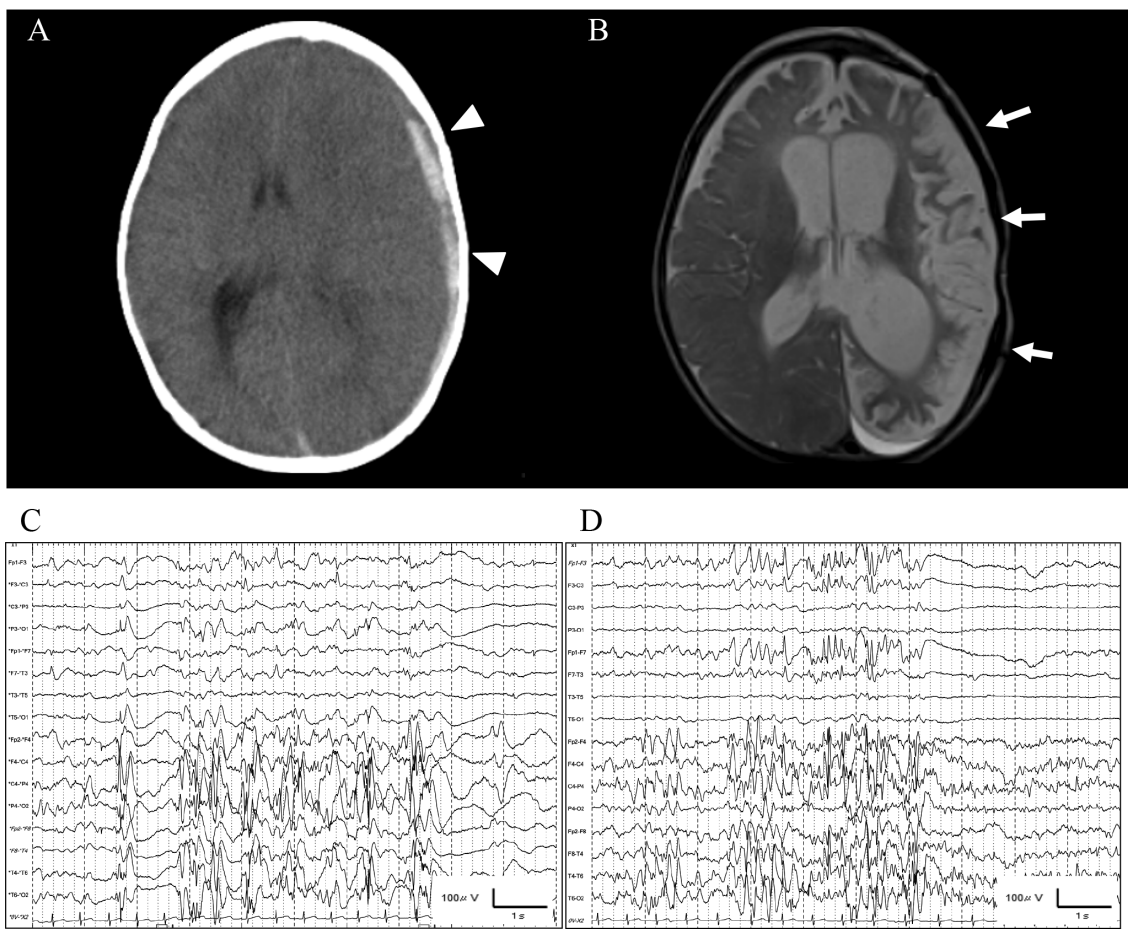

Fig. 1. Neuroimaging and EEG in Case 1.
(A) The axial CT image (taken on admission) shows an acute left subdural hematoma and a posterior, interhemispheric subdural hematoma with subjacent hemispheric swelling and a midline shift (arrowhead). (B) A follow-up MRI T2-weighted image taken at 10 months of age (before the first ACTH therapy) exhibits cerebral atrophy and ventriculomegaly, predominantly in the left hemisphere (white arrow). (C) At the age of 10 months, EEG during sleep showed unilateral, right hemisphere dominant hypsarrhythmia. (D) At the age of 3 years and 10 months, EEG during sleep showed multifocal spikes in the right hemisphere and left frontal area.

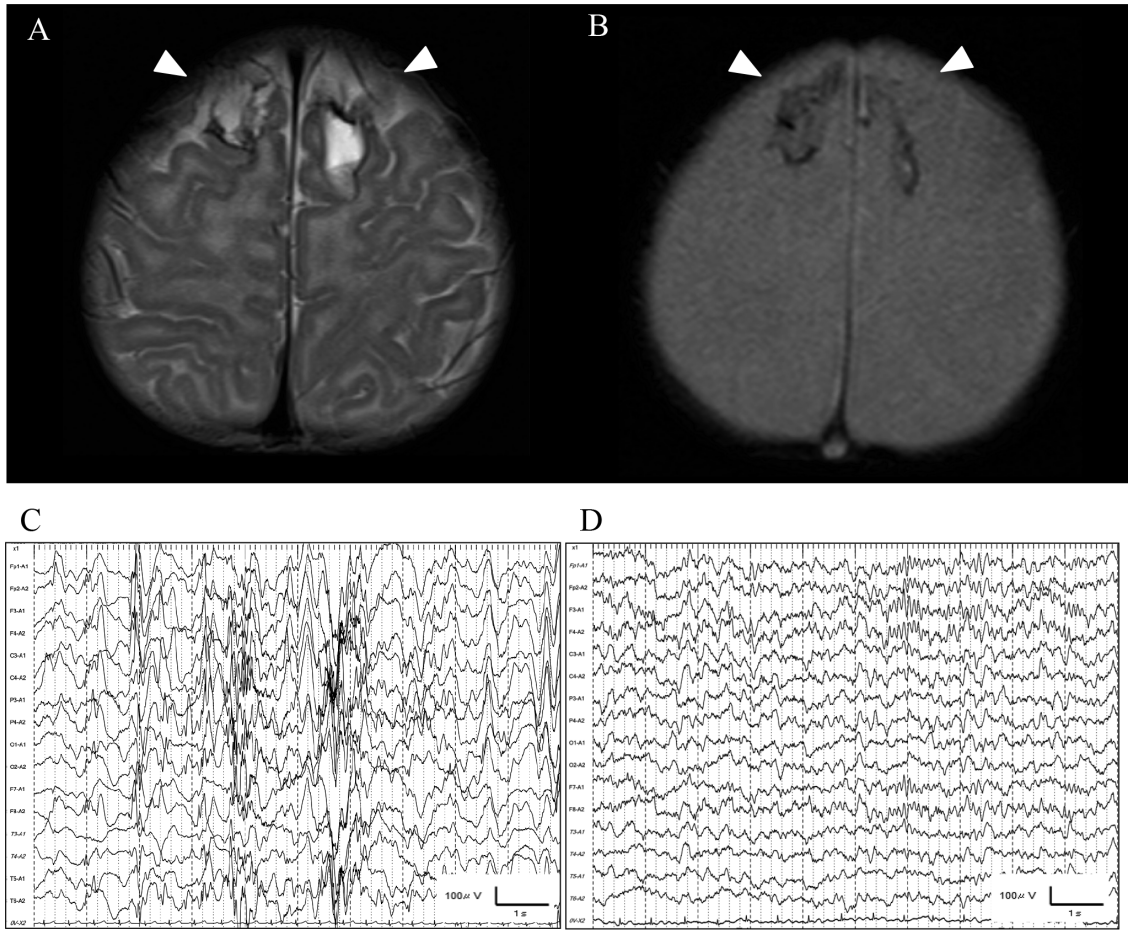

Fig. 2. MRI and EEG in Case 2.
The T2-weighted axial (A) and T2*-weighted axial (B) images reveal parenchymal clefts in the subcortical white matter of the frontal lobes (arrowhead). (C) At admission, EEG during sleep reveals hypsarrhythmia. (D) The EEG during sleep was normal at 2 years and 7 months of age.

been noted during pregnancy. She was admitted for 2 weeks during neonate due to poor weight gain, probably caused by inadequate care by her mother. However, she had no history of trauma, no cutaneous finding, and no apparent developmental delay. At 6 months of age, she could maintain an appropriate neck posture; no paralysis was evident. Infantile spasms then developed (3-4 series per day) and hypsarrhythmia was apparent on EEG (Fig. 2). On examination, she had a normal facial appearance, a G-banded karyotype, while blood amino acid and lactate and pyruvate levels were normal. Brain MRI performed at admission revealed posthemorrhagic lesions on T2-weighted imaging; and T2-star imaging evidenced bilateral, frontal lobe hypointensity, suggesting that contusional tears had preceded her spasms (Fig. 2). Head CT revealed bilateral frontal hypointensity without any skull fracture. A whole-body x-ray did not reveal any bone fracture, and no retinal hemorrhage was evident. Although our child counselling center intervened in the case, because contusional tears raise a suspicion of AHT, the cause of the injury remained unclear. Although the timing of the AHT was thus unknown, the MRI data indicated that the AHT had occurred about 1-2 months prior to the development of West syndrome. Initial intramuscular synthetic ACTH therapy (daily 0.015 mg/kg for 3 weeks, 0.015 mg/kg every 2 days for 1 week), commenced after VPA and ZNS were not effective, was also not effective. Second-time ACTH therapy received at 11 months of age (at which time the infantile spasms continued) was effective; both the spasms and the hypsarrhythmia disappeared. She was maintained on weekly intermittent intramuscular ACTH injections at a dose of 0.015 mg/kg for 1 year; the EEG was normal and no seizure was recorded from the time of ACTH cessation to 4 years of age (Fig. 2). At that time, her development was moderately delayed; she could walk but not speak. No further injury and no abuse were noted.

Ethics statement

Written informed consent was obtained from the mother of Case 1 for publication of his case report and the accompanying images. The report of Case 2 was approved by the ethics committee of Nagoya City West Medical Center.

Table 1. Overview of previous reports on development of West syndrome after AHT.

	Sex	Age at injury	Type of injury	Age at onset of WS	Interval between injury and WS onset
Our Case 1	M	5 months	Subdural hemorrhage with diffuse brain edema and a midline shift	10 months	5 months
Our Case 2	F	4-5 months (estimated)	Contusional tears in the frontal regions	6 months	1-2 months
Wang et al. (2014)	F	3 months	Subdural effusions in the bilateral frontotemporal areas, and brain atrophy	6 months (EEG findings)	3 months
Birca et al. (2014)	M	3 months	Multiple subdural hematomas, a small area of parenchymal contusions, and a subarachnoid hemorrhage	6 months	3 months
Birca et al. (2014)	M	1 month	Multiple subdural hematomas, a subarachnoid intraventricular hemorrhage, an occipital bone fracture, an encephalomalacia in the left frontal and temporal regions	5 months	4 months
Park and Chugani (2017)	M	2 months	Chronic multicystic encephalomalacia	N/D	2 years
Park and Chugani (2017)	M	2.5 months	A subdural hemorrhage with hydrocephalus	N/D	7 months

N/D, no data; M, male; F, female; AHT, abusive head trauma; WS, West syndrome; EEG, electroencephalography.

Discussion

West syndrome is a form of epilepsy associated with many underlying conditions and is often associated with poor developmental outcomes characterized by infantile spasms, hypsarrhythmia evident on EEG, and developmental arrest or regression (Lux and Osborne 2004). Although the syndrome has various etiologies, postnatal etiologies (including central nervous system infection and cerebral injuries) are fewer in number than prenatal or perinatal etiologies. In one study evaluating 127 cases of West syndrome of proven etiology, eight cases (6.3%) with postnatal etiologies were reported, compared to 63 cases (49.6%) with prenatal, 38 (29.9%) with perinatal etiologies and 18 (14.2%) in whom the timing of disease not known (Osborne et al. 2010). It is important to understand the epidemiological and clinical characteristics of West syndrome developing after brain injury in a previously normal child; such work may afford insights into the mechanisms of West syndrome development (Park and Chugani 2017).

Postnatal insults were associated with later-onset epileptic spasms than were prenatal or perinatal incidents (Matsumoto et al. 1981); the time interval between brain insult and spasm onset ranged from approximately 2 months to 2 years (Park and Chugani 2017) or from 6 weeks to 11 months (Guggenheim et al. 2008). We here report two cases of West syndrome attributable to AHT inflicted 5 and 1~2 months earlier, respectively. These latencies are similar to those of previous reports on postnatal West syndrome (Guggenheim et al. 2008; Park and Chugani 2017).

AHT, previously termed non-accidental trauma, refers to serious brain injuries suffered by infants; the incidence of presumptive AHT is increasing (Yamaoka et al. 2020). AHT may be a risk factor for West syndrome. The several types of AHT include subdural hematoma, subarachnoid hemorrhage, subdural effusions, brain swelling, contusional tears, shearing injuries, and diffuse axonal injuries (Gilles and Duhaime 2006). There have been only a few reports on patients with West syndrome associated with AHT (Table 1) (Wang et al. 2014; Birca et al. 2014; Park and Chugani 2017). All cases suffered cerebral insults during early infancy; the latency time between the brain insult and the development of epileptic spasms ranged from 2 months to 2 years. No case exhibited contusional tears; almost all cases suffered from subdural hemorrhages or exhibited extensive brain atrophy. Contusional tears are also termed parenchymal lacerations, subcortical clefts, cerebral contusions, white matter clefts, and gliding contusions (Palifka et al. 2016), and are most commonly caused by deceleration injuries (the brain [principally the frontal lobes] forcibly contacts the rough edges of the skull). The diagnostic evaluation of Case 2 did not detect any abnormality except on MRI and development was normal before the onset of West syndrome, although we cannot deny that an undiagnosed genetic background may still become evident.

As AHT is more likely to be unrecognized in very young children who do not have respiratory compromise or seizures (Jenny et al. 1999), it can be difficult to diagnose AHT if later episodes are lacking. It is significant that evidence of AHT was found only after West syndrome onset in our Case 2. It is possible that more patients may be underdiagnosed than published, although there are no reports of West syndrome due to contusional tears. Our cases suggest that AHT is an important risk factor for postnatal West syndrome, and that the onset of West syndrome may contribute to the discovery of earlier AHT.

Author Contributions

R.T. drafted the initial manuscript. S.K. treated and diagnosed the patients, and reviewed and revised the manuscript. R.T., S.K., N.K. and N.H. collected clinical data and brain image results and prepared the manuscript. K.M. and

S.S. supervised the study. All authors read and approved the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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