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【 CASE REPORT 】

Transient Probst Bundle Diffusion Restriction: An Acute Encephalopathy Equivalent to Clinically Mild Encephalopathy with a Reversible Splenial Lesion

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Abstract:

Probst bundles are selectively seen in patients with agenesis of the corpus callosum (CC) and are thought to be homologous to the CC. We herein report a 19-year-old woman with partial agenesis of the CC. She developed acute encephalopathy during *Bordetella pertussis* infection. Brain magnetic resonance imaging (MRI) showed restricted diffusion of bilateral Probst bundles. She was treated with anti-epileptics and azithromycin and recovered with no neurological sequelae. Follow-up MRI showed the resolution of the diffusion abnormality. The characteristics of diffusion-weighted images on brain MRI and clinical course mimicked those in cases of clinically mild encephalopathy/encephalitis with reversible splenial lesion.

Key words: Probst bundle, agenesis of the corpus callosum, clinically mild encephalopathy/encephalitis with a reversible splenial lesion, MERS, acute encephalopathy

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Introduction

Longitudinal callosal bundles in the deep cerebral white matter were first described by anatomists, including Onufrowicz (1888) and Probst (1901), and today they are commonly called Probst bundles (1). Probst bundles are specific structures involved in the spectrum of commissural agenesis (2-4). In classic commissural agenesis, the commissural fibers fail to cross the midline, such that when they reach the corticoseptal boundary, they turn and run parallel to the interhemispheric fissure within the septal leaves, indenting the medial walls of the lateral ventricles (1-4).

We herein report a case of acute encephalopathy with reversible restricted diffusion of the Probst bundles. Although she did not exhibit any splenial lesion due to her agenesis of the corpus callosum (CC), her clinical course as well as magnetic resonance imaging (MRI) abnormalities were similar to those of clinically mild encephalopathy/encephalitis with a reversible splenial lesion (MERS) (5, 6).

Case Report

A 19-year-old woman with a chromosomal abnormality of partial monosomy Xq and partial trisomy 1q [46, X, der (X) t(X;1)(q27;q24)], epilepsy, and partial agenesis of the CC was referred to the neurology division because of impaired consciousness, repetitive seizures in her right arm, and paresis in the right arm on the fifth hospital day while undergoing treatment for *Bordetella pertussis* pneumonia. She showed impaired consciousness with a Glasgow Coma Scale score of 11 (E4V1M6), flaccid paresis in the right arm, and pyramidal tract dysfunction of the right side.

A cerebrospinal fluid examination revealed elevated protein levels (87 mg/dL) without pleocytosis. Brain MRI on the day of her seizures showed partial agenesis of the CC (Fig. 1) and intensified signals in the parallel bodies of the lateral ventricles and Probst bundles on diffusion-weighted imaging (Fig. 2A, B). An electroencephalogram (EEG) detected alpha rhythms in the left hemisphere that were superimposed on parietooccipital-dominant polymorphic delta ac-

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tivity. Acute encephalopathy caused by *B. pertussis* infection was diagnosed.

She received anti-epileptics and azithromycin and returned to her previous health status within three weeks with no residual neurological sequelae. A follow-up EEG (nine days from the onset) showed slight lazy activity in the left hemisphere and no epileptiform discharges. Follow-up MRI showed the complete resolution of the diffusion restriction (Fig. 2C, D). Six months after the acute encephalopathy, diffusion tensor imaging (DTI)-based tractography showed the classical bilateral Probst bundles running antero-posteriorly just medial to the lateral ventricles, where diffusion-weighted imaging had shown the most significant findings during the acute phase of her infectious encephalopathy (Fig. 3). The fractional anisotropy values on DTI for the genu of the CC, right Probst bundles, and left Probst bundles were 0.66, 0.64, and 0.67, respectively.

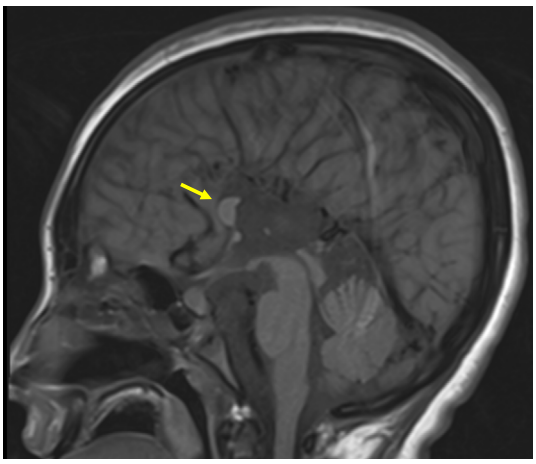

Figure 1. Brain MRI, midsagittal. T1-weighted imaging showing partial agenesis of the corpus callosum (arrows) and the sunburst appearance.

Discussion

We encountered a case of acute encephalopathy with reversible restricted diffusion of the Probst bundles in a patient with partial agenesis of the CC. MRI showed transient restricted diffusion of both the Probst bundles, findings similar to those of MERS.

MERS is an extremely mild and common infectious encephalitis/encephalopathy syndrome in Japanese children and is characterized by mild neurological symptoms with complete clinical recovery within one month and the MRI findings of reversible diffusion restriction in the splenium of the CC (5, 6). Interestingly, our case developed acute encephalopathy with reversible restricted diffusion of the Probst bundles, instead of the splenium of the CC, during

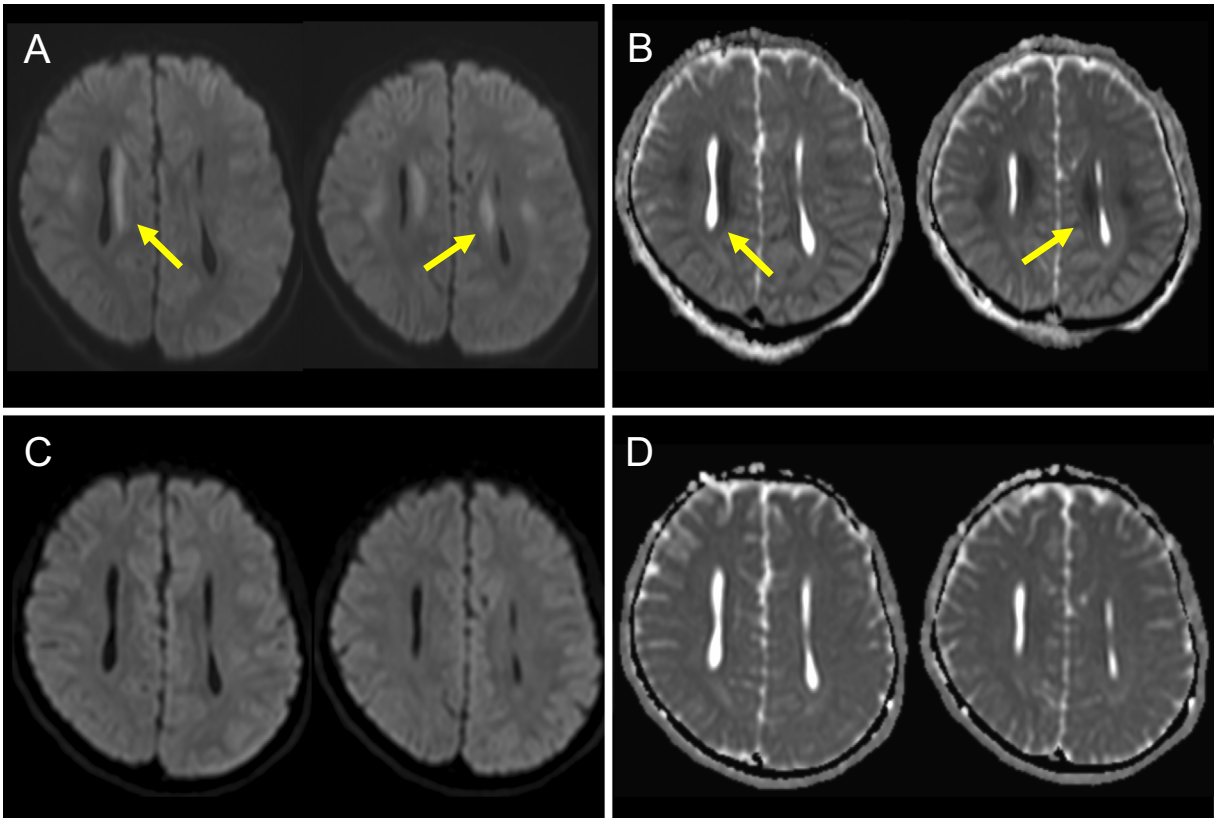

Figure 2. Brain MRI on the day of her seizures. Axial diffusion-weighted imaging (DWI) (A), apparent diffusion coefficient (ADC) imaging (B). Restricted diffusion of the bilateral Probst bundles is shown (arrows). Follow-up MRI, axial DWI (C), and ADC (D); the restricted diffusion lesion in the Probst bundles had disappeared.

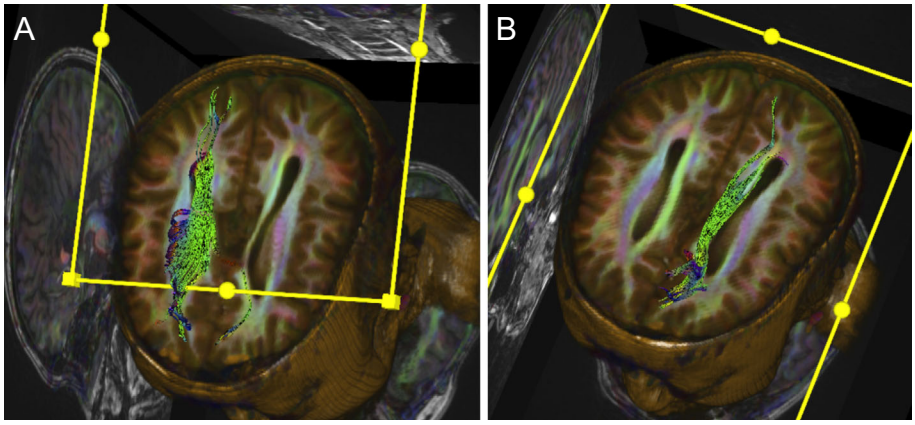

Figure 3. Diffusion tensor imaging (DTI) showing the bilateral Probst bundles. Right Probst bundles (A), left Probst bundles (B).

febrile pneumonia caused by *B. pertussis*.

Probst bundles are neuroanatomical homologues to the CC (7, 8). The CC is formed by two processes during normal brain development: the formation of the callosal primordium called the "massa commisuralis", which is the precursor for the ingrowth of callosal fibers, and the subsequent elongation of the callosal fibers from one side of the neocortical plates of the telencephalon to the other (7, 8). Probst bundles are only formed when the massa commisuralis is inadequately formed and there are adequate numbers of callosal projection neurons in both hemispheres. In our patient, the bilateral cerebral cortices were well formed without gyration abnormality or overt neuronal migration disorder, hence the Probst bundles were well formed (Fig. 3).

Previous studies have revealed several neuroanatomical and MRI characteristics of the Probst bundles. Probst bundles show lower T2-weighted imaging signal intensities than other white matter, indicating more densely packed myelinated axons (4). Indeed, fractional anisotropy maps on tractography show higher values in the Probst bundles than in other white matter structures (2). Furthermore, in our case, the fractional anisotropy values on DTI for both Probst bundles were not significantly different from those of healthy persons (9). Thus, Probst bundle fibers are, when well-developed, highly packed myelinated structures, similar to the splenium of the CC.

It is postulated that the cardinal MR abnormality of MERS is a result of transient edema of the myelin sheaths. Because the axons in splenium CC are so tightly packed and have high density, the intramyelinic edema is most readily detected as diffusion restriction in the splenium CC (10). We speculate that these two apparently distinct brain structures of Probst bundles and CC might produce similar MR signal abnormalities under the same pathophysiological conditions, thus causing acute encephalopathy and intramyelinic edema.

The seizure activity itself during the patient's clinical course might have been responsible for her radiological findings, but we think this is unlikely for two reasons. First, she exhibited seizure clustering that was easily controlled with antiepileptics, and the seizure cessation was further confirmed with point-of-care electroencephalography soon after intensive-care unity admission. Since seizure-induced brain injury predominantly occurs patients with refractory status epilepticus (11), it is unlikely that her MRI abnormality was the sole result of seizure activity itself. Second, MRI depicted transient white matter lesions only, without cortical lesions. Since the cortex is the structure primarily involved in seizure-induced brain injury, it is less likely that her white matter lesions were due to seizure activities. Thus, we postulate that her radiological changes were more likely to be due to the pathophysiology of MERS, rather than that of seizure-induced brain injury.

Conclusion

We herein report a case of acute encephalopathy with reversible restricted diffusion of the Probst bundles in partial agenesis of the CC. To our knowledge, this is the first case of "MERS in the absence of CC," and indicates the structural equivalence of the Probst bundles and the CC.

Informed consent was obtained from the participant included in the study.

The authors state that they have no Conflict of Interest (COI).

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