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Original article

The neurological outcomes of cerebellar injury in premature infants

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Abstract

Aim: Cerebellar injury is a characteristic injury associated with preterm infants. However, the impact of cerebellar injury on the development of preterm infants is unclear.

Method: We reviewed magnetic resonance image studies of preterm infants with cerebral palsy retrospectively and evaluated the developmental outcomes.

Results: Cerebellar injury was recognized in 9 (2.4%) of 381 patients with cerebral palsy who were born preterm. The median gestational age was 26 (range 23–32) weeks and the median birth weight was 938 (range 492–1450) g. Seven of the nine patients had severe symmetric injuries to the inferior cerebellar hemispheres, resulting in a pancake-like appearance of the residual upper cerebellum. Supratentorial lesions were also recognized: periventricular leukomalacia in seven; atrophy of the basal ganglia in two; and intraventricular hemorrhage in two. Importantly, the motor dysfunction was related to the reduction in the white matter volume and severity of basal ganglia atrophy, but not to the cerebellar injury. Four of the nine patients could walk without limitations despite extensive cerebellar disruption. Only four patients could speak meaningful words during the study and only one spoke two-word sentences.

Interpretation: The patients with cerebellar injury might have a communication handicap, rather than altered motor function. Prematurity-related cerebellar complications require more attention in terms of cognitive and speech function, in addition to neuromotor development.

Keywords: Cerebellar injury; Preterm infants; Magnetic resonance image; Cerebral palsy

1. Introduction

The intensive care of preterm neonates has advanced over the past decade, and the increased survival rate of very-low-birth-weight infants has increased the importance of improving their neurological prognoses. However, the proportion of very-low-birth-weight infants with cerebral palsy has not decreased [1–4]. Several types of brain injury can occur secondary to the hemodynamic changes in premature infants, including intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL) [5], which have various neurological consequences for preterm infants. Cerebellar injury has been increasingly recognized as a

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characteristic injury of preterm infants. Neuroimaging studies have shown that the cerebellar injuries in preterm infants are correlated with supratentorial lesions, particularly PVL and intraventricular hemorrhage [6–13]. Despite these reports, the impact of cerebellar injury on the development of preterm infant might be under recognized. This prompted us to investigate the prevalence of cerebellar injury in preterm infants and the correlation of cerebellar injury and the neurological outcomes, including the long-term prognosis.

2. Patients

Premature infants younger than 37 weeks with cerebral palsy (CP) who were followed at the Takuto Rehabilitation Center for Children and underwent brain magnetic resonance imaging (MRI) between 1991 and 2011 were eligible for participation in this study. Patients with cerebral malformations, chromosomal abnormalities, or metabolic disorders were excluded. Since our hospital is the only rehabilitation center for children in Miyagi prefecture, where there are 20,000 live births annually, almost all of the infants with cerebral palsy in this region were referred to our hospital and followed. MRI was performed in all patients with CP, including patients born preterm. The study was approved by the Institutional Review Board of Takuto Rehabilitation Center.

3. MRI investigation

All of the MRI examinations were performed on a 0.5- or 1.5-T magnetic resonance scanner. All patients were sedated during the MRI examinations, which included axial and sagittal T1-weighted spin-echo (TR/TE: 300–600/12–20) and axial T2-weighted spin-echo (TR/TE: 2000–4555/30–121) images in 5-mm slices. Our retrospective review selected the patients with cerebellar injury from cases with CP who were born at less than 37 weeks.

Cerebellar injury was defined as a small, deformed cerebellum, and was classified into symmetric or asymmetric cerebellar injury.

All of the patients with cerebellar injury were reviewed in detail in terms of their gestational age, birth weight, sex, degree of cerebral white matter volume reduction, supratentorial lesions, such as PVL, IVH, basal ganglia lesions, and symmetry of the cerebellar lesion.

The reduction in white matter volume was classified into four groups: none; mild when the ventricular/brain ratio (V/B) at the level of the midbody of the lateral ventricles was <0.34, but the occipital horn was largely dilated; moderate when the V/B exceeded 0.35; and severe when little white matter was seen because of the dilation of the ventricles [14]. PVL was defined as MRI findings of (1) ventriculomegaly with an irregular outline of the body and trigone of the lateral ventricle; (2) a reduced amount of white matter, especially at the level of the trigone, frequently also extending throughout the centrum semiovale; and (3) deep prominent sulci, abutting the ventricle [15]. IVH was diagnosed by the presence of hyperechogenic blood layering in the dependent portions of the ventricle or hyperechogenic clots along the ventricular wall or on the choroid plexuses, as determined from the medical records for the neonatal period. Lesions of the basal ganglia were identified based on atrophy or signal abnormality in the regions.

The MRI images were evaluated independently by two pediatric neurologists. When their interpretations differed, a third pediatric neurologist was consulted and made the final decision.

3.1. Neurodevelopmental follow-up

The clinical outcomes were assessed retrospectively based on the latest patient records, including the classification of CP, gross motor function classification system (GMFCS), epilepsy, and speech ability.

Cerebral palsy was defined as a nonprogressive disorder of movement and posture due to a nonprogressive defect or lesion of the immature brain. The patients were evaluated for the presence of CP at a minimum age of 24 months. The following subtypes of CP were distinguished: spastic, ataxic, dyskinetic, and mixed (spastic–ataxic, spastic–dyskinetic, and dyskinetic–ataxic) [16].

The severity of the impairment of neuromotor development was classified using the GMFCS [17]. Children classified at GMFCS levels I and II have the potential to walk independently both indoors and outdoors, and in the community. By contrast, children classified at GMFCS levels III to V have limited unassisted mobility. They walk with a mobility device and are potential wheelchair users. Speech ability was evaluated as follows: none, limited to meaningful words only, or to two-word sentences. Epilepsy was diagnosed based on recurrent clinical seizures and abnormal electroencephalography (EEG) recordings.

4. Results

We reviewed the MRI studies of 381 patients with CP who were born preterm and found nine patients (2.4%; two males, seven females) who had cerebellar injuries that met our criteria. The median gestational age was 26 (range 23–32) weeks and the median birth weight was 938 (range 492–1450) g. For comparison with a previous study [9], we also evaluated 99 patients born at less than 29 weeks, of whom 8 had cerebellar injuries (8.1%). The nine patients are summarized clinically in Table 1. The median follow-up period was 8 (range 3–30) years.