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Original article

Cerebellar injury in preterm children with cerebral palsy after intraventricular hemorrhage: Prevalence and relationship to functional outcomes

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Abstract

Objectives: To elucidate the prevalence of cerebellar injury and its relationship to functional outcomes in preterm children with cerebral palsy (CP) after intraventricular hemorrhage (IVH).

Participants: We selected 69 children (40 males and 29 females, aged between 6 and 13 years) out of 2049 with cerebral palsy who visited Morinomiya Hospital, the regional center hospital for CP in West Japan. The inclusion criteria were (1) gestational age under 36 weeks at birth, (2) clear history of postnatal intraventricular hemorrhage, and (3) age at investigation over 6 years old. Those without sufficient imaging study or functional evaluation were excluded.

Methods: The participants were divided into four groups according to the presence of post-hemorrhagic hydrocephalus (PH) and cerebellar injury (CI): PH+/CI+, PH+/CI−, PH−/CI+, and PH−/CI−. Type of CP, ability to walk, verbal function, the incidence of severe visual impairment, and the complication of epilepsy were investigated and compared among the groups.

Results: The gestational ages of the participants were between 22 and 34 weeks, and their birth weight was between 412 and 1788 g. PH and CI were found in 39 (57%) and 40 (58%) children, respectively. Both the PH+/CI+ group ($n = 31$) and the PH−/CI+ group ($n = 9$) showed significantly lower walking and verbal abilities and a higher incidence of epilepsy than the PH−/CI− group ($n = 21$), while the PH+/CI− group showed no significant difference from the PH−/CI− group. Severe visual impairment was found only in the PH+/CI+ group and the PH−/CI+ group.

Conclusions: The prevalence of CI in preterm children with CP after IVH (58%) was almost the same as that of PH. CI is one of the most significant complications in preterm infants, affecting motor and verbal functions and being associated with epilepsy more than PH.

Keywords: Cerebral palsy; Preterm; Cerebellar injury; Intraventricular hemorrhage; Hydrocephalus; Outcome

1. Introduction

Recent advances in neuroimaging techniques and perinatal medicine have revealed that cerebellar injury (CI) is not rare among very preterm infants, and CI has been shown to be one of the major factors influencing not only motor but also cognitive, affective, and social functions in very preterm infants [1]. CI is rather common in children with cerebral palsy (CP) born as extremely preterm infants [2], but the influence of CI on their long-term outcome has not been fully analyzed. Information about the prevalence and the influence of CI among children with CP will make it possible to

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provide better child care, rehabilitation, and educational programs. We investigated the prevalence and the influence on functional outcomes of CI among preterm children with intraventricular hemorrhage (IVH) and consequent CP, and compared them with those of post-hemorrhagic hydrocephalus (PH).

2. Participants and methods

2.1. Participants

We selected 69 children (40 males and 29 females, aged between 6 and 13 years) out of 2049 with cerebral palsy who visited Morinomiya Hospital for diagnosis and treatment. Morinomiya Hospital is one of the center hospitals for children with CP in Japan providing comprehensive treatment such as rehabilitation, medication, and orthopedic surgery. The inclusion criteria were (1) gestational age under 36 weeks at birth, (2) clear history of perinatal IVH, and (3) age at investigation over 6 years old. Those without sufficient imaging study or functional evaluation were excluded. The diagnosis of IVH was confirmed from charts, medical referral letters, or summary information of neonatal intensive care unit. This study was approved by the ethical committee of Morinomiya Hospital.

2.2. Methods

The participants were divided into four groups (PH+/CI+, PH+/CI−, PH−/CI+, and PH−/CI−) according to the presence or absence of PH or CI. The definition of PH was progressive post-hemorrhagic ventricular dilatation that needed medical intervention such as serial lumbar puncture, temporary shunts, or permanent ventriculoperitoneal shunt (VP shunt). The diagnosis of CI was based on the morphological changes of cerebellum on MR imaging or Computed Tomography. Most children with CI showed apparent morphological abnormalities such as asymmetrical atrophy of cerebellar hemisphere with or without vermian lesion, or diffuse atrophy of cerebellum often associated with pontine atrophy or dilatation of the fourth ventricul, and the rest showed mild abnormalities such as dilated cerebellar sulci or decreased cerebellar volume with mild flattening. Typical MR images of the four groups are shown in Fig. 1. The number of children in each group, gender, gestational age, birth weight, and age at investigation were examined. In the PH−/CI+ and PH−/CI− groups, types of supratentorial lesions other than PH were also evaluated, although we did not evaluate them in PH+/CI+ and PH+/CI− groups because severe hydrocephalus made it difficult to assess cerebral lesions other than PH accurately. In the PH+/CI+ and PH+/CI− groups, the number of permanent VP-shunt was investigated. As functional outcomes, type of CP, ability to walk (the ratio of GMFCS levels 1 and 2), ability to communicate verbally (more than single word sentence), the complication of epilepsy, and the presence of severe visual impairment (blindness or only sensing brightness) were compared among the four groups.

Statistical analysis was performed by Mann–Whitney *U*-test or Fisher's exact test. $p < 0.05$ was considered significant.

3. Results

3.1. Participants' characteristics (Table 1)

The numbers of children were as follows: PH+/CI+ 31, PH+/CI− 8, PH−/CI+ 9, and PH−/CI− 21. In total, PH and CI were found in 39 (57%) and 40 (58%) children, respectively.

The gestational ages at birth of all participants ranged between 22 and 34 weeks (median 26 weeks), and their birth weights ranged between 412 and 1788 g (median 805 g). The birth weight of the PH−/CI+ group was significantly lower than that of the PH−/CI− group ($p = 0.03$). The gestational age of the PH−/CI+ group was the lowest among the four groups, although the difference was not significant. There were no significant differences in gender and age at investigation among the groups. In the PH−/CI+ and PH−/CI− groups, all of the children had supratentorial lesions other than PH. Unilateral periventricular hemorrhagic infarction (PVHI) was found in 2 in the PH−/CI+ group and 14 in the PH−/CI− group, and a decreased volume of bilateral white matter was found in 7 in the PH−/CI+ group and 7 in the PH−/CI− group. Among the children with PH, the ratio of the children who received VP-shunt in the PH+/CI+ group (68%) was almost the same as that in the PH+/CI− group (63%).

3.2. Functional outcomes (Table 2)

Bilateral spastic type was predominant in the three groups other than the PH−/CI− group, in which unilateral spastic type was predominant. Other types, dyskinetic and ataxic CP, were not found in the PH−/CI− group, and constituted only a minor proportion in the other three groups.

The proportion of those who could walk independently was significantly lower in the PH+/CI+ group (16%) and the PH−/CI+ group (11%) than in the PH−/CI− group (71%) ($p = 0.0001$ and 0.0043, respectively), while the proportion in the PH+/CI− group (37%) was not significantly different from that in the PH−/CI− group ($p = 0.2$). Similarly, the proportion of those who could speak at least single words was significantly lower in the PH+/CI+ group (42%) and the PH−/CI+ group (44%) than in the PH−/CI− group (90%) ($p = 0.0004$ and 0.014, respectively), while the