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Regional volumetric assessment of the brain in moderately preterm infants (30–35 gestational weeks) scanned at term-equivalent age on magnetic resonance imaging

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ABSTRACT

Background: Early volume analyses of the infantile brain may help predict neurodevelopmental outcome. However, brain volumes are not well understood in moderately preterm infants at term-equivalent age (TEA).
Aim: This study retrospectively investigated the relationship between regional brain volumes and infant gestational age (GA) at birth in moderately preterm infants (30–35 weeks' GA) on magnetic resonance imaging (MRI) at TEA.
Methods: Forty infants scanned at TEA were enrolled. Regional brain volumes were estimated by manual segmentation on MRI, and their relationship with GA at birth was assessed.
Results: The regional volumes of the cerebral hemispheres and deep gray matter were larger (Spearman $\rho = 0.40$, $P = 0.01$, and Spearman $\rho = 0.48$, $P < 0.01$, respectively), and volumes of the lateral ventricles were smaller (Spearman $\rho = -0.32$, $P = 0.04$) in infants born at a later GA. The volumes of the cerebral hemispheres of the infants born at 30 weeks' GA were significantly smaller than those born at 33 and 35 weeks' GA ($P < 0.05$). No associations were found between the volume of the cerebellum and brainstem, and GA at birth (Spearman $\rho = 0.24$, $P = 0.13$, and Spearman $\rho = 0.24$, $P = 0.14$, respectively).
Conclusions: The volumes of the cerebral hemispheres at TEA may be smaller in infants born at 30 weeks' GA, whereas those of the cerebellum and brainstem may not be correlated with GA among moderately preterm infants.

1. Introduction

Magnetic resonance imaging (MRI) has been widely used for the brain assessment of neonates and infants in clinical practice to detect and/or rule out various intracranial lesions such as hypoxic-ischemic injury, structural anomalies, infectious changes, and metabolic disorders [1,2]. Recently, not only term infants, but also preterm infants have been assessed by MRI, because preterm infants are susceptible to brain injury due to prematurity [3–7]. These assessments include a detection of signal changes indicating cystic evolution and hemorrhage, some quantitative assessment including T1-, T2- and diffusion-related values, morphometry analysis, blood flow, and magnetic resonance spectroscopy [1,8–11]; research using these methods has shown the utilities of MRI to detect the lesions at an early phase as well as to provide neurodevelopmental prognostic factors, in preterm infants.

Measuring the size or volumes of the infantile brain is one of such analyses. The size analysis, called brain metrics, includes measuring the width or diameter of the some parts of brain parenchyma such as the cerebral hemispheres, basal ganglia, thalami, and cerebellum, for predicting neurodevelopmental outcome [12,13]. On the other hand, volume analyses are much more complex. Recent studies regarding volumetric analyses have shown the volumetric increase in the brain tissue, such as the cerebral cortex and white matter, deep gray matter, cerebellum, and brainstem, from the preterm to the term periods [14–19]. In addition, volumes of the cerebral cortex and deep gray matter were reported to be smaller in very or extremely preterm infants, even scanned at term-equivalent age (TEA), compared to those in term infants [20–22]. Such knowledge is useful to predict neurodevelopment and thus to stimulate an early intervention in infants.

In the usual clinical practice, MRI examinations for preterm infants are often performed at the TEA to assess the configuration and parenchymal injuries to predict neurodevelopment [3,23]. However,

Abbreviations: MRI, magnetic resonance imaging; TEA, term-equivalent age; GA, gestational age; PCA, postconceptual age; ANOVA, one-way analysis of variance

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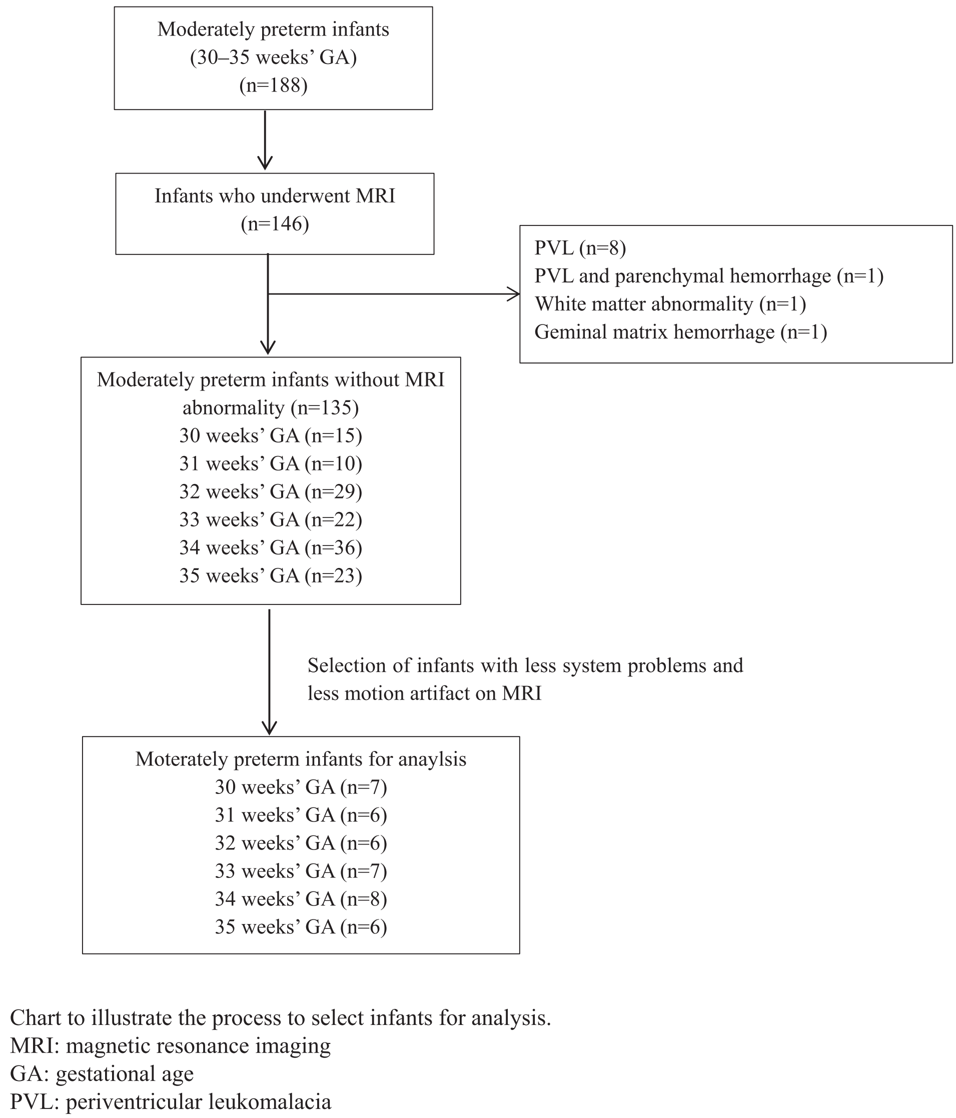

Fig. 1. Chart to illustrate the process to select infants for analysis. MRI: magnetic resonance imaging; GA: gestational age; PVL: periventricular leukomalacia.

volumetric data of the brain in moderately preterm infants (i.e., 30–35 weeks' gestational age [GA]) scanned at the TEA are still sparse. In addition, differences in regional volumes depending on the GA at birth have not been well understood among moderately preterm infants. We expected that such work would be useful to understand the variety of the volumetric changes and the regional impairment in the brain parenchyma in moderately preterm infants. The purpose of this study was, therefore, to assess the relationship between regional brain volumes and GA in moderately preterm infants scanned at TEA using a manual segmentation method on MRI.

2. Material and methods

2.1. Subjects

In our institution, brain MRI is routinely performed for preterm infants at TEA for screening. MRIs are performed for infants with any suspicion of brain abnormalities, such as hypoxic-ischemic injury, hemorrhage, congenital malformation, congenital infection, and metabolic disease; in addition, infants with any suspicious event potentially causing minor injury including the following conditions are also screened on MRI: arterial blood pH $<$ 7.35, blood sugar $\leq$ 60 mg/dl, and requirement of oxygen supplementation for management. Our radiological database was searched for infants who underwent MRI. We reviewed MRI examinations of infants between January 2006 and December 2011; moderately preterm infants (i.e., GA at birth between 30 and 35 weeks) without any abnormalities on MRI were included. MRI findings were considered as abnormal if the findings included white matter abnormality, intracranial hemorrhage, malformation, and irregular dilatation of the lateral ventricles. In total, 135 patients were identified. Because this study was conducted by manual segmentation of the brain MRI, it was difficult to analyze a large cohort. Among the 135 cases, after exclusion of infants who were either small or large for GA, six to eight cases with less systemic problems and less motion-artifact on MRI were selected according to each GA. Finally, 40 infants were included in this study, with seven infants born at 30 weeks of gestation, six at 31 weeks, six at 32 weeks, seven at 33 weeks, eight at 34 weeks, and six at 35 weeks (Fig. 1). Institutional Review Board for Clinical Research approval was not required for analysis of the clinical data.

2.2. MRI

MRI was performed with a 1.5-T MRI unit (Achieva Nova; Intera, Philips Healthcare, Best, The Netherlands) with a combination of surface coils, a knee coil, or a head coil depending on infants' condition. The infants underwent MRI at TEA (postconceptual age [PCA] at MRI,