Neuroimaging of White Matter Injury, Intraventricular and Cerebellar Hemorrhage

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KEYWORDS

• White matter injury • IVH • PWML • Cerebellar hemorrhage • cPVL • Imaging • MRI

KEY POINTS

- Cerebral ultrasound is reliable for the detection of large hemorrhages and cystic periventricular leukomalacia. MRI is more sensitive for detection of cerebellar hemorrhages, punctate and diffuse white matter injury.
- The combination of conventional imaging with sequences such as diffusion-weighted imaging, diffusion tensor imaging, and susceptibility weighted imaging can be used as an noninvasive method of improving detection and understanding of the underlying pathophysiology.
- Further studies are needed to assess neurodevelopmental outcome in infants with noncystic white matter injury.

Neuroimaging of preterm infants has become part of routine clinical care in the neonatal intensive care unit (NICU). Cranial ultrasound (cUS) is still considered the method of first choice for a sick preterm infant in the NICU. Besides the advantage of being a bedside technique, another advantage of cUS is that the examination can be performed as often as indicated, which allows visualization of the evolution of the lesion. Without sequential cUS, it ma y be difficult to make a distinction between a cyst following a periventricular hemorrhagic infarction (PVHI) (**Fig. 1**) and cystic periventricular leukomalacia (c-PVL). In the past, performing sequential cUS has also helped to recognize risk factors, including hypercapnia in germinal matrix–intraventricular hemorrhage (GMH-IVH) and hypocarbia in c-PVL.[1,2]

MRI is increasingly performed in extremely preterm infants at least once during the admission period, either during the acute phase following stabilization, at discharge,

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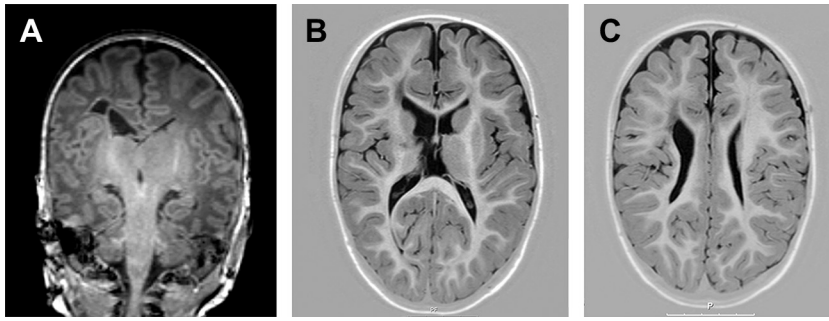

Fig. 1. MRI, T1-weighted image at term-equivalent age and at 2 years of age in a preterm born infant (gestational age 26 weeks). A single cyst is seen adjacent to but not communicating with the lateral ventricle. A PVHI is noted on sequential cUS. Asymmetry in myelination is seen (*A*). At 2 years, an interruption of the posterior limb of the internal capsule is seen as well an area of low signal intensity adjacent to the mildly dilated right ventricle (*B*, *C*). The child developed a mild unilateral spastic cerebral palsy.

and/or at term equivalent age (TEA). MRI may show lesions, which are not always easy to interpret and may be a cause of concern for parents.[3] Several studies have compared cUS and MRI contemporaneously. All investigators concluded that cUS is highly effective in diagnosing severe white matter lesions such as c-PVL and PVHI, but that MRI is necessary to identify smaller cerebellar hemorrhages (CBHs) and more subtle white matter injury (WMI), such as punctate white matter lesions (PWML) or diffuse extensive high signal intensity (DEHSI), which may further improve prediction of outcome.[4–7]

GMH-IVH

Even though WMI is now considered the main determinant of cerebral palsy (CP) later in infancy, a severe GMH-IVH is still a serious condition in preterm infants, which is still associated with a high mortality. cUS is reliable for the diagnosis of a severe GMH-IVH but less so for recognizing a small GMH outside the region of the caudate nucleus. To make a distinction between a GMH only and a GMH associated with a small IVH is more difficult with cUS than with MRI; however, the diagnosis can be made more reliably using the posterior fontanelle as an additional acoustic window.[8]

Whether a small GMH-IVH may have an effect on outcome is still uncertain. An adverse effect was recently suggested, showing a reduced cortical volume on TEA MRI.[9] However, the diagnosis of the GMH-IVH was made using cUS. Whether associated subtle WMI, not detected using cUS, played an additional or even a more important role needs to be established with prospective cUS and preferably serial MRI studies.[9–11] In the EPIPAGE (Etude Epidémiologique sur les Petits Ages Gestationnels) study, 6.8% and 8.1% of infants with a grade I and II GMH-IVH, respectively, developed CP. Once again, however, this was based on cUS instead of MRI data.[12] In another large cohort, no difference was found between infants without a hemorrhage and those with a grade I or II GMH-IVH.[13] In this study there were, again, a high percentage of infants who developed CP: 8% and 9% of infants without or with grade I to II GMH-IVH, respectively. This is likely to be explained by associated WMI not recognized with cUS.

According to Papile and colleagues,[14] a severe hemorrhage, grade III and IV, can be reliably diagnosed with cUS, even though associated WMI and/or cerebellar lesions may not be detected. As the outcome of a grade III hemorrhage (a large GMH-IVH