Neuroimaging for Neurodevelopmental Prognostication in High-Risk Neonates

Elizabeth K. Sewell, MD, MPH[a,*], Nickie N. Andescavage, MD[b]

KEYWORDS

• Neonate • Brain injury • Neurodevelopmental outcome
• Magnetic resonance imaging • Cranial ultrasound • Prematurity-related brain injury
• Hypoxic-ischemic encephalopathy • Extracorporeal membrane oxygenation

KEY POINTS

- Neuroimaging is a promising biomarker of neurodevelopmental outcomes in high-risk neonates.
- Various neuroimaging modalities exist for the detection and delineation of brain injury and maldevelopment in high-risk neonates.
- Additional knowledge on the benefits and limitations of these studies is needed to appropriately counsel families regarding neurodevelopmental outcomes.
- Advances in neuroimaging may improve neurodevelopmental outcome prediction in neonates.

INTRODUCTION

Brain injury in neonates and subsequent neurodevelopmental delays remain a significant source of morbidity despite many advances in obstetric and neonatal care. Early diagnosis of brain injury is important for prognostication as well as decision making and early treatment.[1,2] Advances in neuroimaging have improved our ability to detail and classify neonatal brain injury, although the relative value of each modality in predicting outcome remains controversial. This review discusses existing data relating neuroimaging with neurodevelopmental outcomes (NDO), specifically cranial ultrasound (CUS) imaging and brain MRI (**Table 1**).

Disclosure Statement: The authors have nothing to disclose.
[a] Department of Pediatrics, Emory University School of Medicine, Children's Healthcare of Atlanta, 2015 Uppergate Drive, Room 318, Atlanta, GA 30322, USA; [b] Department of Pediatrics, George Washington University, Children's National Medical Center, 111 Michigan Avenue Northwest, Washington, DC 20010, USA
* Corresponding author. 901 Adair Avenue, Atlanta, GA 30306.
E-mail address: elizabeth.sewell@emory.edu

Clin Perinatol ■ (2018) ■–■
https://doi.org/10.1016/j.clp.2018.05.004
perinatology.theclinics.com

Table 1
Overview of neuroimaging techniques

Technique	Advantages	Disadvantages	Clinical Application
CUS			
• Coronal and sagittal views of the brain are obtained using the anterior fontanelle as an acoustic window for the transducer • Additional views of posterior fossa using posterior and mastoid fontanelles[1,2,20,108]	• Inexpensive • Noninvasive • Performed at beside without sedation • Accurately diagnose IVH, cystic WMI, ventriculomegaly, and large strokes[1,2,20,108]	• Interoperator variability • Interreader variability, especially for small lesions • Less accurate at detecting diffuse noncystic WMI, posterior fossa lesions, myelination, or metabolic disturbances[1,2,20,108]	• Traditional neuroimaging technique that is most widely used • Ideal for screening and serial imaging, especially in sick neonates[1,2,20,108]
MRI			
• Standard T1- and T2-weighted imaging used as qualitative assessment that can evaluate abnormalities in anatomy or myelination • Variety of advanced MR techniques that use quantitative analysis[109]	• Markedly improved structural evaluation, with better visualization of peripheral cerebrum, delineation of cerebral white and gray matter, and visualization of posterior fossa.[1,110]	• Expense • Necessary technical and clinical expertise • Availability, especially in resource limited settings, as well as specialized equipment • Limited feasibility in very ill neonates • Need for transport and at times sedation[109,110]	• More commonly used in high-risk neonates • Development of MRI compatible equipment and protocols, along with technological advances, now allow for safe feasible imaging with proper thermoregulation and cardiorespiratory monitoring[109,110]

Abbreviations: IVH, intraventricular hemorrhage; WMI, white matter injury.

PREMATURITY-RELATED BRAIN INJURY

Prematurity-related brain injury (PRBI) remains a significant cause of morbidity and mortality in preterm infants. PRBI includes cerebral and cerebellar hemorrhages, posthemorrhagic hydrocephalus (PHH), and white matter injury (WMI). Some are primary destructive lesions that occur early in the neonatal period; others are consequences of these early injuries or sequelae of ongoing disruption of brain development.[3] Therefore, predicting NDO for this population depends on both the time point of assessment as well as the mode of neuroimaging.

Intraventricular Hemorrhage

Many studies have demonstrated the reliability of early screening CUS examination in the identification of intraventricular hemorrhage (IVH; **Fig. 1**).[1] The relationship of high-grade IVH with neuromotor deficits including cerebral palsy is well-established; Nongena and colleagues[4] estimated the pooled probability of abnormal 2-year motor development to be 26% with grade III IVH and 53% with periventricular hemorrhagic infarct (PVHI; also referred to as grade IV IVH), although both had wide confidence intervals. A recent meta-analysis by Mukerji and colleagues[5] assessed the association of IVH with death or moderate to severe neurodevelopmental impairment at 18 to