EDITOR'S CHOICE

Neonatal Magnetic Resonance Imaging Without Sedation Correlates With Injury Severity in Brachial Plexus Birth Palsy

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Purpose Which infants with brachial plexus birth palsy (BPBP) should undergo microsurgical plexus reconstruction remains controversial. The current gold standard for the decision for plexus reconstruction is serial clinical examinations, but this approach obviates the possibility of early surgical treatment. We hypothesize that a new technique using 3-dimensional volumetric proton density magnetic resonance imaging (MRI) without sedation can evaluate the severity of BPBP injury earlier than serial clinical examinations.

Methods Infants were prospectively enrolled prior to 12 weeks of age and imaged using 3 Tesla MRI without sedation. Clinical scores were collected at all visits. The imaging findings were graded based on the number of injured levels and the severity of each injury, and a radiological score was calculated. All infants were followed at least until the decision for surgery was made based on clinical examination.

Results Nine infants completed the MRI scan and clinical follow-up. The average Toronto score at presentation was 4.4 out of 10 (range, 0–8.2); the average Active Movement Scale score was 50 out of 105 (range, 0–86). Four infants required surgery: 2 because of a flail limb and Horner syndrome and 2 owing to failure to recover antigravity elbow flexion by age 6 months. Radiological scores ranged from 0 to 18 out of a maximum score of 25. The average radiological score for those infants who required surgery was 12 (range, 6.5–18), whereas the average score for infants who did not require surgery was 3.5 (range, 0–8).

Conclusions Three-dimensional proton density MRI can evaluate spinal nerve roots in infants without the need for radiation, contrast agents, or sedation. These data suggest that MRI can help determine the severity of injury earlier than clinical examination in infants with BPBP, although further study of a larger sample of infants with varying severity of disease is necessary. *(J Hand Surg Am. 2017;■(■):■–■. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Diagnostic II.

Key words Brachial plexus birth palsy, MRI, neonatal brachial plexus palsy, obstetric brachial plexus palsy.

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Which newborns with brachial plexus birth palsy (BPBP) would best be served by microsurgical exploration and plexus reconstruction has been a difficult question to answer without reliable objective tests to guide decision making. The surgeon must balance the fact that 70% to 90% of infants with BPBP will recover spontaneously, with the knowledge that earlier nerve repair is likely to lead to improved outcomes for those infants who do require surgery.[1–3] The benefit of early stratification of these groups would be 2-fold: first, those injuries that do require surgery could be repaired as soon as possible, and second, families of the majority of infants who will make a good recovery could have that information early on and be spared months of worry.

For adults with traumatic brachial plexus injuries, a fairly clear algorithm has been developed to guide treatment.[4–6] Adults can participate in clinical examinations of strength and sensation, and ancillary tests such as magnetic resonance imaging (MRI), electromyography, and myelography have been shown to have good predictive capacity.[7–11] Infants with BPBP, however, cannot participate well in clinical examinations, and the tests used in adults are fraught with difficulty. Electromyography and nerve conduction studies have been called "overly optimistic" in infants.[12] Various explanations have been given for this, including different innervation patterns of the infants' musculature.[13,14] Computed tomography (CT) myelography, which involves general anesthesia, a lumbar puncture, and radiation, has been shown to have high specificity for nerve root avulsion when pseudomeningoceles are seen.[15] A recent evaluation of magnetic resonance myelography found that it had a similar specificity for avulsed nerve roots as for CT myelography.[16] However, the sensitivity of both techniques remains low, and neither can evaluate infants with postganglionic neurotmesis due to poor soft tissue contrast. Furthermore, both magnetic resonance and CT myelography in infants require general anesthesia owing to the long examination times.

The current reference standard for evaluating severity in BPBP is the clinical examination repeated over several months. At our institution, the Active Movement Scale (AMS) and the Toronto Test Score are used for this evaluation[17,18] (Fig. 1). It is generally accepted that infants with global injuries and nerve root avulsions should undergo surgery by 3 months of age.[3,19] However, there is controversy regarding which infants with upper trunk injuries would benefit from surgery, with recommendations for considering biceps recovery to have failed ranging between 3 and 6 months.[2,3] Ultimately, this controversy stems from the fact that the infant's recovery pattern over time is used to differentiate between types of nerve injuries. Earlier diagnosis of the specific pattern of injury might make this clearer.

We have developed an imaging protocol of 3-dimensional volumetric proton density (PD) MRI that can be performed without sedation in infants. This technique involves no radiation, no contrast, and no anesthetic risk. The hypothesis of this study was that this new MRI sequence can evaluate the severity of BPBP injury earlier than serial clinical examinations.

MATERIALS AND METHODS

Subjects

Infants who presented to our BPBP clinic prior to 12 weeks of age were eligible for enrollment once the diagnosis of BPBP was confirmed through history and physical examination. Infants older than 12 weeks of age were excluded. By limiting the study to infants 12 weeks and younger, we hoped to capture those who would be easiest to swaddle (and thus comply with the MRI protocol), as well as those who would benefit most from the information given by early MRI. Informed consent was obtained from the legal guardians of all participants. Subjects were excluded after enrollment if they were unable to complete the MRI scan owing to excessive movement. All subjects were followed at least until the decision on whether to proceed with microsurgery was made.

Demographic data, birth history, and Narakas type[20] (Table 1) were collected during the enrollment visit. Toronto and AMS score data were collected prospectively at the enrollment visit and all subsequent routine clinic visits. It is our practice to follow infants monthly until 6 months of age or until a decision for surgery is made, then every 2 to 3 months until 1 year of age depending on the infant's recovery. After 1 year of age, the progression of clinic visits varies based on the severity of the child's injury. Toronto and AMS scores are routinely collected at each visit. The decision for surgery in this study was made by the same surgeon (A.S.B.) who also performed all of the surgeries. Surgery was considered indicated for subjects with a flail arm and Horner syndrome at 3 months and for subjects with an upper trunk injury if they failed to demonstrate antigravity elbow flexion (AMS $\geq$ 5) by 6 months. For those infants in the study who underwent microsurgical plexus exploration, the status of each nerve root was

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