Ultrasonography for neonatal brachial plexus palsy

Case report

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Ultrasonography has previously been reported for use in the evaluation of compressive or traumatic peripheral nerve pathology and for its utility in preoperative mapping. However, these studies were not performed in infants, and they were not focused on the brachial plexus. The authors report a case in which ultrasonography was used to improve operative management of neonatal brachial plexus palsy (NBPP). An infant boy was born at term, complicated by right-sided shoulder dystocia. Initial clinical evaluation revealed proximal arm weakness consistent with an upper trunk injury. Unlike MRI or CT myelography that focus on proximal nerve roots, ultrasonography of the brachial plexus in the supraclavicular fossa was able to demonstrate a small neuroma involving the upper trunk (C-5 and C-6) and no asymmetry in movement of the diaphragm or in the appearance of the rhomboid muscle when compared with the unaffected side. However, the supra- and infraspinatus muscles were significantly asymmetrical and atrophied on the affected side. Importantly, ultrasound examination of the shoulder revealed posterior glenohumeral laxity. Instead of pursuing the primary nerve reconstruction first, timely treatment of the shoulder subluxation prevented formation of joint dysplasia and formation of a false glenoid, which is a common sequela of this condition. Because the muscles innervated by proximal branches of the cervical nerve roots/trunks were radiographically normal, subsequent nerve transfers were performed and good functional results were achieved. The authors believe this to be the first report describing the utility of ultrasonography in the surgical treatment planning in a case of NBPP. Noninvasive imaging, in addition to thorough history and physical examination, reduces the intraoperative time required to determine the extent and severity of nerve injury by allowing improved preoperative planning of the surgical strategy. Inclusion of ultrasonography as a preoperative modality may yield improved outcomes for children with NBPP.

Key Words • neonatal brachial plexus palsy • muscle atrophy • ultrasonography • peripheral nerve

Neonatal brachial plexus palsy (NBPP) affects approximately 1.5 of every 1000 live births, 2 similar in incidence to cerebral palsy. A subset of NBPP patients will not recover spontaneously and will require surgical intervention to regain adequate arm function. Currently, operative exploration can confirm the extent (number of involved nerve roots) and severity of nerve injury within the brachial plexus, which is partially delineated by using preoperative modalities such as CT myelography, MRI, and electrodiagnostic studies. 3,6,10,12,14,17,18 These studies demonstrate the proximal nerve roots without showing the distal brachial plexus or terminal muscles.

Ultrasonography has been reported for use in the evaluation of compressive or traumatic peripheral nerve pathology in one study 3 and for its utility in preoperative mapping in several studies. 4,7,8 However, these studies were not performed in infants, and they were not focused on the brachial plexus. In adults, a recent study comparing MRI and ultrasound for peripheral nerve pathology did find increased sensitivity for ultrasound and equal specificity for the two. 20 That study included patients with brachial plexopathies, and 3 of the patients were misdiagnosed by MRI and 1 patient by ultrasound. Ultrasound has been reported to be useful in determining the severity of NBPP because it evaluates the muscle quantitatively. 19 However, ultrasound has not yet been used in routine preoperative evaluation of NBPP with regard to the affected musculoskeletal elements. In the present report, we describe a case in which preoperative ultrasound assessment in a patient with NBPP altered management significantly and optimized functional outcome.
Case Report

History. The birth of an infant male at term was complicated by approximately 50 seconds of shoulder dystocia. The infant was noted at that time to have decreased movement of the right upper extremity. There was no tone throughout the extremity, but the patient had preserved finger extension and flexion with preserved palmar grasp. There was some suggestion of Horner’s syndrome immediately after birth, although this quickly resolved on its own. On reassessment 2 weeks after birth, the patient had recovered some strength in his triceps and wrist extensors, but he continued to have no function in deltoid and biceps muscles. Occupational therapy began to work with the patient and included electrical stimulation and kinesitherapy. An electrodiagnostic study obtained at 4 weeks of age revealed an upper trunk plexopathy with active axon loss and the absence of voluntary motor unit activity; abnormal median sensory nerve action potentials, suggesting postganglionic nerve disruption, were also observed. At 2 months, the patient developed some tension in his triceps and biceps muscles, but with no resultant motion at the shoulder and elbow joints. At 4 months, he did exhibit elbow flexion without significant supination. The patient was noted to also have difficulty with external rotation. A repeat electrodiagnostic study performed at this time did show minimal improvement, with limited evidence of axonal continuity in the supraspinatus, biceps, and deltoid muscles.

Preoperative Examination. Magnetic resonance imaging performed at 5 months did not demonstrate any evidence of nerve root avulsions or pseudomeningoceles. Ultrasonography was also performed. This included visualization of the nerve roots and trunks from the foramina between anterior and middle scalene muscles, and laterally toward the clavicle; assessment of rhomboid and serratus muscles for atrophy; assessment of supraspinatus and infraspinatus muscles for atrophy; assessment of cervical spinal canal for root avulsion; assessment of phrenic nerve integrity by visualizing diaphragmatic motion during spontaneous respiration; and evaluation of the stability of the glenohumeral joint. This study (which was performed by an ultrasonographer without knowledge of the clinical details) revealed an echogenic interscalene neuroma involving the C-5 and C-6 roots, with potentially some involvement of C-7 (C-7 was seen at the inferior perimeter of the neuroma but was not obviously encased) (Fig. 1). The rhomboid and the serratus anterior muscles appeared symmetric without atrophy. The supraspinatus and infraspinatus muscles appeared slightly more echogenic and atrophied on the affected side (Fig. 2). Also seen was increased laxity and posterior subluxation of the right shoulder that did not reduce with external rotation (Fig. 3).

Treatment. Due to shoulder instability, the patient underwent Botox injections of the pectoralis major, subscapularis, and teres major muscles, followed by spica casting of the arm externally rotated in full abduction for 6 weeks. The patient then underwent brachial plexus surgery when he was 6 months of age. Intraoperatively, a neuroma involving the C-5 root, C-6 root, suprascapular nerve, and anterior and posterior divisions of the upper trunk was revealed, consistent with the ultrasound findings. The neuroma was not resected, as direct stimulation of the C-5 nerve root revealed deltoid contraction with abduction at the shoulder. Instead, the spinal accessory nerve was coapted to the suprascapular nerve, and an ulnar fascicle was transferred to the musculocutaneous nerve (Oberlin transfer).

Postoperative Course. Postoperatively, the patient again underwent cast placement with the shoulder externally rotated in abduction. Six weeks later, the cast was...
removed, and the patient was subsequently noted to have gained supination and improved elbow flexion. At last follow-up 5 months postoperatively, he had no evidence of any shoulder subluxation (Table 1). In addition, he was able to feed himself using the affected arm.

**Discussion**

We report a case of NBPP in which preoperative ultrasonography of the brachial plexus significantly altered surgical management of the NBPP. The typical procedure would include resection of the neuroma with graft repair from the nerve roots to the divisions of the upper trunk. This procedure has been shown to generally provide good functional results. However, it does involve complete transection of the nerves, sacrificing any potentially functional axons that remain. In addition, it would require harvesting at least one, but likely both, sural nerves.

In our patient, ultrasound revealed that both hemidiaphragms elevated and depressed equally, demonstrating no phrenic nerve palsy. The dorsal scapular nerve also appeared to be functional, given the symmetric rhomboid muscles. Also, the serratus anterior appeared to be symmetric, suggesting that the long thoracic nerve was also intact. Overall, the ultrasound provided insight into the function that was present from both the proximal C-5 and C-6 nerve roots. Given the intraoperative findings consistent with the preoperative imaging studies and the movement seen around the shoulder when it was relocated, we proceeded with a nerve transfer strategy instead of nerve graft repair. Nerve transfers have been reported to also provide good functional results in external rotation. The spinal accessory nerve was transferred to the suprascapular nerve to provide innervation to the shoulder girdle. This was undertaken due to the supraspinatus and infraspinatus muscular atrophy demonstrated on ultrasound. Then, an Oberlin transfer, coapting ulnar nerve fascicles to the biceps motor branch of the musculocutaneous nerve, was performed to provide elbow flexion and forearm supination.

![Fig. 2. Normal-appearing left supraspinatus (A) and infraspinatus (B) muscles. The supraspinatus (C) and infraspinatus (D) muscles on the affected right side appear more echogenic and atrophic.](image)

![Fig. 3. The left normal glenohumeral joint (left) is shown for comparison with the affected right glenohumeral joint (right), which displays increased laxity and posterior subluxation. Asterisks indicate the location of the glenoid, and arrows indicate the humeral head. Note that the right humeral head is shifted posteriorly (upward in the image) with respect to the glenoid as compared with the left.](image)
TABLE 1: Degree of active range of motion on the patient’s preoperative and postoperative examinations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Examination (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preop 5 Mos Postop</td>
</tr>
<tr>
<td>shoulder (0°–180°)</td>
<td></td>
</tr>
<tr>
<td>abduction</td>
<td>30 110</td>
</tr>
<tr>
<td>flexion</td>
<td>90 90</td>
</tr>
<tr>
<td>external rotation (0°–90°)</td>
<td></td>
</tr>
<tr>
<td>adduction</td>
<td>−90 60</td>
</tr>
<tr>
<td>abduction</td>
<td>0 80</td>
</tr>
<tr>
<td>elbow flexion (0°–150°)</td>
<td></td>
</tr>
<tr>
<td>adduction</td>
<td>30 150</td>
</tr>
<tr>
<td>abduction</td>
<td>90 150</td>
</tr>
<tr>
<td>elbow extension (−150°–0°)</td>
<td></td>
</tr>
<tr>
<td>supination (0°–90°)</td>
<td>−80 30</td>
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Of note, the preoperative ultrasound demonstrated significant laxity in the glenohumeral joint with posterior subluxation when clinical assessment did not reveal obvious shoulder subluxation. Ultrasound has previously been reported as a useful tool in screening for instability in this joint.15 Longstanding muscle imbalances in the shoulder girdle can result in progressive glenohumeral joint deformity and joint dysplasia. Patients can also develop functionally limiting internal rotation contractures that require subsequent surgical intervention.3 In our patient, where the instability had previously gone unrecognized, the affected arm was rotated in full abduction and casted externally for 6 weeks prior to the procedure. His arm was also casted in this position postoperatively. This contrasts sharply with the typical practice of immobilizing the arm after nerve reconstruction, which would have been to cast the arm internally rotated in full adduction. Maintaining the arm in adduction and internal rotation likely would have resulted in an exacerbation of his internal rotation contracture and caused joint dysplasia or a false glenoid.

At our institution, we have begun to use ultrasound as a preoperative evaluation tool to guide the operative plan. This has thus far proven to be useful in several circumstances. In one child, ultrasound revealed atrophy of the serratus anterior. This finding suggested that the C-5 root was incompetent, and coupled with an intraoperative assessment showing a C-5 root of equivocal integrity, nerve transfers were performed instead of graft repair using the C-5 root as donor. In several other children, increased laxity was found in the glenohumeral joint during the ultrasound examination. These patients were referred to the orthopedics department early in their management course, and they received appropriate subsequent management of the shoulder.

Although ultrasonography of adult brachial plexus nerves has been useful,13 we suggest that obtaining routine preoperative ultrasonography images in selected infants with NBPP can significantly improve their overall management. Ultrasonography is a noninvasive test that can be used to supplement information from electromyography and other imaging studies such as CT myelography and MRI. In our patient, the information gleaned from the ultrasound examination allowed us to appropriately prevent the worsening of a developing glenohumeral deformity while addressing the nerve reconstruction. We propose that ultrasonography can potentially be a valuable adjunctive study and should be considered in the overall treatment of appropriately selected NBPP patients.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Yang, Parmar. Acquisition of data: Joseph, Dipietro, Somashekar, Parmar. Analysis and interpretation of data: Joseph, Dipietro, Somashekar, Parmar. Drafting the article: Joseph, Somashekar. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Yang. Study supervision: Yang, Parmar.

References

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