

International Federation of Societies for Surgery of the Hand Committee Report: The Role of Nerve Transfers in the Treatment of Neonatal Brachial Plexus Palsy

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Nerve transfers have gained popularity in the treatment of adult brachial plexus palsy; however, their role in the treatment of neonatal brachial plexus palsy (NBPP) remains unclear. Brachial plexus palsies in infants differ greatly from those in adults in the patterns of injury, potential for recovery, and influences of growth and development. This International Federation of Societies for Surgery of the Hand committee report on NBPP is based upon review of the current literature. We found no direct comparisons of nerve grafting to nerve transfer for primary reconstruction of NBPP. Although the results contained in individual reports that use each strategy for treatment of Erb palsy are similar, comparison of nerve transfer to nerve grafting is limited by inconsistencies in outcomes reported, by multiple confounding factors, and by small numbers of patients. Although the role of nerve transfers for primary reconstruction remains to be defined, nerve transfers have been found to be effective and useful in specific clinical circumstances including late presentation, isolated deficits, failed primary reconstruction, and multiple nerve root avulsions. In the case of NBPP more severe than Erb palsy, nerve transfers alone are inadequate to address all of the deficits and should only be considered as adjuncts if maximal re-innervation is to be achieved. Surgeons who commit to care of infants with NBPP need to avoid an over-reliance on nerve transfers and should also have the capability and inclination for brachial plexus exploration and nerve graft reconstruction. (*J Hand Surg Am.* 2015;40(6):1246–1259. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)

Key words Brachial plexus, obstetrical, nerve, microsurgery, nerve transfer.

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Received for publication October 15, 2014; accepted in revised form January 21, 2015.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/15/4006-0034\$36.00/0
<http://dx.doi.org/10.1016/j.jhsa.2015.01.027>

NEONATAL BRACHIAL PLEXUS PALSY (NBPP) occurs in 1 in 1,000 newborn infants.^{1,2} Downward traction on the shoulder is associated with lesions of the upper plexus with progressive injury resulting in additional lesions of more inferior roots.^{1–4} Common clinical patterns are detailed in Table 1.⁵ Erb (or type 1) palsy involves deficits of C5 and C6, resulting in a posture of shoulder abduction, shoulder internal rotation, elbow extension, and forearm pronation. Extended Erb (or type 2) palsy extends further to C7 or C8 with additional loss of wrist extension, producing a “waiter’s tip” posture. Type 3 and 4 palsies involve the entire plexus, resulting in a flail arm without

TABLE 1. Classification of Common NBPP Presentations

| Type | Common Terminology | Root/Nerve Deficits | Typical Posture/Presentation |
|---------|------------------------------------|-----------------------------|---|
| 1 | Erb | C5-6 | Erb* |
| 2 | Extended Erb | C5-7 (or C5-8) | Erb with wrist flexion (“waiter’s tip”) |
| 3 | Pan plexus without Horner syndrome | C5-T1 | Flail arm |
| 4 | Pan plexus with Horner syndrome | C5-T1 and sympathetic chain | Flail arm with Horner syndrome |
| Klumpke | Klumpke | C8-T1 | Paralyzed hand |

*Shoulder adduction, shoulder internal rotation, elbow extension, and forearm pronation.

TABLE 2. Commonly Described Nerve Transfers for NBPP

| Donor Nerve | Nerve Type | Transfer | Abbreviation |
|--------------------|-------------------------|---|--------------|
| Intraplexus | | | |
| | Motor | Median and/or ulnar to biceps and/or brachialis | M/U-Bi/Br |
| | Motor | Radial triceps branch to axillary anterior deltoid branch | Tri-Del |
| | Motor | Medial pectoral nerve to musculocutaneous | MPN-MSC |
| | Mixed motor and sensory | Ipsilateral C7 | iC7 |
| Extraplexus | | | |
| | Motor | Spinal accessory to suprascapular nerve | SAN-SSN |
| | Mixed motor and sensory | Intercostals to musculocutaneous | ICN-MSC |
| | Mixed motor and sensory | Contralateral C7 | cC7 |

or with a Horner syndrome, respectively. Upward traction is associated with isolated lower plexus palsy, but this is rare.^{6,7}

Treatment of NBPP differs greatly from adult brachial plexus palsy given that the mechanisms, patterns, and extent of injury are disparate. Infants have a much greater potential for recovery, have shorter limbs along which axons need to regenerate, and have greater brain plasticity. In addition, the influences of growth and development with NBPP must be considered.

Although most infants recover satisfactory function spontaneously, 10% to 30% will not recover and these will benefit from surgery.^{8–11} Lesions of the upper plexus, in general, tend to be postganglionic injuries (ruptures), whereas lesions of the lower plexus are more frequently preganglionic injuries (avulsions), in which there is no spinal cord continuity and no potential for axonal regeneration.⁴ In the case of breech delivery, avulsions commonly occur in the upper roots.¹² Avulsions may be identified by computed tomography or magnetic resonance myelography.^{1,2,13–15}

Interposition nerve grafting has been the mainstay of surgical treatment.^{3,4,9,10,16–18} In the case of nerve root avulsion(s), distal targets are prioritized in the

following order: hand (if affected), elbow flexion, and shoulder abduction and rotation.^{5,8}

Nerve transfers take functioning donor nerve branches or fascicles to innervate nonfunctioning distal targets. The donor may be part of the brachial plexus on the affected side (intraplexus) or may originate outside of the affected brachial plexus (extraplexus); it may be motor, sensory, or mixed. Given that voluntary control of distal targets requires central relearning, available donor nerves are selected to best match reconstructive priorities and distal target function.^{6,7,19}

Nerve transfers have gained popularity in the treatment of adult brachial plexus palsy^{8–11,20} and many have been applied to NBPP (Table 2). For example, the combination of median/ulnar nerve fascicle to biceps/brachialis branch of musculocutaneous (M/U-Bi/Br), triceps branch of radial to axillary (Tri-Del), and spinal accessory to suprascapular (SAN-SSN) nerve transfers can be used to treat upper trunk palsy.^{4,21–24} Although a recent systematic review suggests that nerve transfer may produce superior outcomes to nerve grafting in adults,^{12,25} the presentation and treatment of NBPP differs greatly. The purpose of this report is to review the current

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