Delayed Selective Neurotization for Restoration of Elbow and Hand Functions in Late Presenting Obstetrical Brachial Plexus Palsy

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J Reconstr Microsurg 2014;30:271–274.

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Abstract

The published experience of obstetrical brachial plexus palsy (OBPP) cases with poor recovery and late neurosurgical intervention are sparse. This study included 19 cases who presented after the age of 1 year with poor recovery of elbow and/or hand function and electrophysiological evidence of reinnervation. Age at surgery averaged 41 months, and the follow-up averaged 50 months. Distal neurotization was performed for restoration of elbow flexion in 11 cases, elbow extension in 3 cases, and finger flexion and/or sensibility in 5 cases. Active elbow flexion increased from an average of 2.7 to 91.8 degrees with an average gain of 89 degrees. Active elbow extension increased from an average of 10 to 56.7 degrees with an average gain of 46.7 degrees. Although, three out of five cases (60%) showed satisfactory recovery of finger flexion, all cases scored < 2 using Raimondi score. Four cases gained protective sensation and one case gained discriminative sensation. The results of neurotization in late OBPP are variable. The best and most consistent results are obtained by necrotizing the biceps by the intercostal nerves or, in selected cases, by the flexor carpi ulnaris fascicle of the ulnar nerve. Delayed neurotization is the only way to recover sensory function in the hand.

Keywords
- delayed neurotization
- late OBPP

Late presenting obstetrical brachial plexus palsy (OBPP) is a decision-making and surgical challenge. The published experience of cases with poor recovery and late neurosurgical intervention are very sparse. Kawabata[1] stated that he is reluctant to cut nerves recovered in the brachial plexus in a patient seen for the first time and is already 1 year old and showing poor recovery. His attitude is conservative and considers neurosurgical procedures that will never result in deterioration of functions already recovered.

Grossman et al[2] stated that undertaking a late nerve reconstruction in properly selected infants with persistent severe shoulder sequelae following a birth injury to the upper plexus can be beneficial. They also had limited experience in two patients with a sensory nerve transfer. Both cases involved untreated global palsies with chronic problematic trophic charges and absent sensibility on the ulnar aspect of the hand.

In Chuang and Ma's[3] series, 10 cases had primary nerve surgery at an age older than 1 year, and all had at least one root avulsion. The most significant benefits from these late primary nerve reconstructions were nearly 100% improved shoulder and elbow functions, however, little or no improvement was achieved for the hand functions. One patient had contralateral C7 transfer to the median nerve, using a vascularized ulnar nerve graft, but without improved hand function after 3 years of rehabilitation. According to Chuang and Ma, poor hand function is not an indication for exploration at this late age.

received
February 8, 2013
accepted after revision
August 15, 2013
published online
April 1, 2014

DOI http://dx.doi.org/10.1055/s-0033-1357280.
ISSN 0743-684X.

Materials and Methods

The study included 19 patients with late OBPP who presented after the age of 1 year and whose clinical examination showed poor recovery of elbow and/or hand function together with electrophysiological evidence of reinnervation of the involved muscles. Overall 14 cases were originally of the total type palsy and 5 were of the upper type.

The average age at surgery was 41 months (range, 18 mo–4 y), and the average follow-up was 50 months (range, 12–106 mo). Out of the 19 patients studied, 14 were male patients and 5 female patients. The right upper limb was involved in 11 cases and the left in 8 cases. The brachial plexus was not explored in any case in order not to disturb the already recovered functions. Distal elective neurotization was performed for restoration of elbow flexion in 11 cases, elbow extension in 3 cases, and finger flexion and/or sensibility in 5 cases. Donor nerves included the intercostal nerves (ICNs) T3–T5, the flexor carpi ulnaris (FCU) fascicle of the ulnar nerve, and contralateral C7 root (the anterior division in two cases and the whole trunk in one case). Assessment of motor recovery was performed using the Toronto Active Movement Scale. Recovery was classified as poor, fair, good, and full when the Toronto muscle grade was 4 or less, 5, 6, and 7 respectively. Poor and fair recovery was considered unsatisfactory, while good and full recovery was considered satisfactory. Sensory recovery was evaluated using Narakas classification of sensory response in infants[4].

Results

Active elbow flexion increased from an average of 2.7 degrees preoperatively (range, 0–30 degrees) to 91.8 degrees (range, 0–130 degrees) postoperatively with an average gain of 89 degrees (range, 0–130 degrees). Using the Toronto Active Movement Scale elbow flexion increased from an average grade of 0.4 (range, 0–2) to 4.7 (range, 0–6) with an average gain of 4.3 grades (range, 0–6). Overall, 91% of cases achieved satisfactory recovery (grade 6 or more). Six cases developed flexion contracture; this is why passive elbow range of motion decreased from an average of 137.3 degrees preoperatively (range, 120–150 degrees) to 125.9 degrees postoperatively (range, 110–150 degrees). There was a positive significant correlation between follow-up duration and gain in terms of power grade ($r = 0.006$) but not in terms of motion range. There was no statistically significant difference using intercostal versus Oberlin transfer in regards to range of motion, power grade, or onset of contraction (►**Table 1**). Two representative cases are shown in ►**Figs. 1** and **2**.

Active elbow extension increased from an average of 10 degrees preoperatively (range, 0–30 degrees) to 56.7 degrees (range, 0–100 degrees) postoperatively with an average gain of 46.7 degrees (range, 0–70 degrees). Using the Toronto Active Movement Scale elbow extension increased from an average grade of 1.0 (range, 0–2) to 3 (range, 0–5) with an average gain of 2 grades (range, 0–3). Overall, elbow extension recovery was good in one case and fair in two cases.

Table 1 Recovery of elbow flexion following delayed neurotization using intercostal versus Oberlin transfer

	Intercostal nerve transfer	Oberlin transfer
Number	5	6
Average follow-up (mo)	73.4	51.5
Onset of contraction (mo)	5.6	5.7
Average active motion gain (degrees)	104	76.7
Power gain (grades)	4.6	4

Abbreviation: mo, months.

Hand sensation was absent preoperatively in three cases (60%) and trophic ulceration was present in two (40%). On the last follow-up, four cases (80%) gained protective sensation and one case (20%) gained discriminative sensation. Results of finger flexion recovery are shown in ►**Table 2**. Functional results of selective median delayed neurotization were generally poor. Although, three of five cases (60%) showed satisfactory recovery of finger flexion, using the Toronto Active Movement Scale (grade 6 or more), all cases scored < 2 using the Raimondi score. None of our cases of contralateral C 7 transfer developed donor site motor weakness. One

Fig. 1 (A) Case of neglected total left obstetrical brachial plexus palsy presented at the age of 5 years. (B) After 40 months of transfer of T3–5 intercostal nerves to the musclocutaneous nerve and contralateral C7 to the median nerve via ulnar nerve graft. Elbow flexion improved to MRC grades 0 to 4. Trophic ulcers disappeared and the hand recovered protective sensation. MRC, medical research council.

Fig. 2 After 48 months of Oberlin transfer at the age of 3 years. Elbow flexion improved from MRC grade 2 to grade 5. MRC, medical research council.

case developed parethesia on the medial side of the forearm and hand at the early postoperative period then recovered spontaneously.

Discussion

In late presenting cases of OBPP, the decision whether to explore and reconstruct the plexus or to selectively neurotize certain functions depend on whether single or multiple functions need to be restored. Multiple functions are better managed by brachial plexus exploration and reconstruction, while a single function can be better restored by selective distal neurotization without disturbing the already recovered functions. The level of evidence concerning which technique is best for a given lesion is rather poor. The use of ICNs to directly neurotize the musculocutaneous nerve continues to be a standard in infants with OBPP. Kawabata reported his experience with this procedure in OBPP and found that 84% of his patients who were operated on earlier than 5 months of age achieved a muscle grading of M4.[5] In a previous study, we have reported satisfactory recovery of elbow flexion in 93.5% of cases following ICN transfer.[6] Another alternative neurotization is transferring the FCU fascicle of the ulnar nerve (Oberlin 1) or the flexor digitorum superficialis fascicle of the median nerve (Oberlin 2) to the biceps branch of the musculocutaneous nerve. Noaman et al, obtained elbow flexion in 5 of 7 (71.4%) OBPP cases using the Oberlin ulnar nerve fascicle transfer.[7] In the present study, biceps neurotization resulted in a satisfactory elbow flexion in 91% of cases. There was no significant difference in the gain of active elbow flexion when using ICN or Oberlin transfer. In our opinion Oberlin transfer is preferred whenever C7 is intact clinically in the form of good triceps and wrist extensors, for example, cases of C5, C6 avulsion, because Oberlin transfer is more simple, less morbid, and less time-consuming.

Table 2 Recovery of finger flexion following delayed neurotization using contralateral C7 versus intercostal nerve transfer

	Contralateral C7	Intercostal nerves
Number	2	3
ROM gain (degrees)	40	33.3
Power gain (grades)	2	2.7
Toronto score	1/2 satisfactory	2/3 satisfactory
Raimondi score	< 2	< 2

The results of triceps neurotization with ICNs are relatively poor with an average gain in active elbow extension of 46.7 degrees and average gain in triceps muscle power of 2 grades. Doi et al, reported that only 32% of their adult patients achieved M3 or more after ICN transfer to the triceps.[8] In our opinion the cause of such poor results in the current series may be due to the relatively old age at surgery (average 5.8 y). In their study on restoration of elbow extension, Terzis and Kokkalis found that the timing of plexus reconstruction was a significant factor. Patients who underwent plexus reconstruction within 6 months had significantly better functional results for the triceps strength compared with those who had surgery after 6 months.[9] They concluded that in early cases, intraplexus reconstruction of the posterior cord can give excellent results. In late cases, or in cases of multiple avulsions, extraplexus motor donors that selectively target the triceps can give variable results.[9]

From ►**Table 2**, our results of contralateral C7 transfer are relatively poor compared with other reports because most of these reports included adult traumatic cases with easy postoperative cortical adaptation.[10] Also, using the anterior division only instead of the whole trunk in two cases might affect the results because the posterior division contains twice the number of motor fibers as the anterior division of the C7 root.[11]

Sensory reconstruction was performed in five cases in this study. A different opinion supported by Chuang et al, who considered sensory disturbance of the forearm and hand in late obstetric brachial plexus palsy a minor problem, and further sensory reconstruction is unnecessary. They believed that most patients become accustomed to the paralyzed hand, and do not incur any injury from hypoesthesia of the hand.[12] We do not agree with this idea, because some cases may develop trophic ulcers if neglected. Birch et al achieved sensory recovery in cases with late innervation. In their series, the lateral root of median nerve was neurotized in four cases for lost sensation over the median nerve territory of the hand, all cases regained S2 sensation.[13]

The results of different neurotization techniques in late presenting OBPP are variable. The reason for that, in our opinion, is the lack of clear sharp lines defining when and what to do. Depending basically on electrophysiological studies may be a weak point in decision-making because the presence of motor activity in a muscle has not been an accurate predictor of an acceptable level of motor recovery in that same muscle. However, we can conclude that the best and most consistent results of delayed selective neurotization are obtained by neurotizing the biceps muscle by the ICNs or,

in selected cases, by the FCU fascicle of the ulnar nerve. Functional results of selective median delayed neurotization were generally poor, however, delayed neurotization is the only way to recover sensory function in an insensate hand.

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