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Electro Physiologic Recovery of the Abductor Pollicis Brevis after Contralateral Seventh Cervical Nerve Transfer in Children with Global Brachial Plexus Avulsion

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Abstract

The restoration of intrinsic hand muscles was a forbidden zone in the treatment of Global Brachial Plexus Avulsion (GBPA). However, further studies showed the possibility of the reinnervation of the Abductor Pollicis Brevis (APB) in adult patients with GBPA after contralateral seventh cervical (cC7) to the affected Median Nerve (MN) transfer. Generally, children have stronger capacity of nerve regeneration and shorter upper limbs than adults. Therefore, the APB reinnervation after cC7-MN transfer might be better in children theoretically. In this study, we retrospectively reviewed the EMG data of 16 child patients who underwent cC7-MN transfer because of GBPA caused by trauma. The mean age when patients underwent the first stage of cC7-MN transfer was 7.6 (rang, 4 to 12) years. The mean interval from the injury to the first stage of cC7-MN transfer was 8.6 (range, 6 to 12) months. EMG showed that all patients gained electro physiologic recovery of APB - the motor unit potential (MUP) and Compound Muscle Action Potential (CMAP) appeared 16 (range, 12 to 20) months after the second stage of cC7-MN transfer. This finding indicates that it may be possible to restore the intrinsic hand muscle function of child patients with GBPA. The treatment and rehabilitation strategy for child patients with GBPA may have to be amended. However, further studies with larger sample size are needed to investigate the specific process of the recovery of intrinsic muscles and the possible affecting factors.

Keywords: Brachial plexus avulsion; Contralateral C7; Intrinsic muscle; Electromyography

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Introduction

Global Brachial Plexus Avulsion (GBPA) is one of the most severe types of peripheral nerve injuries. In the past decades, certain effects have been achieved for the function restoration of the upper limb [1-3]. However, the restoration of intrinsic hand muscles is still a forbidden zone in the treatment of GBPA. Intrinsic muscles are of great importance to hand functions, especially to fine motors of the hand [4-6]. Disabilities of the intrinsic hand muscles will significantly decline the life quality of patients, making them hardly to complete some daily tasks, like writing, eating, etc. Therefore, restoration of hand intrinsic muscles for patients with GBPA is a glamorous and arduous mission for hand surgeons and neurosurgeons at present. Encouragingly, the abductor pollicis brevis still showed the potential to be reinnervated after contralateral C7 (cC7) to the affected Median Nerve (MN) transfer in adult patients with GBPA. A previous study reported the function recovery of the thenar muscle after cC7-MN transfer in five patients with GBPA [7]. In that study, obvious contraction of APB was observed in all five patients. Inspired by that study, we reviewed the postoperative Electromyography (EMG) data of 95 adult patients who underwent cC7-MN transfer after GBPA and found that more than half patients showed electro physiologic recovery - 53 patients regained Motor Unit Potential (MUP) of APB [8]. These findings indicate that the restoration of hand intrinsic muscle function, which was overlooked before, may be still possible in patients with GBPA.

The above-mentioned findings are all observed in adult patients. In China, there is a considerable quantity of children who accepted cC7-MN transfer after GBPA. Therefore, it is meaningful to study the outcomes of cC7-MN transfer in children. Generally, children have stronger capacity of nerve regeneration and shorter upper limbs. Therefore, the outcomes of cC7-MN transfer might be better

in children theoretically [9]. In fact, a few studies has demonstrated that the recovery of wrist and finger flexion is indeed better in children than that in adult patients after cC7-MN transfer [10]. Like most studies in adult patients, few studies paid attention to the recovery of intrinsic muscles in children with cC7-MN transfer. Based on the investigation in adult patients, we hypothesized that the recovery rate of APB was higher in children than that in adult patients with GBPA. To verify this hypothesis, we performed this study.

Patients and Methods

Patients

We searched the database of the EMG record system of our hospital. Patients were included according to the following criteria:

•GBPA was caused by trauma;

•cC7–MN transfer was performed;

•the follow-up time was at least 2 years;

•Three or more times of EMG were performed postoperatively; and

•no other severe injuries except GBPA were present in the affected upper limb.

Finally, 16 patients, including 12 males and 4 females, were enrolled into this study. Six patients injured on the left side and the others injured on the right side. They accepted treatments from September 2010 to March 2016 in our hospital. The mean age when patients underwent the first stage of cC7-MN transfer was 7.6 (rang, 4 to 12) years. The mean interval from the injury to the first stage of cC7-MN transfer was 8.6 (range, 6 to 12) months.

Surgical techniques

Each patient underwent two-staged cC7-MN transfer as described in related articles [8,11]. At the first stage, the ulnar nerve with the pedicle of the superior ulnar collateral artery was isolated upward and pulled to the contralateral side through a subcutaneous tunnel as a nerve bridge connecting to the cC7. Three months later, the second stage was performed. The proximal ulnar nerve was exposed and transected at the level of the axilla. The cC7-ulnar nerve was only used to neurotize the affected MN in 10 patients (One-Nerve Group). In the rest six patients (Two-Nerve Group), the proximal ulnar nerve was transected and longitudinally dissected into two parts, which then were used to repair the MN and another one nerve - musculocutaneous nerve (MCN, four patients), or triceps motor branch of the radial nerve (TRN, two patients).

Follow-up

Patients were followed up every six months at the out-patient department. EMG test was performed. Both MUP and Compound Muscle Action Potential (CMAP) of the affect APB were recorded through a needle electrode inserting into APB. During the EMG test, patients were asked to try to simultaneously abduct the affected thumb to evoke MUP of the affected APB. To record CMAP of APB, the median nerve was percutaneously stimulated by electrodes at the midpoint of the proximal volar wrist stripes. EMG signals were acquired and recorded using a Key point® EMG system (Medtronic USA, Inc., Minneapolis, MN, USA).

Statistical analysis

Data analysis was performed on SPSS 22. The regression analysis was used to explore the possible factors (age, surgery-injury interval & surgery type) affecting the CMAP amplitude and latency of APB. The P value indicating statistical significance was set to <0.05.

Results

The mean follow-up period was 46 months (range, 24 to 81 months). All patients showed MUP and CMAP recovery of APB 16 (range, 12 to 20) months after the second stage of cC7 transfer. The overall average latency and amplitude of CMAP were 6.2ms (range, 3.0 ms to 15.0 ms) and 5.9mv (range, 0.1mv to 16.6mv), respectively. Specifically, in the one-nerve group, the average CMAP latency was 5.2ms and the amplitude was 7.0mv; in the two-nerve group, the latency and the average amplitude were 7.8ms and 4.2mv, respectively. The regression analysis showed that the age, surgery-injury interval and surgery type had no significant influence on the CMAP latency and amplitude in this study.

Discussion

The function restoration of intrinsic hand muscles in patients with GBPA has puzzled hand surgeons for decades. It was considered to be impossible to restore the intrinsic hand muscle function when the median or ulnar nerve is injured above the elbow, because of the irreversible muscle atrophy during the long time of nerve regeneration [12,13]. Therefore, the reinnervation of intrinsic hand muscles was entirely given up in the present treatment of GBPA. And this is the reason why we used ulnar nerve as the nerve bridge when performing cC7 transfer [14].

However, further studies showed that APB can be reinnervated in some patients after cC7-MN nerve transfer [7]. This finding indicates that it is potential to restore the function of hand intrinsic muscles of patients with GBPA. Therefore, it might be meaningful to preserve the affected ulnar nerve, instead of using it as Nerve Bridge when performing cC7 transfer, because most intrinsic hand muscles are controlled by ulnar nerve, which is especially essential to fine motors of the hand. At present, no case is available to investigate the recovery of all hand intrinsic muscles of patients with GBPA after nerve repair. Hence, an investigation of the recovery of APB after cC7-MN transfer is a feasible way to explore the possibility of the restoration of intrinsic hand muscles for patients with GBPA. EMG can reflect the reinnervation before visible muscle contraction appears. Given that visible function recovery is really rare in clinic, to study the electro physiologic recovery of APB is meaningful to discover the potential of function recovery of hand intrinsic muscles in patients with GBPA. In the previous study, we analyzed electro physiologic records of adult patients with cC7-MN transfer and identified age as a factor affecting MUP recovery of APB. Age is further confirmed as an affecting factor by the result that MUP was gained in APB of all patients in this study, because a child in this study was much younger than adult patients in the previous study. However, age seems not to be an important affecting factor anymore when it is in a certain range, for instance, under 14 years. And so does the injury-surgery interval. Surgery delay was not identified as an factor affecting the electro physiologic recovery of APB neither in this nor the previous study when qualitatively analyzing MUP only.

MUP and CMAP are two common indexes to evaluate the reinnervation of muscles after nerve repair. MUP reflects the electrical activity of muscle fibers under active contraction, whereas CMAP reflects the electrical activity of the muscle when its dominant nerve is electrically stimulated [15]. We used to deem MUP most suitable for evaluating the recovery of the APB. However, there is a obvious

limitation that the MUP data is not suitable for quantitative analysis, because MUP of APB was only record as "visible" or "none" in the follow-up of previous patients with cC7-MN transfer. Therefore, in this study, we also used CMAP as a complementary index for quantitative analysis. Two indices - the latency and amplitude - of CMAP were analyzed. The latency mainly reflects the function of nerve conduction and the amplitude reflects the nerve's domination of its target muscles. Theoretically, the number of nerve fibers may influence the latency and amplitude of CMAP. Indeed, the APB CMAP latency was prolonged, and the amplitude was lower in the two-nerve group. However, because the sample size is too small in this study, we cannot identify surgery type as a factor affecting the CMAP recovery of APB after cC7-MN transfer in children.

GBPA not only bring physical disability to patients, but also make some patients lose confidence in life [16]. GBPA may even influence the language development of infants by limiting their social contact with peers [17]. Therefore, restoration of the hand function is not only helpful to improve patients' ability to perform activities of daily living, but also meaningful to the mental health of child patients with GBPA. No doubt, there is still a long way from the goal of useful function restoration of hand intrinsic muscles of patients with GBPA. However, electro physiologic recovery of APB after cC7-MN transfer, especially the high recovery rate in child patients, definitely brings us new hope. With the development in the field of nerve regeneration and muscle atrophy, the solution will be closer.

Conclusion

For child patients with GBPA, it is easy to gain electro physiologic recovery of APB after cC7-MN transfer. This indicates that it may be necessary to amend the treatment and rehabilitation strategy, in which the restoration of intrinsic hand muscle function was ignored. Further studies are needed to investigate the specific process and possible affecting factors.

Limitations

Some limitations exist in this study. First and foremost, this is a retrospective study with a very small sample size from our single center. This will inevitably waken the strength of the evidence. Second, EMG record is the only evaluation data of the recovery of APB. EMG with a needle electrode can only reflect the function recovery of a part of the muscle fibers. EMG test may influenced by the environment or the condition of patients. Thus, it is necessary to gather more data, especially the clinical function outcomes, to evaluate the progress of intrinsic hand muscles recovery. Third, the electro physiologic recovery of APB only reflects the recovery potential of intrinsic muscles controlled by MN. Most intrinsic hand muscles are innervated by the ulnar nerve. Therefore, direct observations have to be performed on animal models or other type of clinical cases. At last, we failed to draw clear conclusion on affecting factors, because of the small sample size. Prospective studies of more cases from multicenters are needed for further exploration of the intrinsic hand muscle recovery of child patients with GBPA.

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