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Comparative study of phrenic nerve transfers with and without nerve graft for elbow flexion after global brachial plexus injury

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ABSTRACT

Background: Nerve transfer is a valuable surgical technique in peripheral nerve reconstruction, especially in brachial plexus injuries. Phrenic nerve transfer for elbow flexion was proved to be one of the optimal procedures in the treatment of brachial plexus injuries in the study of Gu et al.

Objective: The aim of this study was to compare phrenic nerve transfers with and without nerve graft for elbow flexion after brachial plexus injury.

Methods: A retrospective review of 33 patients treated with phrenic nerve transfer for elbow flexion in posttraumatic global root avulsion brachial plexus injury was carried out. All the 33 patients were confirmed to have global root avulsion brachial plexus injury by preoperative and intraoperative electromyography (EMG), physical examination and especially by intraoperative exploration. There were two types of phrenic nerve transfers: type1 – the phrenic nerve to anterolateral bundle of anterior division of upper trunk (14 patients); type 2 – the phrenic nerve via nerve graft to anterolateral bundle of musculocutaneous nerve (19 patients). Motor function and EMG evaluation were performed at least 3 years after surgery.

Results: The efficiency of motor function in type 1 was 86%, while it was 84% in type 2. The two groups were not statistically different in terms of Medical Research Council (MRC) grade ($p = 1.000$) and EMG results ($p = 1.000$). There were seven patients with more than 4 month's delay of surgery, among whom only three patients regained biceps power to M3 strength or above (43%). A total of 26 patients had reconstruction done within 4 months, among whom 25 patients recovered to M3 strength or above (96%). There was a statistically significant difference of motor function between the delay of surgery within 4 months and more than 4 months ($p = 0.008$).

Conclusion: Phrenic nerve transfers with and without nerve graft for elbow flexion after brachial plexus injury had no significant difference for biceps reinnervation according to MRC grading and EMG. A delay of the surgery after the 4 months might imply a bad prognosis for the recovery of the function.

Brachial plexus injury is usually very complex, because of the involvement of both spinal nerve and spinal root ruptures, with associated avulsion of one or several roots from the spinal cord.[1] Midha[2] reported the prevalence of brachial plexus injuries in the multiple trauma population to be about 1.2%. The primary goal in salvaging upper extremity function in adult patients is restoration of elbow flexion,[3–5] because most action of the upper limbs needs elbow flexion to be complete in day-to-day activity. While the recovery of shoulder abduction seemed more important than elbow flexion in infants due to the short upper limbs, nerve transfer is a valuable surgical technique in nerve reconstruction for brachial plexus injuries.[6–8] Widely used nerve transfer sources for elbow flexion of patients with global brachial plexus injuries include the intercostals,[9–12] the spinal accessory,[13–15] the contralateral C7[16] and phrenic nerve. In the study of Gu et al.,[21] a phrenic nerve transfer for elbow flexion proved to be one of the optimal procedures in the treatment of brachial plexus injuries, with the efficiency of M3 or better at 84.6% recovery.

When the phrenic nerve transfer for elbow flexion was performed, the phrenic nerve could be directly sutured on anterolateral bundle of anterior division of upper trunk or sutured via nerve graft if there was not sufficient length from the phrenic nerve to the recipient nerve. Because sometimes the whole upper trunk of brachial plexus was buried in the scar and integrated with the scar caused by trauma, mobilising could not be performed and a long segment of upper trunk was ruined, which lead to insufficient length from the phrenic nerve to the upper trunk directly. In the present study, we analysed the results of 33 patients treated with these two types of phrenic nerve transfers to restore elbow flexion after global brachial plexus injuries.

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Materials and methods

A retrospective review of 33 patients treated with phrenic nerve transfer for elbow flexion after posttraumatic global brachial plexus injury was carried out. All of them underwent surgical exploration and reconstruction of the brachial plexus in the HuaShan Hospital, Department of Hand Surgery. The inclusion criteria were global root avulsion brachial plexus injury confirmed by intraoperative exploration, patients' age between 15 and 60 years, minimum postoperative interval of 3 years and musculocutaneous nerve or anterolateral bundle of anterior division of upper trunk as the recipient nerve. The exclusion criteria included diabetes, Volkmann contracture, fracture on the affected limb, rib fracture on the affected side and brain trauma.

All 33 patients were confirmed to have global root avulsion brachial plexus injury by preoperative and intraoperative electromyography (EMG), physical examination and especially by intraoperative exploration.

Surgical technique and reconstruction methods

Each patient was placed in the supine position with the head turned towards the healthy side. We used supra- and infraclavicular incision for exploration. The entire structure of the brachial plexus was exposed and there was no nerve root in the intervertebral foramen.

The phrenic nerve could be found on the surface of the scalenus anterior and was proved fine by a nerve stimulator. We isolated the phrenic nerve sufficiently (Fig. 1) to the costal end of the scalenus and cut it off distally.

Type 1: Phrenic nerve to anterolateral bundles of anterior division of upper trunk: upper trunk of brachial nerve was exposed to the level of its divisions; a longitudinal epineurotomy was carried out in the anterior division to expose the anterolateral bundles. Then the proximal cut end of the phrenic nerve was coapted to the anterolateral bundles of the anterior division of the upper trunk end to end using 8/0 nylon.

Type 2: Phrenic nerve to anterolateral bundles of musculocutaneous nerve via nerve graft: when the whole upper trunk of brachial plexus was buried and integrated in the scar, mobilising could not be performed and a long segment of upper trunk was ruined. In the event when there was insufficient length of the phrenic nerve to the anterior division of the upper trunk, a nerve graft such as sural nerve or superficial branch of radial nerve was used as a bridge connecting the phrenic nerve and anterolateral bundles of musculocutaneous nerve end to end by 8/0 nylon.

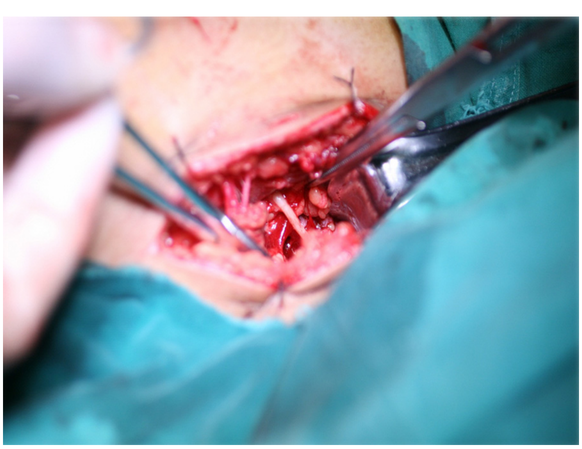

Fig. 1. The phrenic nerve was sufficiently isolated towards the deep layer to the costal end of the scalenus.

Postoperative rehabilitation

Physical therapy and electrostimulation therapy were started 6 weeks postoperatively. Patients were instructed to do elbow flexion while taking a deep breath and electrodes were put on supraclavicle and biceps muscle for electrical stimulation, which could promote nerve axons growing from the phrenic nerve to the recipient nerve by electric current.

Evaluation

The British Medical Research Council (MRC) grading system was used for motor assessment. Return of muscle power of M3 or better was regarded as effective.

EMG evaluation was performed to understand the condition of nerve regeneration. EMG showed the condition of biceps muscle contraction after nerve regeneration, which included a simple or a mixed phase, newborn potential with little motor unit and no motor unit on the EMG screen. Normal muscle contraction could be recorded as a simple or a mixed phase on the EMG screen; so a simple or a mixed phase was regarded as effective biceps reinnervation, while newborn potential with little motor unit or no motor unit implied poor recovery.

Statistical analysis

Comparisons among postoperative groups were performed using Fisher's exact test. p-Values were two-tailed and p-values < 0.05 were considered significant. All analyses were performed using Statistical Package for Social Sciences (SPSS) 15.0 software.

Results

Among the 33 patients (Table 1), there were 32 males and one female. The mean age at the time of injury was 26.5 years (range: 15–59 years). The mean follow-up period was 7.0 years (range: 4–17 years). The delay in surgery ranged from 20 days to 17 months. Of the 33 patients, 23 underwent phrenic nerve transfer within 3 months, five patients had the reconstruction between 3 and 6 months and five had the reconstruction over 6 months. The injuries were caused by traffic accidents in 25 patients, a traction injury of the upper extremity in a machine in three patients, a weight dropping on the shoulder in three, dropping from height in one and explosion in one patient. In the current series, the phrenic nerve transfer to anterolateral bundle of the anterior division of the upper trunk was used in 14 patients (45%) and the phrenic nerve via nerve graft to anterolateral bundles of musculocutaneous nerve was used in 19 patients (55%) (Table 2).

MRC grading

The grade for elbow flexion strength is summarised in Table 3. Grade three or above was regarded as an effective recovery of motor function.

In type 1 with phrenic nerve to anterolateral bundles of the anterior division of the upper trunk, there were nine cases (64%) who obtained the recovery of M4 strength of biceps muscle (Fig. 2), three patients (22%) recovered to M3, while M2 or less power was obtained in two patients (14%) after surgery. The efficiency of motor function in the group was 86%.

In type 2 with phrenic nerve via nerve graft to anterolateral bundles of musculocutaneous nerve, there were 12 cases (63%) who obtained the recovery of M4 strength of biceps muscle, four patients (21%) recovered to M3, while M2 or less power was