Phrenic nerve transfer to the musculocutaneous nerve

Phrenic nerve transfer is a major dynamic treatment used to repair brachial plexus root avulsion.

Liu et al. analyzed 72 relevant articles on phrenic nerve transfer to repair injuredbrachial plexus that were indexed by Science Citation Index. The keywords searched were brachial plexus injury, phrenic nerve, repair, surgery, protection, nerve transfer, and nerve graft. In addition, they performed neurophysiological analysis of the preoperative condition and prognosis of 10 patients undergoing ipsilateral phrenic nerve transfer to the musculocutaneous nerve in their hospital from 2008 to 201 3 and observed the electromyograms of the biceps brachii and motor conduction function of the musculocutaneous nerve. Clinically, approximately 28% of patients had brachial plexus injury combined with phrenic nerve injury, and injured phrenic nerve cannot be used as a nerve graft. After phrenic nerve transfer to the musculocutaneous nerve, the regenerated potentials first appeared at 3 months. Recovery of motor unit action potential occurred 6 months later and became more apparent at 12 months. The percent of patients recovering 'excellent' and 'good' muscle strength in the biceps brachii was 80% after 18 months. At 12 months after surgery, motor nerve conduction potential appeared in the musculocutaneous nerve in seven cases. These data suggest that preoperative evaluation of phrenic nerve function may help identify the most appropriate nerve graft in patients with an injured brachial plexus. The functional recovery of a transplanted nerve can be dynamically observed after the surgery [1)].

Case series

In a study, Socolovsky et al. sought to identify the relationship between breathing and elbow flexion in patients with a traumatic brachial plexus injury (TBPI) who undergo a phrenic nerve (PN) transfer to restore biceps flexion. More specifically, the authors studied whether biceps strength and the maximal range of active elbow flexion differ between full inspiration and expiration, and whether electromyography (EMG) activity in the biceps differs between forced maximum breathing during muscular rest, normal breathing during rest, and at maximal biceps contraction. All these variables were studied in a cohort with different intervals of follow-up, as the authors sought to determine if the relationship between breathing movements and elbow flexion changes over time.

Methods: The British Medical Research Council muscle-strength grading system and a dynamometer were used to measure biceps strength, which was measured 1) during a maximal inspiratory effort, 2) during respiratory repose, and 3) after a maximal expiratory effort. The maximum range of elbow flexion was measured 1) after maximal inspiration, 2) during normal breathing, and 3) after maximal expiration. Postoperative EMG testing was performed 1) during normal breathing with the arm at rest, 2) during sustained maximal inspiration with the arm at rest, and 3) during maximal voluntary biceps contraction. Within-group (paired) comparisons, and both correlation and regression analyses were performed.

Results: Twenty-one patients fit the study inclusion criteria. The mean interval from trauma to surgery was 5.5 months, and the mean duration of follow-up 2.6 years (range 10 months to 9.6 years). Mean biceps strength was 0.21 after maximal expiration versus 0.29 after maximal inspiration, a difference of 0.08 ($t = 4.97$, $p < 0.001$). Similarly, there was almost a 21° difference in maximum elbow flexion, from 88.8° after expiration to 109.5° during maximal inspiration ($t = 5.05$, $p < 0.001$). Involuntary elbow flexion movement during breathing was present in 18/21 patients (86%) and averaged almost 20°. Measuring involuntary EMG activity in the biceps during rest and contraction, there were statistically significant direct correlations between readings taken during normal and deep breathing, which were moderate ($r = 0.66$, $p < 0.001$) and extremely strong ($r = 0.94$, $p < 0.001$), respectively. Involuntary activity also differed significantly between normal and deep breathing (2.14 vs 3.14, $t = 4.58$, $p < 0.001$). The degrees of involuntary flexion were significantly greater within the first 2.6 years of follow-up than later.

These results suggest that the impact of breathing on elbow function is considerable after PN transfer for elbow function reconstruction following a TBPI, both clinically and electromyographically, but also that there may be some waning of this influence over time, perhaps secondary to brain plasticity. In the study cohort, this waning impacted elbow range of motion more than biceps muscle strength and EMG recordings [2].

Transferring the phrenic nerve to the musculocutaneous nerve using video-assisted thoracoscopy may lead to an increase in biceps strength to BMRC M3 or greater in most patients. Considering the deterioration in the parameters of spirometry observed in our patients and the future effects of aging in the respiratory system, it is not possible at the moment to guarantee the safety of this operative technique in the long term [3].

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.

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 ($p=0.008$).

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 [4].

Case reports

A middle age male presented a right total brachial plexus injury after motorcycle accident one year ago. Subsequent electromyographic evaluation was consistent with C5, C6, C7, C8 and T1 root avulsion. The patient was submitted to a right Phrenic nerve transfer to the musculocutaneous nerve , using sural nerve graft [5].

1)

Liu Y, Xu XC, Zou Y, Li SR, Zhang B, Wang Y. Phrenic nerve transfer to the musculocutaneous nerve for the repair of brachial plexus injury: electrophysiological characteristics. Neural Regen Res. 2015 Feb;10(2):328-33. doi: 10.4103/1673-5374.152388. PMID: 25883637; PMCID: PMC4392686.

2)

Socolovsky M, Malessy M, Bonilla G, Di Masi G, Conti ME, Lovaglio A. Phrenic to musculocutaneous nerve transfer for traumatic brachial plexus injuries: analyzing respiratory effects on elbow flexion control. J Neurosurg. 2018 Aug 24;131(1):165-174. doi: 10.3171/2018.4.JNS173248. PMID: 30141757.

3)

Cardoso MM, Gepp RA, Mamare E, Guedes-Correa JF. Results of Phrenic Nerve Transfer to the Musculocutaneous Nerve Using Video-Assisted Thoracoscopy in Patients with Traumatic Brachial Plexus Injury: Series of 28 Cases. Oper Neurosurg (Hagerstown). 2018 Dec 28. doi: 10.1093/ons/opy350. [Epub ahead of print] PubMed PMID: 30597096.

4)

Liu Y, Lao J, Gao K, Gu Y, Zhao X. Comparative study of phrenic nerve transfers with and without nerve graft for elbow flexion after global brachial plexus injury. Injury. 2014 Jan;45(1):227-31. doi: 10.1016/j.injury.2012.12.013. Epub 2013 Jan 16. PubMed PMID: 23332620.

5)

Macêdo LP, Freire Filho JBM, de Souza FHM, Almeida NS, Azevedo-Filho HRC. Transfer of the phrenic nerve to musculocutaneous nerve via sural nerve graft after total brachial plexus injury. Br J Neurosurg. 2021 Jun 26:1-2. doi: 10.1080/02688697.2021.1908518. Epub ahead of print. PMID: 34180321.