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Original Article

Neurotization of musculocutaneous nerve with intercostal nerve versus phrenic nerve – A retrospective comparative study

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ABSTRACT

Background: Brachial plexus injuries are common after both blunt and penetrating traumas resulting in upper limb weakness. The nerve transfer to the affected nerve distal to the injury site is a good option where proximal stump of the nerve is unhealthy or absent which has shown early recovery and better results. Commonly used procedures to restore elbow flexion are ipsilateral phrenic or ipsilateral intercostal nerves (ICNs) in global plexus injuries. The use of both intercostal and phrenic nerves for elbow flexion is well described and there is no definite consensus on the superiority of one on another.

Methods: All patients presented in the outpatient department of LNH and MC from January 2014 to December 2017 with pan plexus or upper plexus injury with no signs of improvement for at least 3 months were included in the study. After 3 months of conservative trial; surgery offered to patients.

Results: A total of 25 patients (n = 25) were operated from January 2015 to December 2017. Patients were followed to record Medical Research Council (MRC) grades at 3, 6, 9, 12, and 18 months. The patients achieved at least MRC Grade 3; 70% at 12 months follow-up to 80% at 18 months in the phrenic nerve transfer group. While in the ICN transfer group, it is 86% and 100% at 12 and 18 months postoperative, respectively.

Conclusion: Our study has shown better results with ICN transfers to musculocutaneous nerve, recorded on MRC grading system.

Keywords: Brachial plexus injury, Intercostal nerve transfer, Musculocutaneous nerve injury, Neurotization, Phrenic nerve transfer

INTRODUCTION

Brachial plexus injuries are common after both blunt and penetrating traumas. Treatment modalities depend on the mechanism of injury, location, as well as the timing of presentation of the patient to reconstructive surgeon.[1] In case of penetrating injuries which results in upper limb weakness, immediate exploration is recommended while a more conservative approach is chosen for blunt injuries, with the hope of spontaneous recovery as seen in neuropraxia (Sunderland Class I) due to traction mechanism.[2,3] Diagnostic modalities commonly employed include nerve conduction studies of upper limbs, computed tomography (CT) myelogram,

and/or magnetic resonance (MR) imaging.[4] There is recent advancement in diagnostic modalities with the development of high-resolution ultrasound probes and 3D MR sequences with provide more accurate information about injury and its extent.

Failure of conservative approach, that is, no signs of improvement after 3–6 months, needs surgical exploration.[5] Nerve repair either with or without nerve grafts is only possible in postganglionic injury and it yields poorer results due to long distance from injury area to motor nerves endplates, results in endplate atrophy by the time nerve reaches its target.[6] Transfer of a healthy expandable nerve to the affected nerve distal to the injury site remains a good option in cases where the proximal stump of the affected nerve is not healthy or not available as in preganglionic avulsion injuries, with early recovery and better results.[7,8] The targets of brachial plexus reconstruction are restoration of elbow flexion, finger and wrist flexion, and extension to achieve grip strength/pinch and shoulder abduction.[9]

Commonly used procedures to restore elbow flexion are fascicle transfer from the median or ulnar nerve in isolated musculocutaneous nerve injury (single/double Oberlin transfer),[10] and ipsilateral phrenic and ipsilateral intercostal nerves (ICNs) in global plexus injuries.[12,13] ICNs transfer was first described by Seddon in1963; he used two ICNs for neurotization with an intervening nerve graft. This method remains effective since then, while the actual number of ICNs to be used as donors is debatable. Most surgeons preferred using three ICNs to accurately match the number of fascicles in donor and recipient nerves.[14] Strategies to gain length of ICNs are either distal dissection up to costochondral junction or division of serratus anterior muscle.[15] The phrenic nerve contains a large number of thick motor fibers making itself a powerful donor nerve with the least effect on pulmonary functions postoperatively.[16]

Although neurotization of musculocutaneous nerve with intercostal nerves and phrenic nerve is well known time tested procedures with abundant studies in literature, there are limited data which show comparison of these when both performed at a single center by the same surgeon. Our study is one of its kinds showing comparison of the two above-mentioned donor nerves.

This study aims to compare the difference in functional outcomes of phrenic and ICN transfer when used as donor nerve for musculocutaneous nerve to restore elbow flexion.

MATERIALS AND METHODS

Patient population

All the patients who presented in the outpatient department of Liaquat National Hospital and Medical College from January 2014 to December 2017 with pan plexus or upper plexus injury with no signs of improvement for at least 3 months were included in the study. Patients with a history of rib fracture, thoracotomy, or chest tube placement are not considered for ICN transfer. After 3 months of conservative trial, NCS/EMG was done in all patients, and surgery was offered to patients with no clinical or electromyographical signs of improvement. A routine hematological workup was done for anesthesia assessment. Chest X-ray was done in all patients preoperatively to exclude phrenic nerve injury by checking diaphragm level.

Statistical analysis

Preoperative clinical examination was performed by operating surgeon with its documentation. Postoperatively, the patients followed at 3, 6, 9, 12, and 18 months. The outcome of elbow flexion is assessed through the MRC grading system by the operating surgeon and recorded. MRC Grade 3 was considered useful. Data analyzed on SPSS version 2019.

Operative technique

For ICN

We used three ICNs (3rd, 4th, and 5th) for transfer. Patients with a history of rib fracture or any surgical intervention to ipsilateral hemithorax were excluded from the study. Harvest is done through a single inframammary incision extending from the mid-axillary line to the costochondral junction. ICNs are identified by dissecting through subcutaneous tissues, pectoralis major, pectoralis minor, and intercostal muscles.[21] Intraoperative nerve stimulation is used to precisely locate the motor component. The nerve is divided anteriorly at the costochondral junction and dissected carefully. We usually divide the lateral branch to achieve length and coaptation done directly to the musculocutaneous nerve, which was explored in the proximal arm. Coaptation is done using 8-0 polypropylene suture without intervening nerve graft under microscope with shoulder abducted and arm extended to avoid undue tension during limb movements.[15,17]

For phrenic nerve

The phrenic nerve is explored through the supraclavicular incision and mobilized until it enters into thorax where it is divided and transferred directly to the musculocutaneous nerve without nerve grafts. The subjects in which nerve graft is required are excluded from the study to keep homogeneity.[12,18,19]

RESULTS

A total of 25 patients (n = 25) were operated from January 2015 to December 2017. Musculocutaneous

nerve was neurotized with ICNs in 15 patients (group 1) while in 10 patients, phrenic was used as a donor nerve (Group 2). All the patients were male. The mean age of patients was 26 ± 2 years in phrenic and 26 ± 3 in the ICNs transfer group [Figure 1]. Most of the patients lie in the 19–33 years age group in both groups. The average duration from trauma to surgery was 7.4 ± 0.9 months in the phrenic and 7.9 ± 1.5 in the ICNs group. Mechanism of trauma was blunt in three and penetrating in seven in phrenic group and, blunt in six and is penetrating in nine in the ICNs group [Figure 2]. Patients were followed to record MRC grades at 3, 6, 9, 12, and 18 months. The number of patients achieved at least MRC Grade 3, that is, elbow flexion against gravity increased from 70% at 12 months follow-up to 80% at 18 months in the phrenic nerve transfer group. While in the ICN transfer group, it was 86% and 100% at 12 and 18 months postoperative, respectively [Figure 3].

At 18 months of follow-up, MRC grade-wise distribution of patients of phrenic nerve transfer group showed one patient in MRC Grade 5, four patients in MRC Grade 4, three patients in MRC Grade 3, two in MRC Grade 2, and no patient in MRC Grades 1 and 0 (no muscle contraction at all) while in the ICN transfer group, most of the patients were in MRC Grade 4 (46% n = 7), 40% (n = 6) achieved MRC Grade 5, two patients achieved MRC Grade 3 while no patient was in MRC Grades 0, 1, and 2 [Figures 4 and 5].

No respiratory complications were observed in postoperative period in both groups.

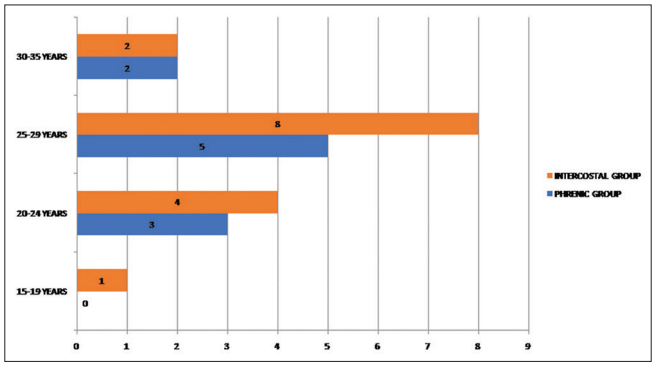

Figure 1: Age-wise distribution of patients in two groups.

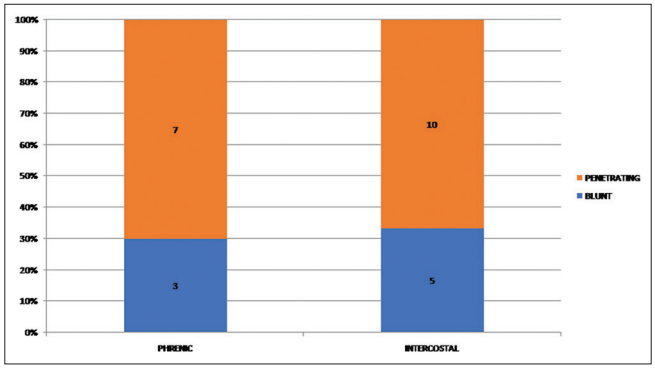

Figure 2: Mechanism of injury.

DISCUSSION

Traumatic global brachial plexus injury is a debilitating injury and more severe if dominant side is affected. It may hinder the daily activities of life including feeding, writing, and house chores. The recovery of elbow function is the elemental function with brachial plexus injury. Surgical intervention is usually deferred till 3–6 months in hope of spontaneous recovery in blunt injuries. Nerve surgery is usually advised from 6 to 9 months postinjury. Nerve surgery after 1 year is typically not advised.[20] The nerve transfer has gained importance mostly in cases of root avulsion injuries when there is the absence of proximal stump. The biceps is prime mover for elbow flexion, supplied by musculocutaneous nerve. The options available for donor nerve transfers include spinal accessory

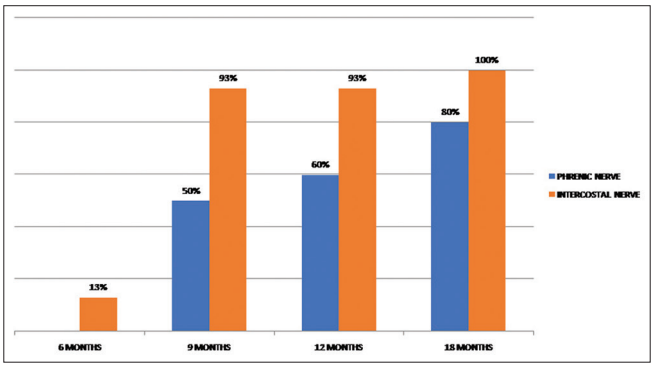

Figure 3: Percentage of patient's achieving medical research council Grade 3 of elbow flexion.

		MRC GRADE AT 18 MONTHS			
		2	3	4	5
DONOR NERVE USED	PHRENIC	2	3	4	1
	INTERCOSTAL	0	2	7	6

Figure 4: Donor nerve used * Medical Research Council grade at 18 months.

FOLLOW UP VISITS	NO. OF PATIENTS ACHIEVING AT LEAST MRC GRADE 3	
	PHENIC NERVE	INTERCOSTAL NERVE
6 MONTHS	0	2 (13%)
9 MONTHS	5 (50%)	14 (93%)
12 MONTHS	6 (60%)	14 (93%)
18 MONTHS	8 (80%)	15 (100%)

Figure 5: Percentages of patients achieving at least Medical Research Council Grade 3.

nerve, phrenic, and ICNs mostly second, third, fourth, and fifth.[9,19]

The ICN contains both motor and sensory fibers. It has approximately 1300 axons having fewer motor fibers distally rather than proximally. However, in comparison to it, the phrenic nerves contain approximately 1756 myelinated nerve fibers and are mostly motor (70.1%).[22]

As per Kang *et al*., the study showed elbow flexion MRC grade of M3 or greater at 2 years[23] comparatively to our study showing the ICN transfer group most of the patients in MRC Grade 3 (60%), with few having MRC Grade 4, while no patient in MRC Grades 0 and 5. However, a study of Cordoso *et al*. showed better results of recovered biceps strength for phrenic (≥M3) rather than ICN transfer[4] which was contradictory to our results, as shown better MRC grading for ICNs. There were no significant differences between the age of patients, mechanism of injury, and duration from injury to surgery in the two groups rendering them comparable.

It has been observed in studies that after phrenic nerve transfers, the patients develop respiratory symptoms that have comorbidities including chronic obstructive pulmonary diseases and obesity, as it may worsen dyspnea, mostly in lying position.[12] It is recommended to avoid phrenic nerve transfer in such conditions.

The phrenic nerve plays an important role in respiration; but it can be sacrificed without causing much difficulty in respiratory function in most patients. As per the study of Luedemann *et al*., the division of right phrenic nerve affects more respiration rather than the left-sided phrenic nerve transection.[11] However, most of our patients are young with good pulmonary function and intact contralateral phrenic nerve, therefore, we did not encounter any respiratory compromise after harvesting phrenic nerve for musculocutaneous neurotization.

There is no agreement about the paramount functional outcome scale for patients with brachial plexus injuries; the disabilities of the arm, shoulder, and hand (DASH) outcome questionnaire are frequently used. Wilcox *et al*. recommended that fatigue was a clinically pertinent characteristic of reinnervated muscles after surgery while in most studies, the MRC grading system is used to evaluate the outcome and a biceps strength ≥M3 is considered a good result.[16,24] For comparison between the two groups, that is, intercostal versus phrenic, we evaluated biceps strength by clinical examination and graded it on an MRC scale between 0 and 5, being it as an easy, practical, and reliable marker to assess conclusion.

Limitation of the study included retrospective design and there was no control group. It was single center with limited number of patients. Besides that, it was not blinded. Either there was no evaluation of pulmonary function or documentation of any complications. They would have strengthened our study if they were reported.

CONCLUSION

Our study has shown better results with ICN transfers to musculocutaneous transfer without any respiratory sequel. We strongly recommend use of intercostal for musculocutaneous neurotization whenever possible because of higher MRC grades achieved as compared to phrenic nerve.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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