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Brachial Plexus Injury

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ADEQUACY OF SHOULDER ABDUCTION AFTER SINGLE NERVE TRANSFER FOR BRACHIAL PLEXUS INJURY

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ABSTRACT

Objective: To describe the functional outcome of spinal accessory to supra-scapular nerve transfer procedure for shoulder abduction following closed brachial plexus injury.

Study Design: Case series.

Place and Duration of Study: Combined Military Hospital Rawalpindi from Jan 2013 to May 2014. (Nerve transfer operations during 6 months from Jan 2013 to July 2013, post-operative follow ups for 10 months till 31 May 2014).

Material and Methods: Military and civilian trauma patients presenting with loss of shoulder abduction following closed brachial plexus injury at plastic surgery outpatient department (OPD) and accident & emergency (A&E) were included in the study. For early presentations, clinical evaluations and nerve conduction studies at 3 weeks and then again at 3 months after injury were done. For late presentations clinical evaluation and nerve conduction studies (NCS) were done and compared with previous data if available. Twelve patients that showed no recovery at least 3 months post-injury underwent spinal accessory to suprascapular single nerve transfer operation between 31 Jan 2013 to 31 July 2013 (6 months). Ten months post-operative follow up was done till 31 May 2014 and the shoulder abduction power was documented.

Results: All 12 patients were males. Mean age was 29 years. Age range was 22-41 years. Average time interval from trauma to operation was 5 months. Six (50%) patients achieved medical research council (MRC) grade 3-4 power shoulder abduction. Two (17%) patients achieved grade 1-2 power. Four (33%) patients did not show any improvement at 10 months.

Conclusion: Spinal accessory (SA) to supra-scapular (SS) nerve transfer is important shoulder stabilization operation and if done at appropriate time, can result in an acceptable shoulder function.

Keywords: Brachial plexus injury, Nerve transfer, Nerve conduction studies.

INTRODUCTION

Nerve transfer is one of the important nerve injury treatment modalities to restore limb function. Primary nerve repair, nerve grafting, tendon transfer and free muscle transfer being the other possible options. Tendon transfer and free muscle transfer are at no time bar but nerve repair and transfers have a limited window period. Although the potential for sensory recovery is under no apparent time constraint[1], the Cinderella time for the motor nerve procedures closes in 1 to 1.5 years after the nerve injury. Motor nerve repair and transfers are unlikely to progress to end organs because the motor end plates lose their reinnervation potential and denervated muscle atrophies[1]. This implies improved results with early intervention. On the other hand partial nerve injuries and conduction blocks are important to differentiate as they are likely to improve by a period of observation and unnecessary exploration is more likely to do more harm than good. This opens the debate of early verses late nerve procedures. Various algorithms have been devised for closed and open nerve and brachial plexus injuries to calculate appropriate time for intervention.

Recent concept of supercharged end to side (SETS) motor nerve transfer by Barbour might help break the 12 to 18 months time barrier for motor nerve operation. He used anterior

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interosseous nerve end to pronator quadratus for end to side coaptation to deep motor fascicle to ulnar nerve in distal forearm for intrinsic hand function restoration. The idea is to augment partial recovery and/or "babysit" motor end plates until the native parent axons regenerate the target[2].

The first nerve transfer for restoration of shoulder function was reported by Lurje in 1948. He promoted phrenic nerve as donor nerve but also used triceps branch radial nerve to reconstruct axillary nerve[3]. Since then many other donor nerves have been promoted which include intercostal nerves[4-6], thoracodorsal nerve[4], medial pectoral nerve[4,7], long thoracic nerve[4], distal accessory nerve[4,5], ipsilateral C7 root[8], contralateral C7 root[9], suprascapular nerve[4],and hypoglossal nerve[10].

In 1972, Kotani[11] used the spinal accessory nerve, for the first time, as a donor motor nerve for nerve transfer in patients with brachial plexus injury. The spinal accessory nerve is a pure motor nerve adjacent to the brachial plexus in the supraclavicular region; it can be directly anastomosed with the brachial plexus[12-14].

C5 and C6 palsies occur in 15 to 20 percent of supraclavicular plexus injuries[15]. In upper brachial plexus injuries loss of elbow flexion, shoulder abduction and external rotation are the main functional deficits to be addressed. Spinal accessory nerve has been the most commonly used donor for restoration of shoulder abduction and external rotation with varying results in different centers[16-18].

The purpose of this study was to describe the usefulness of single nerve transfer procedure, spinal accessory (SA) to supra-scapular (SS) nerve transfer (fig-2,3), used to treat a single aspect of brachial plexus injury (BPI) i.e. loss of shoulder abduction.

PATIENTS AND METHODS

This study was a case series of SA to SS single nerve transfer operations to achieve shoulder abduction for closed brachial plexus injury (BPI), conducted at Combined Military Hospital Rawalpindi. Duration of study was 16 months, from 31 Jan 2013 to 31 May 2014. The fraction of BPI patients that underwent SA to SS single nerve transfer for shoulder abduction between 31 Jan to 31 July 2013 (first 6 months of study) were included in this study and their post-operative follow up for 10 months till 31 May 2014 was done. Patients from both sexes and belonging to all age groups were included in the study. All treatment modalities for BPI, other than nerve transfers, like tendon transfers and free muscle transfers were excluded from the study. Double nerve transfer like SA to SS and triceps branch radial nerve to axillary nerve were excluded from the study as it was difficult to access the functional outcome of shoulder abduction of either nerve transfer separately. BPI due to open injuries with communicating wound, like neck gun shot wounds, were also excluded from the study.

Twelve military and civilian trauma patients underwent SA to SS nerve transfer for restoration of shoulder abduction as part of closed BPI between 31 Jan to 31 July 2013 (first 6 months of study). These included patients reporting directly at plastic surgery OPD and accident & emergency (A&E), transfer from military field areas or referred from other civil and military hospitals of the country. For early presentations, pre-operative clinical evaluations and nerve conduction studies (NCS) at 3 weeks and then again at 3 months after injury were done to differentiate conduction blocks and partial nerve injury showing signs of recovery from those of complete injury. For late presentations clinical evaluation and NCS were done and compared with previous data if available.

Recovering patients were observed and those showing no recovery, at least 3 months after trauma were operated. No surgery was undertaken earlier than 3 months from time of injury. Only SA to SS single nerve transfer cases for shoulder abduction restoration were studied.

Post-operative follow up was done for 10 months till 31 May 2014 to access the improvement clinically. Shoulder abduction power according to medical research council (MRC) muscle grading scale was measured and degree of abduction recorded. Details of each patient were entered on a separate proforma noting age, sex, mode of injury, time since injury, initial clinical findings, NCS results, clinical re-assessments and NCS dates confirming no recovery at 3 months post-injury, SA to SS operation procedure details, 10 months post-operative power and degree of shoulder abduction achieved. Data were entered in SPSS version 20 and results were compiled and evaluated.

RESULTS

All 12 patients subjected to SA to SS nerve transfer (fig-2,3) were males. Mean age was 29 years with age range of 22-41 years. Mode of injury in 7 (58%) patients was due to motorcycle accidents, 4 (33%) were due to other road traffic accidents and 1 (8%) was due to fall from height. Average time interval from trauma to operation was 5 months.

Power of shoulder abduction was calculated 10 months after operation using Medical Research Council score 0 to 5.

There was good recovery in 6(50%) patients showing grade 3-4 muscle power shoulder abduction. 2 (17%) patients had grade 1-2 power but 4 (33%) patients had grade 0 no functional recovery (fig-1). None of the patients achieved grade 5 power. The average range of shoulder abduction in 6 (50%) cases achieving grade M3-4 power was 45 degrees; 30 degrees in 2 (17%) cases, 40 and 50 degrees in 1 (8%) case each, and 60 degrees in 2 (17%) cases.

DISCUSSION

Restoration of shoulder abduction and elbow flexion are important functional targets in debilitating BPI. In isolated upper plexus C5, C6 injuries, hand and elbow function may be preserved but unfortunately, isolated injuries form a small fraction of the spectrum of BPI. Root avulsions and pan BPI account for the larger fraction and with all three major upper limb nerves function loss, operative possibilities and final outcomes are not so enormous.

Although Carlstedl et al[19] have tried repairing roots into the ventral spinal cord and Bertelli & Ghizoni[20] have reported the direct replantation of the nerve graft into the spinal cord with some promising results, the surgical treatment of choice for brachial plexus root avulsion is nerve transfer.

The long distance from the injured segment of brachial plexus (BP) at the cervical spine and the neck / shoulder region to the motor end plates of the muscles in the limb has instigated us to think of borrowing neighbour nerves near the end organs for quicker functional recovery. There are more options at the shoulder from nerves supplying the trunk than there are at the elbow if all three nerves are gone. The favourite nerve transfers to achieve shoulder abduction are spinal accessory to supra-scapular nerve transfer

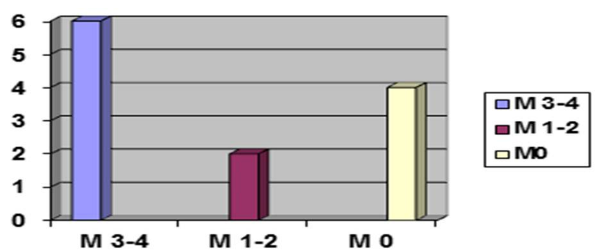

Figure-1: Shoulder abduction power achieved 10 months post-operatively.

Figure-2: Spinal accessory nerve over forceps and suprascapular nerve slinged with IV tubing. (Head end of patient inferior).

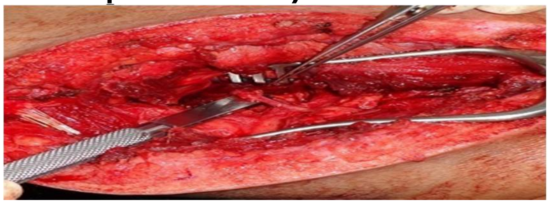

Figure-3: Coaptation of spinal accessory to supra-scapular nerve.

and/or triceps branch radial nerve to axillary nerve. The later nerve transfer, however, is only possible when the roots supplying the posterior cord are intact and triceps has grade 4 or 5 power. This, clearly, is not an option for the pan plexus injury patients. In this study we have excluded the double nerve transfers so as to be able to clearly access the functional return of individual transferred nerve.

A meta-analysis[21] of 26 studies with 965 nerve transfers for elbow flexion and 8 studies with 123 transfers for shoulder abduction was published by Merrell et al. The 2 major donor nerves were spinal accessory (41%) and intercostal nerves (ICN) (26%). Twenty two percent used multiple donor nerves and were excluded. SA donor nerve (98%) achieved better M3 or more shoulder abduction than inter-costal nerves (ICN) (56%). In analysing the recipient nerves, axillary nerve was neurotized in 58% and SS nerve in 30% of cases. Thirteen percent cases with 2 or more recipient nerves were excluded. Reinnervation of recipient SS nerve (92%) demonstrated significantly better outcomes for M3 or more shoulder abduction than axillary nerve (69%).

In this meta-analysis out of the 123 transfers, IC donor nerves were used in 26 cases. Out of these only 2 cases had intercostal to supra-scapular nerve transfers. Although Merrell has concluded by recommending shoulder restoration should focus on either a spinal accessory nerve to suprascapular nerve transfer or dual nerve transfer to both suprascapular nerve (SSN) and axillary nerve, the above 2 cases where ICNs were used for SS neurotization achieved 100% M3 or more shoulder abduction. No interposition graft was required in both these cases. We never used any ICNs for SS neurotization at our centre and the reason was easy availability of nearby spinal accessory donor nerve with average 2000 motor fibres[22] as compared to 500 motor fibre strength ICN requiring tedious dissection of 3 or 4 ICNs harvest in addition of possibility of nerve graft requirement. Merrell has pointed the figures of just 2 cases of ICN to SSN transfer resulting in 100% M3 or more shoulder abduction were too low for any conclusion but further studies in the utilization of ICNs for SSN might be illuminating.

Assessment of the recipient nerve for shoulder abduction for comparison of axillary (AX) and SS nerve is an ongoing debate. Usual donor for SS remains to be SA nerve while triceps branch radial nerve is usually used to neurotize AX due to neighbourhood availability. Recent publication by Kostas-Agnantis recommends dual nerve transfer as excellent choice for shoulder abduction and external rotation[23]. Although NCS/EMG may help, with dual nerve transfers it is difficult to access which nerve regeneration has surpassed the other in achieving the final shoulder abduction. The regeneration of each nerve can only be clearly studied in single nerve transfer cases to calculate its neurotizing potential. This was the reason of exclusion of dual nerve transfers in our study. Chuang et al used SA to SS nerve transfer for 24 cases and SA to AX transfer in 23 cases and there was no difference in results as all patients achieved 100% M3 or more shoulder abduction[5].

Chuang also reported that transfer of the SA nerve to the SS nerve produces an average of 45 degrees of shoulder abduction (range from less than 20 to 80 degrees)[5]. Bertelli et al reported average recovery of 30% of normal range of abduction but there was no external rotation recovery in any of the patients[24].

Shoulder abduction achieved in our study was on average around 45 degrees for the 6 cases where power was M 3-4. It is believed that average nerve regeneration speed is roughly 1mm per day (or almost 1 inch per month). The time for the final assessment of our results were done at 10 months postoperatively. It is thought that regeneration speed may vary in individuals and in different age groups. However, ongoing nerve regeneration may lead to improvement of abduction power over time. A longer post-operative follow up may yield more precise results.

A recent systematic review by Yang covering a 20 year period from 1990 to 2010 compared 3 treatment modalities for adult brachial plexus injuries-nerve transfers, nerve repairs, and nerve transfer and repairs. For shoulder abduction, no significant difference was found in the rates ratio (comparative probabilities of event occurrence) among the 3 methods to achieve a MRC scale score of 3 or higher or a score of 4 or higher. Although nerve transfer is somewhat more effective for elbow flexion recovery than nerve repair, no particular reconstruction strategy was found to be superior to recover shoulder abduction[25].

In our study we never tried any brachial plexus exploration for closed injuries. Wasting of supraspinatus, infraspinatus and deltoid in upper BPI lead to loss of shoulder stability. This is one of the main pre-requisites of possible useful limb function. In cases where shoulder function cannot be restored by procedures like nerve transfers, as in very late presentation, arthrodesis can achieve shoulder stability and abduction.

Chaung[5] advocated voluntary control of the shoulder abduction produces more satisfied patients than fusion.

In our 4 cases where there was no shoulder abduction after nerve transfers in 10 months, all had pan plexus injuries and we advised them to continue with physiotherapy and if there were no improvement on assessment at 18 months post-operatively, they would then be offered shoulder fusion.

CONCLUSION

SA to SS nerve transfer is important shoulder stabilization operation and if done at appropriate time can result in acceptable shoulder function.

CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

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