Mid-Term Follow-Up and Critical Analysis of the Traditional Spinal Accessory Nerve to Suprascapular Nerve Transfer

Alvaro Baik Cho*, Gustavo Bersani Silva, Raquel Bernardelli Iamaguchi da Costa, Leandro Yoshinobu Kiyohara, Luiz Sorrenti, Marcelo Rosa de Rezende, Teng Hsiang Wei and Rames Mattar Júnior

Department of Orthopedics and Traumatology, University of São Paulo, Brazil

Abstract

Introduction: The aim of this retrospective study was to evaluate the restoration of shoulder flexion and external rotation by neurotization of the Suprascapular Nerve with the Spinal Accessory Nerve (SAN-SSN) in patients with severe traction injuries of the brachial plexus involving C-5 and C-6 cervical roots.

Methods: Eleven SAN-SSN neurotizations by direct suture were performed. Inclusion criteria were: root avulsion/rupture of C-5 and C-6; suprascapular nerve and upper trunk not stimulable intraoperatively; Minimum follow-up: 12 months. Patient average age at surgery was 28 years (13-43). The mean interval between trauma and operation was 7 months (4-13). The mean follow-up was 31 months (13-60). Shoulder function was evaluated by determining the muscular strength of abduction and external rotation according to the British Medical Research Council.

Results: 73 % of the patients (8/11) did not regain useful shoulder function after SAN-SSN. Only 3 patients reached muscle strength grade 3 or greater, and in only one child the neurotization had been the isolated procedure for shoulder reconstruction. The other two patients that recovered shoulder flexion and external rotation had an upper trunk reconstruction with sural nerve grafts concurrently with SAN-SSN neurotization.

Discussion: Postoperative clinical evaluation of the SAN-SSN neurotization showed poor reestablishment of shoulder function and these results led to a critical analysis of this procedure - classic and widely popular among hand surgeons - especially when performed in isolation for restoration of shoulder flexion and external rotation. The authors recommend the transfer of accessory nerve to the Suprascapular nerve only when direct coaptation is possible and when other procedures for reinnervation of the shoulder, such as grafting to the upper trunk or radial nerve transfer to axillary nerve may be performed concurrently.

ABBREVIATIONS

TIBP: Traction Injuries of the Brachial Plexus; SAN-SSN: Neurotization of the Suprascapular Nerve with the Spinal Accessory Nerve

INTRODUCTION

Patients with severe Traction Injuries of the Brachial Plexus (TIBP) often have spinal cord avulsion or ruptures of nerve roots C5 and C6, which result in loss of active glenohumeral abduction and external rotation, together with loss of elbow flexion [1]. The main goal for the treatment of this type of injury is the restoration of elbow flexion through biceps muscle reinnervation followed by the restoration of shoulder function [1,2].

Recent evidence questions the effectiveness of the classical neurotization of the Suprascapular Nerve with branches of the Spinal Accessory Nerve (SAN-SSN), although this procedure figures among the favorites for reconstruction of shoulder function after brachial plexus injury [2-4]. The critical analysis of this classical procedure was carried out because of the difficulty to interpret published data regarding this specific neurotization.
shoulder range of motion. The force exerted by the deltoid, examined, focusing on the presence of articular contractures. in adduction and external rotation at maximum abduction were measured using pre- and postoperative shoulder functional evaluation tests. The authors critically reviewed the clinical outcome of the classical neurotization of the Spinal Accessory Nerve to Suprascapular Nerve (SAN-SSN) for shoulder reconstruction in upper-type paralysis of the brachial plexus.

**MATERIALS AND METHODS**

**Patient Population**

Eleven neurotizations of the suprascapular nerve with the terminal branch of the spinal accessory nerve by direct suture without graft interposition were performed. Inclusion criteria were: 1) root avulsion or rupture of C-5 and C-6 should be present. 2) The suprascapular nerve and upper trunk or its subsequent divisions were not stimulable intraoperatively. 3) Postoperative follow-up period of at least 01 year.

Three patients (27%) had isolated lesions of C5 and C6 cervical roots, three (27%) had C5-C6-C7 injury and five patients (46%) had avulsion of all nerve roots (C5 to T1). The average patient age at surgery was 28 years (13-43). The mean interval between trauma and operation was 7 months (4-13). The mean follow-up was 31 months (15-62). Shoulder function was measured using the Shoulder and Arm Function Test (SAFT).

**Shoulder function examination**

The assessment of shoulder function was adapted from reports made by Narakas and applied as follows: First, the Range of Motion (ROM) of passive abduction, external rotation in adduction and external rotation at maximum abduction were examined, focusing on the presence of articular contractures. None of the patients had joint contractures that limited active shoulder range of motion. The force exerted by the deltoid, supraspinatus, infraspinatus and biceps was evaluated according to the BMRC scale (British Medical Research Council) and was graded from 0 to 5.

**Surgical Technique**

The brachial plexus was exposed in all cases in the supraclavicular region through a transverse incision parallel to the clavicle and about 2 cm above it, extending from the medial border of the trapezius muscle to the lateral border of the sternocleidomastoid muscle. Root avulsions were confirmed by their absence in the intervertebral foramen. When a viable root was encountered following a post-ganglionic injury, neuroma or fibrous scar tissue was excised to obtain a usable nerve stump. Should a neuroma-in-continuity be the case, Electrical Stimulation (ES) of the brachial plexus was performed. General anesthesia did not include the use of neuromuscular blockers. In all cases, the priority of repair was to restore the function of the biceps, being the shoulder the secondary target.

The transfer of the accessory nerve to suprascapular nerve was performed when both C5 and C6 roots were avulsed and the upper trunk and the suprascapular nerve were not responsive to intra-operatively electrical stimulation. Two patients had a C5 root stump available for grafting with sural nerve to the upper trunk. We performed a direct coaptation between the accessory nerve and suprascapular nerve without tension in all cases. If the suprascapular nerve or the upper trunk was has been dislodged to the retro- or infraclavicular area due to severe traction injury, the plexus was neurolysed as distally as possible and transposed back to the supraclavicular region. The spinal accessory nerve was identified on the inside edge of the trapezius muscle close to its insertion on the clavicle with the help of an electrical stimulator. It was dissected as distal as possible and divided to the brachial plexus muscle close to its insertion on the clavicle with the help of an electrical stimulator. It was dissected as distal as possible and divided to its insertion on the clavicle with the help of an electrical stimulator. It was dissected as distal as possible and divided to its insertion on the clavicle with the help of an electrical stimulator. It was dissected as distal as possible and divided to its insertion on the clavicle with the help of an electrical stimulator.

The axillary nerve was cut as closely as possible after its separation from the posterior cord and connected to the motor branch of the radial nerve innervating the long head of the triceps in 01 case (Leechavengvong’s procedure).

Similarly the musculocutaneous nerve was dissected and the major branch innervating the biceps was identified and cut as distally as possible without tension and then sutured to a fascicle of the ulnar nerve innervating the flexor carpi ulnaris (estimated by electrical stimulation) or the median nerve in 07 cases.

In four other cases the intercostal nerve of the fifth and sixth ribs were dissected from its terminal part up to the posterior axillary line, and then transposed to the medial arm region and sutured to the largest branch of the musculocutaneous nerve innervating the biceps directly, in a tension-free manner and without graft interposition (intercostal nerve to musculocutaneous neurotization).

**RESULTS**

Seventy-three percent (73%) of the patients (8/11) did not regain useful shoulder function after SAN-SSN neurotization. Only 3 patients reached muscle strength grade 3 or greater for...
shoulder abduction or external rotation, and in only one case (13 years old boy) the SAN-SSN neurotization had been the isolated procedure for shoulder reconstruction. The other two patients that recovered shoulder abduction and external rotation had an upper trunk reconstruction with sural nerve grafts concurrently with SAN-SSN neurotization.

The average time between the neurological lesion and reconstructive surgery was 07 months for both the patients that had no functional recovery of the shoulder and the three patients that had a favorable result.

The mean age of patients achieving useful return of shoulder muscle strength was 24 years (13-39), while in the group with absence of adequate response the average age was 30 years (22-43).

The results are summarized in Table 1.

**DISCUSSION**

1. The aim of this study was to evaluate the recovery of useful shoulder function after nerve reconstruction performed as a secondary objective in the treatment of severe traction injuries of the brachial plexus. The restoration of shoulder function was based on the neurotization of the suprascapular nerve with the accessory nerve (SAN-SSN). However postoperative clinical evaluation of 11 patients followed for a mean period of 31 months showed poor animation of the shoulder muscles, especially external rotation. Many factors are intrinsically related to SAN-SSN nerve transfer results and may influence clinical outcome: The more distal the transection of the accessory nerve for directs coaptation with the suprascapular nerve, the greater the decrease in motor axons in that level [6-8]. Branches to the medial portion of the trapezius muscle leave the main accessory nerve along its trajectory, and the distal transection of the accessory nerve therefore increases the existing discrepancy between the normal number of nerve fibers of the suprascapular nerve (3800) and the accessory nerve (1700) at the proximal level [9].

2. Second, after cutting the accessory nerve, the trapezius denervation is difficult to predict and may result in internal rotation of the lower angle of the scapula that will reduce final abduction of the shoulder [2,10-15]. This inconsistent denervation is caused by the anatomical variability of the cervical plexus contribution to the accessory nerve and anatomical variations of the nerve itself, regarding the number of branches and the branching point to the medial and lower trapezius muscle that cause denervation to becomes unpredictable [12,13,16].

3. Third, the restoration of useful nerve function after the SAN-SSN neurotization requires some degree of brain plasticity for the transfer to become functionally effective, and there is evidence to suggest that the volitional control of the reinervated supraspinatus and infraspinatus muscles [17-21] may be limited. The suprascapular nerve consists of axons responsible both for the abduction and external rotation of the shoulder and this dual function could hinder the proper brain control after neurotization.

Other factors involved are the possibility of injury of the suprascapular nerve at two levels [22,23], and bone or soft tissue injuries (shoulder girdle fractures, glenohumeral instability) that occurred during the original brachial plexus trauma and could

<table>
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<th>Age (years)</th>
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<td>62</td>
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<td>C5-graft-ST; OB 1, SAN-SSN</td>
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<td>TOTAL R 4</td>
<td>ICN-BI; SAN-SSN</td>
<td>22</td>
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<td>Mean</td>
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Notes:
BMRC: British Medical Research Council grading of muscle strength; ICN-BI: Two intercostal nerves to biceps motor branch through direct coaptation; SAN-SSN: Neurotization of the spinal accessory nerve to suprascapular nerve; OB1: Neurotization of biceps motor branch with fascicles of the ulnar nerve; OB2: Neurotization of biceps motor branch with fascicles of the median nerve; EXPL: Brachial plexus exploration and neurolysis; C5: Anterior division of the C5 nerve root; ST: Superior trunk

**Table 1: Study Results.**
limit the final function obtained after the nerve transfer [24,25].

Based on our findings the recovery of active flexion and external rotation of the shoulder after SAN-SSN neurotization as an isolated procedure for shoulder reconstruction in adults with severe traction injuries of C-5 and C-6 nerve roots are unpredictable. The authors recommend the transfer of accessory nerve to the suprascapular nerve only in patients with good hand function, when direct coaptation is possible and when other procedures for reinnervation of the shoulder, such as grafting to the upper trunk or radial nerve transfer to axillary nerve may be performed concurrently.

CONCLUSION

Postoperative clinical evaluation of the SAN-SSN neurotization showed poor reestablishment of shoulder function and these results led to a critical analysis of this procedure - classic and widely popular among hand surgeons especially when performed in isolation for restoration of shoulder flexion and external rotation.

REFERENCES