Somsak's Procedure: A Review

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Abstract

Somsak's procedure is a type of intraplexal nerve transfer technique in which the nerve to the long head of triceps is neurotized to the anterior branch of the axillary nerve, via a posterior approach, to restore function to the deltoid muscle, thus enabling shoulder abduction and external rotation. It was a new technique of neurotization which provided better outcomes as compared with the previously available techniques, and at present it is the method of choice for deltoid muscle reinnervation for shoulder abduction. The surgical procedure, its development, and related outcomes in literature are discussed.

Keywords
- axillary nerve
- brachial plexus injury
- nerve to long head of triceps

Introduction

Upper trunk brachial plexus injury (BPI) has been defined as C5 and C6 root injury, with or without C7 injury. Patients suffering from upper trunk BPI present with loss of motor function in shoulder elevation/abduction/external rotation and elbow flexion. Nerve transfer technique (neurotization) reduces the distance to reinnervate target organs by delivering (expendable) motor and/or sensory axons close to the denervated end organs. Somsak's procedure is a type of intraplexal nerve transfer technique in which the nerve to the long head of triceps is neurotized to the anterior branch of the axillary nerve, via a posterior approach (►**Fig. 1**), to restore function to the deltoid muscle, thus enabling shoulder abduction and external rotation.[1,2]

History

Historically, axillary nerve neurotization had been performed through an anterior approach, utilizing donor nerves such as the phrenic nerve, distal spinal accessory nerve, intercostal nerves, or medial pectoral nerve. Due to the long course that the donor has to traverse, this approach not only requires nerve grafts, but also results in dilution of nerve fibers entering the deltoid muscle. In response to suboptimal outcomes of nerve grafting and prior nerve transfer techniques,[3-7] Somsak Leechavengvongs devised a novel method of neurotization. He along with Witoonchart et al[1] did an anatomical feasibility study in 2003 investigating the potential use of a branch of the radial nerve to the long head of triceps as a donor to the anterior branch of the axillary nerve. The authors found the diameter, the number of axons, and the anatomical proximity of the nerve to the long head of the triceps to be suitable for the same. They followed it up with a clinical study on seven patients with C5 and C6 avulsion injuries who had satisfactory outcome.[2] And thus was devised what is today known as Somsak's procedure, with some modifications made in the ensuing years.

Surgical Technique

Patient is positioned prone or in a semilateral position with upper arm over the thorax.[2] A longitudinal incision is made on the posterior aspect of the arm from the acromion to the midarm region. The deltoid is retracted laterally. Axillary nerve is identified in the quadrilateral space, bounded above by the teres minor muscle, below by the teres major muscle, laterally by the humerus, and medially by the long head of triceps muscle. It emerges from the quadrilateral space and gives off branches to teres minor muscle. The nerve then divides into 1 to 3 anterior branch(es) and one posterior branch. The anterior division of the axillary nerve is carefully dissected from the posterior division. It is dissected intraneurally as proximal as possible and transected. Through the inferior part of incision, the long and lateral heads of triceps muscle are separated and

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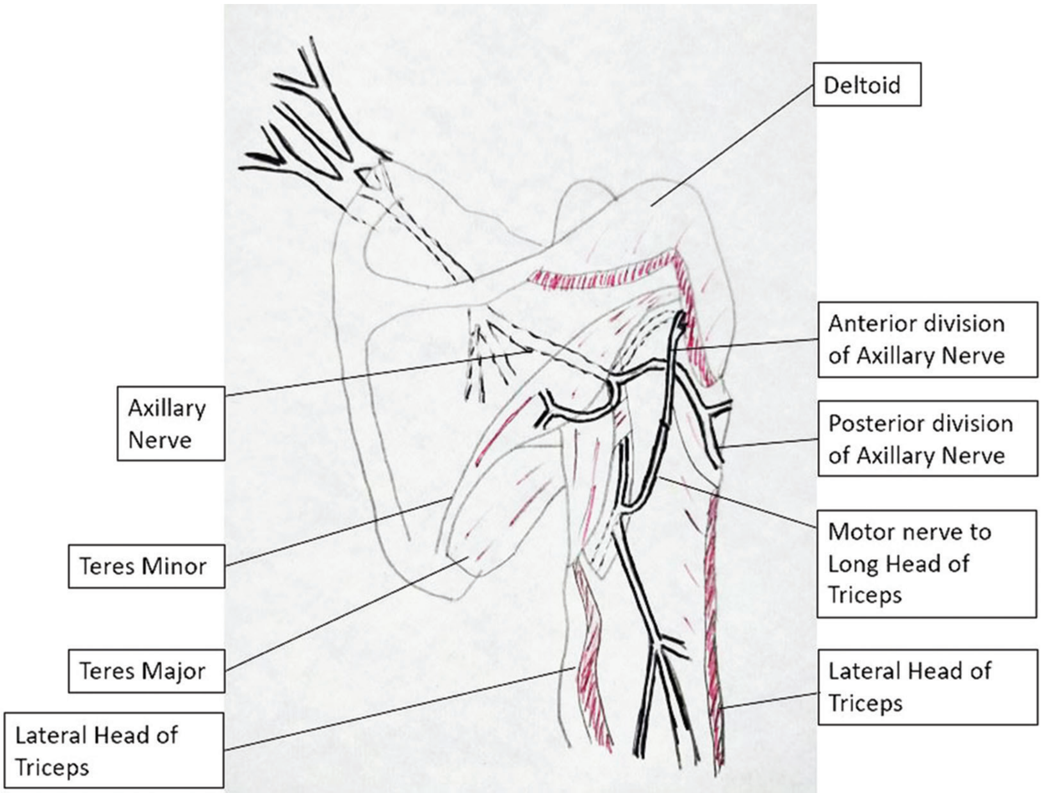

Fig. 1 Posterior view depicting the anastomosis between the nerve to long head of triceps muscle to the anterior division of the axillary nerve, along with surrounding anatomical structures.

the radial nerve visualized in the triangular space. If needed, release of the teres major fascia can be performed to increase mobilization of the donor triceps branch. The longest possible length of the motor branch to long head of triceps is dissected, and sectioned as distally as possible. It is then flipped to be attached with the anterior branch or branches of the axillary nerve. Direct repair is accomplished without tension under an operating microscope using 10–0 nylon sutures. A tension-free repair is verified by full passive range of motion of the shoulder intraoperatively. The patients' arm is placed in a sling for 10 days[8,9] to 3 weeks[2] after surgery to allow for soft tissue healing and maturation of the nerve coaptation. Patients are followed up 10 and 30 days after surgery, then every 3 months for a year, and then every 6 months. The patients receive regular physiotherapy.

An axillary approach has also been described, with the patient's arm in abducted and externally rotated position.[10] The authors argued that dissection of the branches of the axillary nerve was easier and safer with all major vessels being under direct visual control.

Discussion

Timing of Surgery

The first electromyogram (EMG) and nerve conduction velocity (NCV) are performed 6 weeks following trauma, and the second EMG/NCV studies are performed 3 to 4 months after injury if indicated. If no recovery is identified on the EMG/NCV or during physical examination, then a computed tomography (CT) myelogram or magnetic resonance myelogram is obtained and plexus exploration is performed.

It is also commonly accepted that time to surgery will affect outcome after nerve repair, grafting, or transfer.[11] Bonnard et al[12] demonstrated that a delay of 6 months resulted in a decrease in the number of successful outcomes following nerve grafting. Terzis and Barmpitsioti1[13] reported that patients with a denervation time of less than 4 months had improved shoulder function after nerve grafting. Because the donor nerve is closer to the target muscle, better motor recovery should be expected after delayed repair with a nerve transfer procedure when considering the time for nerve regeneration across a longer nerve graft segment. Although Bertelli and Ghizoni[14] did report success with nerve transfers performed in patients greater than 9 months from injury, Lee et al[11] noted a significant decrease in deltoid motor strength after 9 months with no patients obtaining useful recovery after 12 months.

Concerns Regarding Axillary Nerve

Zao et al,[3] on the basis of an anatomical study on cadavers, divided the axillary nerve into three segments in relation to the subscapularis muscle. Zone 1: Proximal to the subscapularis muscle, a single trunk of the axillary trunk, with nerve fascicles to the deltoid muscle identified at its lateral part. Zone 2: In front of the subscapularis muscle, the axillary nerve divides into the lateral and medial fasciculi groups. Zone 3: Distal to the subscapularis muscle, the nerve divides into anterior and posterior branches, which are continuations of the lateral and medial fasciculi groups, respectively. They found that the anterior branch contains all fibers that innervate to the anterior and middle deltoid muscle, while in majority of the specimens, the posterior branch supplies nerve fibers to the posterior deltoid muscle along with nerve fibers to the teres minor and cutaneous sensory fibers. They concluded that to give the highest percentage of reinnervation of the deltoid muscle, the best approach is to match the donor nerve to the lateral fasciculi group, which continues as the anterior branch of the axillary nerve.

Witoonchart and Leechavengvongs in their anatomical study[1] also reiterated that the posterior branch of the axillary nerve contained nerve fibers to the teres minor, to the cutaneous sensory fibers, and in 70.8% of the specimens examined, to the posterior part of the deltoid muscle. Concern that using the anterior branch of the axillary nerve as a recipient will not always result in reinnervation of the posterior part of the deltoid was alleviated by previous studies of electromyographic and mechanical data that suggested that the posterior part of the deltoid played no role during elevation in the plane of scapula.[15]

Somsak differed from Zao et al in that he proposed reinnervation of the axillary nerve in the zone 3 (distal to the subscapularis muscle). This avoided the decrease in the motor fibers innervating the deltoid due to the misdirection of the regenerated axons into the superior lateral brachial cutaneous nerve and teres minor.[1]

Concerns Regarding Radial Nerve

Travill[16] showed that among the three heads of the triceps the long head played the least important role, whereas the medial and the lateral heads showed a considerable amount of activity during elbow extension. Thus, if the nerve to the long head of the triceps is transferred, the functional loss will be minimal and will be compensated by the remaining two heads of triceps and the teres muscle group. Leechavengvongs[1,2] showed that the nerve to the long head of triceps could directly reach the level of the anterior branch of the axillary nerve without nerve grafting. They further reported that while the anterior branch of the axillary nerve contains approximately 2,704 myelinated axons, the nerve to the long head of the triceps contains approximately 1,233 myelinated axons. This enables potential reinnervation of 45.5% of the original motor neuron pool. A previous study by Totosy et al[17] has shown that normal muscle force could be achieved with a minimum of 30% of the original motor neuron pool.

Triceps motor branch activity is synergistic to shoulder abduction and external rotation, and this facilitates the postoperative re-education of the deltoid.[18]

Concomitant lesions of the triceps long head motor branch and axillary nerve have also been reported.[19,20] After intraneural dissection and electrical stimulation, these authors found that the triceps long head motor branch most often arose from the axillary nerve rather than from the radial nerve. This explains why the triceps long head motor branch may be affected in patients with an axillary nerve injury. Other authors have since reported concerns with a short donor nerve with harvesting of the branch to the long head.[9] They have suggested that the branch to the medial head has the benefit of being a long donor allowing an easier tension-free coaptation.[21] Recently, Al-Meshal et al[22] dissected 25 cadavers and found that the long head of the triceps received a single branch in 23 cases (92%) and double branches in 2 cases (8%) only. The medial head had a single branch in 22 cases (88%) and double branches in 3 cases (12%). The lateral head was the most bulky one and received more than one branch in all cases (100%), ranging from two to five branches. They thus concluded that transfer of the most proximal branch to the lateral head of the triceps seems to be most apt for deltoid muscle innervation, although this has not been backed by a clinical study. More often than not, intraoperative patient anatomy will dictate the choice of the radial nerve branch donor.

Combined with Other Neurotization Techniques

Paralysis of the deltoid and rotator cuff is seen commonly in patients with upper BPIs. Restoration of shoulder stabilization and elevation/abduction/external rotation are the second most important priorities in primary reconstruction of BPI, after elbow flexion.[14,23-25] A stable shoulder is required to prevent the elbow flexion force from being dissipated into proximal humeral displacement. It is difficult to get satisfactory shoulder abduction by one or multiple tendon/muscle transfers.[18] In addition to the axillary nerve (innervation of the deltoid muscle), suprascapular nerve (innervation of the supra- and infraspinatus muscles of rotator cuff), is also compromised in C5–C6 injuries.[23,25] Nerve transfers to both the suprascapular and axillary nerves may restore the function of rotator cuff and deltoid muscles which may abduct/elevate/externally rotate, and stabilize the shoulder joint.

Outcome

In 2011, Garg et al[23] performed a systematic analysis comparing the results of nerve transfers and nerve grafts in patients with traumatic upper plexus (C5–C6 or C5–C7) palsy. They showed more favorable outcomes in patients with nerve transfers than in patients undergoing neurorrhaphy and nerve grafting.

In the first clinical study by Leechavengvongs et al[2] using this technique, they evaluated seven patients with an average follow up of 20 months; all patients recovered deltoid power against resistance (Medical Research Council [MRC] grade 4). The average shoulder abduction was 124 degrees. No notable weakness of elbow extension was observed. Bertelli et al,[9] in their series of nine patients who underwent axillary neurotization using nerve to the medial head of triceps, reported that all patients recovered deltoid function while maintaining full active elbow extension. They also reported an improvement in abduction strength from 40 to 60% of normal strength, and an improved endurance in abduction from 25 to 65% that of the normal side following surgery. Similar good outcomes have been described by various authors using triceps nerve transfers for treatment of isolated axillary nerve injuries.[19,26,27] Chim et al[28] reported their results of this procedure in pediatric population. Six patients, ranging in age from 10 to 17 years, underwent Somsak's procedure and were followed up for 38 months. The average postoperative MRC grading of deltoid muscle strength achieved was 3.6 ± 1.3. McRae et al[29] reported similar good outcomes in their series of five patients (average age 6.3 years). Lee et al[11] studied factors affecting outcomes of Somsak's procedure. They concluded that the delay from injury to surgery, age of the patient, and body mass index (BMI) of the patient were the most important factors, in that order, that affected the outcome of this procedure. The average deltoid strength decreased dramatically if the treatment was delayed for more than 9 months. No patient whose treatment was delayed 12 months after injury regained useful recovery of deltoid muscle strength. Outcome seems to be better in patients younger than 25 years. This has been reaffirmed by various other authors.[12,30] Lee at al[11] also identified BMI as one of the factors affecting the deltoid strength. They postulated that because patients with higher BMI do not necessarily have larger deltoid muscles, they need more deltoid strength to elevate their heavier arms.

Leechavengvongs et al[8] in a series of 15 patients combined their technique of Somsak's transfer (the nerve to the long head of the triceps to the anterior branch of the axillary nerve) along with transfer of spinal accessory nerve to the suprascapular nerve and a part of the ulnar nerve to the biceps motor branch. All of their patients achieved useful functional recovery. At an average of 32 months follow-up, all patients had recovered full elbow flexion: 13 scored MRC grade 4 and 2 scored grade 3. The mean shoulder abduction was 115 degrees. No clinical donor nerve deficits were observed. Bertelli et al[14] similarly did combined nerve transfers in 10 patients and reported favorable outcomes. They reported an abduction recovery angle of 92 degrees (range: 65–120) and an average external rotation of 93 degrees, when measured from full internal rotation. All patients achieved MRC grade 3 or more grade power in elbow flexion and shoulder abduction. Kostas et al[31] reported their series of nine patients with age ranging from 21 to 35 years (average, 27.4 years), whose interval between injury and surgery ranged from 4 to 11 months (average, 7.2 months). All patients received combined suprascapular and axillary nerve neurotization. Postoperative shoulder abduction reported was 112.2 degrees (range: 60–170), while shoulder external rotation was 66 degrees (range: 35–110). Bhandari et al[32] reported surgical outcomes following combined nerve transfers in upper BPIs. Axillary nerve neurotization was done in seven patients using radial nerve branch to the long head triceps. All patients had fair (MRC grade 2+ to 3) or good results (MRC grade 3+). The achieved abduction averaged 95 degrees. Recently, favorable outcome has also been reported by using da Vinci robot for Somsak's procedure.[33]

Conclusion

Somsak's procedure provided a new technique of neurotization which provided better outcomes as compared with the previously available techniques, and at present it is the method of choice for deltoid muscle reinnervation for shoulder abduction. The donor nerve is the radial nerve branch to either the long head or medial head of triceps. It is co-apted to the anterior division of the axially nerve. A combined approach along with suprascapular nerve reinnervation and restoration of elbow flexion is currently applied for upper trunk BPIs.

Presentation at a Meeting
This report has not been published previously or presented in part/or full in a conference/seminar.

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ConflictiS of Interest
None declared.

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