Anterior deltopectoral approach for axillary nerve neurotisation

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ABSTRACT

Purpose. To report outcome of axillary nerve neurotisation for brachial plexus injury through the anterior deltopectoral approach.

Methods. Nine men aged 20 to 52 (mean, 27.8) years with brachial plexus injury underwent axillary nerve neurotisation through the anterior deltopectoral approach. Three of the patients had complete avulsion of C5-T1 nerve roots. The remaining 6 patients had brachial plexus injury of C5-C6 nerve roots, with associated subluxation of the glenohumeral joint, atrophy of the supraspinatus, deltoid and elbow flexors. They had no active shoulder abduction, external rotation, and elbow flexion. The pectoralis major and minor were cut and/or retracted to expose the underlying infraclavicular plexus. The axillary nerve was identified with respect to the available donor nerves (long head of triceps branch, thoracodorsal nerve, and medial pectoral nerve). In addition to the axillary nerve neurotisation, each patient had a spinal accessory nerve transferred to the suprascapular nerve for better shoulder animation.

Results. Patients were followed up for 24 to 30 (mean, 26) months. In the 3 patients with C5-T1 nerve root injuries, the mean active abduction and external rotation were 63º and 20º, respectively, whereas the mean abduction strength was M3 (motion against gravity). In the 6 patients with C5-C6 nerve root injuries, the mean active abduction and external rotation were 133º and 65º, respectively, whereas the strength of the deltoids and triceps was M5 (normal) in all. In 4 patients with the pectoralis major cut and repaired, the muscle regained normal strength.

Conclusion. The anterior deltopectoral approach enabled easy access to all available donor nerves for axillary nerve neurotisation and achieved good outcomes.

Key words: axilla; brachial plexus neuropathies; nerve transfer

INTRODUCTION

Shoulder abduction is important for upper limb functions, as more distal functions depend on a
Reconstruction of both axillary and suprascapular nerves can improve shoulder function and glenohumeral joint stability. A number of approaches to axillary nerve neurotisation for brachial plexus injuries have been reported, but all have limitations. We report outcomes of axillary nerve neurotisation for brachial plexus injury through the anterior deltopectoral approach.

**MATERIALS AND METHODS**

In March 2009, 9 consecutive men aged 20 to 52 (mean, 27.8) years with brachial plexus injury of the right (n=6) and left (n=3) shoulders after falling from a bike underwent axillary nerve neurotisation through the anterior deltopectoral approach. The power of the muscle involved was assessed using the Medical Research Council (British) system. Radiographs, computed tomographic myelography, and/or magnetic resonance imaging of the cervical spine, shoulder, and chest were obtained. The preganglionic injury and nerve root avulsion were confirmed electrophysiologically and clinically (d-efferentation pain, Horner syndrome, absent Tinel sign, and weak rhomobd and serratus muscles).

Three of the patients had complete avulsion of C5-T1 nerve roots, without any associated chest wall or lung injury. The remaining 6 patients had brachial plexus injury of C5-C6 nerve roots, with associated subluxation of the glenohumeral joint, atrophy of the supraspinatus, deltoid and elbow flexors. They had no active shoulder abduction, external rotation, and elbow flexion. All 9 patients had at least M4 power (motion against resistance) in the triceps.

The patient was placed in a supine position, with a sandbag beneath the affected extremity. Under general anaesthesia, the supraclavicular part of the plexus was exposed through a transverse incision 2 cm above the clavicle at the root of the neck. The extent of injury was confirmed by electrical stimulation. The spinal accessory nerve was identified along the superior border of the trapezius and transferred to the suprascapular nerve preserving its proximal branch. For C5-T1 nerve root injuries, the intercostal nerve was transferred to the axillary and musculocutaneous nerves through the anterior deltopectoral approach. For C5-C6 nerve root injuries, the patients underwent the Oberlin procedure (transferring ulnar nerve fascicle to the biceps branch of the musculocutaneous nerve) for elbow flexion through the distal extension of the deltopectoral approach, and the long head of the triceps branch was transferred to the axillary nerve (Fig.).

Postoperatively, the patients were put on broad arm sling for 3 weeks. Electrical stimulation was started at week 6. The range of movement and muscle power were regularly assessed.

**RESULTS**

The mean interval from injury to surgery was 4.3 (range, 2–6) months. Patients were followed up for 24 to 30 (mean, 26) months (Table 1). Shoulder control and palpable contractions were noted at postoperative month 2. In the 3 patients with C5-T1 nerve root injuries, the mean active abduction
and external rotation were 63º and 20º, respectively, whereas the mean abduction strength was M3 (motion against gravity). In the 6 patients with C5-C6 nerve root injuries, the mean active abduction and external rotation were 133º and 65º, respectively, whereas the strength of the deltoids and triceps was M5 (normal) in all. The outcome of transferring the long head of triceps branch was superior to transferring the intercostal nerve to the axillary nerve. In 4 patients with the pectoralis major cut and repaired, the muscle regained normal strength.

**DISCUSSION**

The posterior, lateral, and medial cords of the brachial plexus receive their respective names from their spatial orientation to the second part of the axillary artery. Nonetheless, there are considerable variations in the orientation and interconnections of the cords to each other and to the major vessels. A few specific nerves emerging from the posterior, lateral, and medial cords can be used as donors for neurotisation in brachial plexus injuries.\(^{14,15}\)

For axillary nerve neurotisation through the anterior deltopectoral approach, the key landmarks are the cephalic vein (as a guide to the deltopectoral groove), the clavicular fascia (covering the infraclavicular brachial plexus as it exits under the tendon of the pectoralis minor), the lateral cord, and the axillary artery. The pectoralis major and pectoralis minor are cut and/or retracted to view the infraclavicular plexus. If exposure is difficult, these muscles are cut and taken up with tie sutures for final approximation. The lateral cord and the axillary artery are swept medially to enable access to the posterior cord and axillary nerve. The axillary nerve is neurotised, depending on the length of the donor nerves. The axillary nerve exits the posterior cord at the level of the lower border of the pectoralis minor, curves backward and passes through the quadrangular space together with the posterior circumflex humeral artery,\(^{13-16}\) where it divides into anterior and posterior branches.

The axillary nerve is located high in the axilla, posterior to the axillary artery, lateral to the radial nerve, and anterior to the subscapularis. The long head of triceps branch (first branch of the radial nerve) is posterior and medial to the radial nerve at this region. These 3 nerves course more or less parallel in their exit at this level of approach. In this region, the axillary nerve is lateral, the radial nerve is in the middle, and the long head of triceps branch is medial (Fig.). The long head of triceps branch is transferred to the axillary nerve. For C5-C6 brachial plexus injuries, the anterior deltopectoral approach enables easy access to various donor nerves. The long head of triceps branch can be transferred to thoracodorsal or mediopectoral nerves. The median nerve fascicles, ulnar nerve fascicles, thoracodorsal and mediopectoral nerves can be transferred to the axillary nerve.

The axillary nerve is one of 2 terminal branches of the posterior cord of the brachial plexus. It contains fibres from C5 and C6 ventral rami. The anterior branch innervates the anterior deltoid and the largest posterior branch innervates the teres minor and deltoid. The supraspinatus and deltoid are equally

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Sex/age (years)</th>
<th>Side involved</th>
<th>Interval from injury to surgery (months)</th>
<th>Injury area</th>
<th>Donor nerve*</th>
<th>Follow-up (months)</th>
<th>Postop shoulder abduction†</th>
<th>Postop shoulder range of motion</th>
<th>Postop external rotation†</th>
<th>Additional nerve transfers*</th>
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<tbody>
<tr>
<td>1</td>
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<td>Left</td>
<td>2</td>
<td>C5-T1 IC</td>
<td>25</td>
<td>M3</td>
<td>60º</td>
<td>M3</td>
<td>IC to MCN, SAN to SSN</td>
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<tr>
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<td>M/30</td>
<td>Right</td>
<td>6</td>
<td>C5-T1 IC</td>
<td>24</td>
<td>M3</td>
<td>70º</td>
<td>M3</td>
<td>IC to MCN, SAN to SSN</td>
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</tr>
<tr>
<td>3</td>
<td>M/52</td>
<td>Right</td>
<td>4</td>
<td>C5-C6 LHTB</td>
<td>30</td>
<td>M5</td>
<td>130º</td>
<td>M5</td>
<td>SAN to SSN, Oberlin transfer</td>
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<td>Left</td>
<td>4</td>
<td>C5-T1 IC</td>
<td>28</td>
<td>M5</td>
<td>140º</td>
<td>M5</td>
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<td>Right</td>
<td>5</td>
<td>C5-C6 LHTB</td>
<td>24</td>
<td>M5</td>
<td>130º</td>
<td>M5</td>
<td>SAN to SSN, Oberlin transfer</td>
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<tr>
<td>6</td>
<td>M/25</td>
<td>Left</td>
<td>5</td>
<td>C5-C6 LHTB</td>
<td>26</td>
<td>M5</td>
<td>130º</td>
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<td>7</td>
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<td>3</td>
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<td>27</td>
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<td>SAN to SSN, Oberlin transfer</td>
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<td>8</td>
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<td>M5</td>
<td>130º</td>
<td>M5</td>
<td>SAN to SSN, Oberlin transfer</td>
<td></td>
</tr>
</tbody>
</table>

* IC denotes intercostal nerve, LHTB long head of triceps branch, MCN musculocutaneous nerve, SAN spinal accessory nerve, SSN suprascapular nerve, and Oberlin transfer transferring ulnar nerve fascicle to biceps branch of musculocutaneous nerve
† M3 denotes motion against gravity, M4 motion against resistance, M5 normal strength
responsible for producing torque about the shoulder joint in the functional planes of motion, whereas the deltoid is capable of initiating elevation in the plane of the scapula. The infraspinatus is a powerful external rotator, followed by the teres minor and the posterior deltoid.15,16

There are different approaches to neurotise the axillary nerve. The interval between the lateral and the long heads of the triceps is located in the posterior approach11 at the level of the triangular space to expose the radial nerve, nerves to the long head and lateral head of the triceps. Through the posterior approach, excessive retraction of the deltoid is required and may result in injury to the posterior branch of the axillary nerve and limited arm abduction.17,18 Therefore, caution is necessary. The disadvantages of the posterior approach are difficulty in dissecting the teres minor branch, change of position following the brachial plexus exploration and the suprascapular neurotisation procedures, separate incision, and extended operating time.

The entire axillary and suprascapular nerves are explored through a sabre-cut incision12 starting anteriorly near the axillary fold and continuing along the deltopectoral groove over the clavicle to the quadrilateral space posteriorly. The success of this extensive procedure depends on a meticulous surgical technique and secure reattachment of muscles. The axillary recess approach13 exposes the axillary nerve in a triangle bounded by the latissimus dorsi tendon, posterior circumflex humeral artery, and subscapular artery. The anterior and middle deltoid branch is the most laterally located, curving around the humerus, whereas the teres minor branch is close to the long head of the triceps. Although the axillary nerve can be exposed by the axillary approach, its proximal portion is difficult to dissect through this approach. Thus, the anterior deltopectoral approach is preferable for the proximal dissection of the axillary nerve.

In our study, the outcome of transferring the intercostal nerve to the axillary nerve was only moderate. Intercostal nerves contain 500 to 700 nerve fibres. In complete brachial plexus injury, the results of transferring the intercostal nerve vary widely, depending on the level of the intercostal nerve transection, the number of transferred nerves, the level of the nerve anastomosis, and the use of nerve grafts. In 4 patients with complete brachial plexus palsy, shoulder control to a maximum of 30º abduction was achieved using the intercostal, phrenic, and spinal accessory nerves as donors.19 The mean improvement was 10º in abduction when concomitant connection (double nerve transfers) of the suprascapular nerve to the phrenic nerve and the axillary nerve to the cranial nerve XI.19 The overall and useful recovery rates were 63% and 33%, respectively, for the axillary nerve,20 whereas the shoulder abduction was <40º with M3-/M3 motor power.21 None of the above studies provided any results on external rotation recovery.

In our study, 3 patients achieved a mean abduction of 65º with M3 grade of external rotation. Shoulder re-animation was achieved with suprascapular nerve neurotisation, because supraspinatus function (rotator cuff) is important in the shoulder arc of motion and stabilisation along with axillary nerve neurotisation. Functional improvement of the shoulder is better in patients with successful re-innervation of the biceps. Although transferring the intercostal nerve to the axillary nerve does not confer muscle strength, speed, range of motion, and endurance,22 it enables better shoulder abduction and external rotation.

In C5-C6 nerve root injuries, concomitant neurotisation of the suprascapular nerve and the axillary nerve enabled better outcomes in shoulder

<table>
<thead>
<tr>
<th>Studies</th>
<th>No. of patients</th>
<th>Approach</th>
<th>Donor nerve</th>
<th>Mean abduction</th>
<th>Deltoid strength*</th>
<th>External rotation</th>
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<tbody>
<tr>
<td>Lurje,23 1948</td>
<td>1</td>
<td>Anterior</td>
<td>Unnamed branch</td>
<td>35º</td>
<td>Good</td>
<td>Satisfactory</td>
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<tr>
<td>Colbert and Mackinnon,2 2008</td>
<td>1</td>
<td>Posterior</td>
<td>Medial head of triceps branch</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Vekris et al,13 2010</td>
<td>5</td>
<td>Posterior</td>
<td>Long head of triceps branch</td>
<td>110º</td>
<td>M4- to M4</td>
<td>30º±10º</td>
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<tr>
<td>Bertelli et al,12 2007</td>
<td>3</td>
<td>Axillary recess</td>
<td>Long/medial head of triceps branches</td>
<td>45º</td>
<td>M4</td>
<td>-</td>
</tr>
<tr>
<td>Bertelli and Ghizoni,8 2004</td>
<td>7</td>
<td>Posterior</td>
<td>Long head of triceps branch</td>
<td>92º</td>
<td>M3+ to M4</td>
<td>3º (-10º to 30º)</td>
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<tr>
<td>Leechavengyongs et al,11 2003</td>
<td>7</td>
<td>Posterior</td>
<td>Long head of triceps branch</td>
<td>124º</td>
<td>M4</td>
<td>M4</td>
</tr>
<tr>
<td>Our study</td>
<td>6</td>
<td>Anterior deltopectoral</td>
<td>Long head of triceps branch</td>
<td>133º</td>
<td>M5</td>
<td>M5</td>
</tr>
</tbody>
</table>

* M3 denotes motion against gravity, M4 motion against resistance, M5 normal strength
abduction and external rotation. Transferring the long head of triceps branch to the axillary nerve is superior, because the nerve is close to the target muscle. It increases the likelihood of reinnervation under voluntary control and is not tied to antagonist co-contractions owing to aberrant axonal growth. Also, it significantly improves the external rotation when combined with simultaneous transfer of the spinal accessory nerve to the suprascapular nerve. Transferring the long head of triceps branch to the axillary nerve through different approaches has been reported (Table 2). In our study, the anterior deltopectoral approach enabled good exposure and access to various donor nerves within close vicinity.

REFERENCES


