



All-endoscopic Brachial Plexus Complete Neurolysis for Idiopathic Neurogenic Thoracic Outlet Syndrome: Surgical Technique

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Abstract: Neurogenic thoracic outlet syndrome is caused by a neurologic compression of the brachial plexus before it reaches the arm. Three anatomic areas are common locations for such an entrapment because of their congenital and/or acquired tightness: the interscalene triangle, the costoclavicular space, and the retropectoralis minor space. Because the compression level usually remains unknown, the treatment is still controversial and most teams focus on only one potential site. We propose an all-endoscopic technique of complete brachial plexus neurolysis that can be divided into three parts, one for each entrapment area. First, with a subacromial approach, the suprascapular nerve is released distally from the transverse ligament and then followed up to the upper trunk. Once the upper trunk is located, the middle and lower trunks are dissected in the interscalene triangle. Then, by use of an infraclavicular approach, the brachial plexus is released from the costoclavicular space by detaching the subclavian muscle from the clavicle. Finally, the pectoralis minor is released from the coracoid so that the brachial plexus is distally freed. This technique seems to be safe and reproducible, but expert knowledge of the neurovascular anatomy and advanced endoscopic skills are required.

Neurogenic thoracic outlet syndrome is an uncommon condition affecting primarily young and healthy patients, caused by a compression of the brachial plexus (BP). Responsible for more than 90% of all thoracic outlet syndrome cases, the nonspecific neurogenic thoracic outlet syndrome is a controversial entity, without anatomic, clinical, or electrophysiological objective evidence of compression and with a mostly unknown etiology.¹ In this presentation, the entrapment can occur in 3 main locations: in the interscalene triangle, in the costoclavicular space, and/or beneath the pectoralis minor (PM) muscle.² Therefore, the treatment remains controversial. The primary surgical options are PM tenotomy, scalenectomy, and

first-rib resection.²⁻⁵ During the past decade, shoulder arthroscopy has led surgeons outside of the glenohumeral joint cavity, around the terminal branches of both the infraclavicular and supraclavicular BP, requiring the ability to approach and release it.⁶⁻¹² In addition, an anatomic feasibility study regarding arthroscopic BP neurolysis was published in 2015 by Lafosse et al.¹³ The purpose of this Technical Note is to assess the clinical feasibility and reproducibility with an educational step-by-step approach.

Technique

Patient Setup

The patient is placed in the beach-chair position and operated on under general anesthesia, combined with interscalene locoregional anesthesia. The whole upper extremity is included in the field, and there is one assistant holding and manipulating the arm.

Endoscopic Portals

Eight endoscopic portals are needed: four supraclavicular and four infraclavicular (Fig 1).

Supraclavicular Portals. Two subacromial portals are established: Portal C is a lateral portal, located at the level of the middle of the acromion 2 cm distal to its

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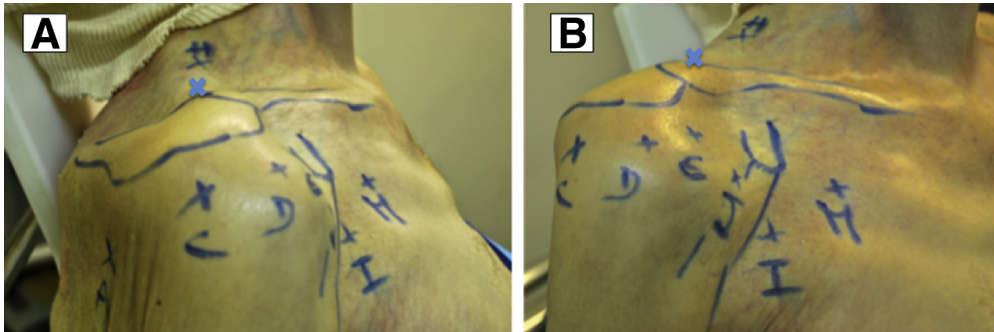


Fig 1. Lateral (A) and anterior (B) views of cutaneous drawings of shoulder surface anatomy and portal locations for a right shoulder. The supraclavicular portals are portal C (lateral), portal D (anterolateral), transtrapezial portal 1 (TT1, lateral—appended blue cross), and transtrapezial portal 2 (TT2, medial). The infraclavicular portals are portal E (anterior), portal I (coracoid axis), portal J (mid distance from portals I and E), and portal M (medial). (A, posterior portal for articular assessment.)

lateral border, and portal D is an anterolateral portal, 2 cm distal to the anterior angle of the acromion. In addition, 2 transtrapezial portals are established and are located 2.5 cm posterior to the anterior border of the trapezius, with the lateral transtrapezial portal (portal TT1) at the level of the suprascapular notch (created under endoscopic control from portals C and D) and the medial transtrapezial portal (portal TT2) at the level of the middle of the clavicle (created under endoscopic control from portals D and TT1).

Infraclavicular Portals. Portal E is an anterior portal, 2 cm distal to the acromioclavicular joint, facing the rotator interval. Portal I is established in the axis of the coracoid process, 2 to 3 cm below. Portal J is created at the mid distance from portals I and E. Finally, portal M is a medial portal, 4 cm distal to the clavicle and 3 cm medial to the coracoid process.

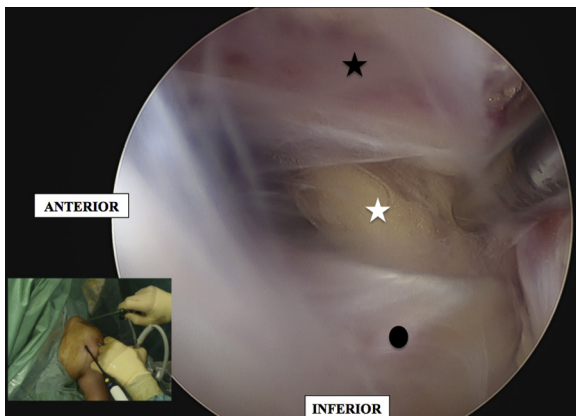


Fig 2. Endoscopic view of proximal part of suprascapular nerve (white star) before cutting transverse ligament (black circle). The suprascapular nerve is exiting from the upper trunk and being routed under the transverse ligament, whereas the suprascapular artery remains superficial (black star). A left shoulder is shown through portal C.

Supraclavicular Plexus and Interscalene Triangle

Suprascapular Nerve Release. Every patient initially should benefit from an arthroscopic exploration of the glenohumeral joint to eliminate any intra-articular condition that may be responsible for his or her symptoms. The first step is to release the suprascapular nerve (SSN) distally from the transverse ligament with

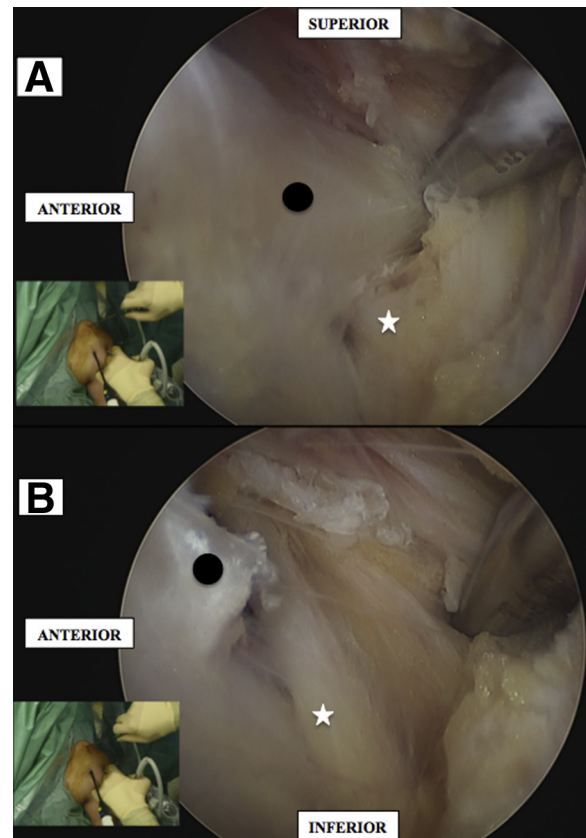


Fig 3. Endoscopic release of suprascapular nerve (white stars), first constrained by transverse ligament (black circles) intact and exposed (A) and then released by cutting transverse ligament (B). A left shoulder is shown through portal C.

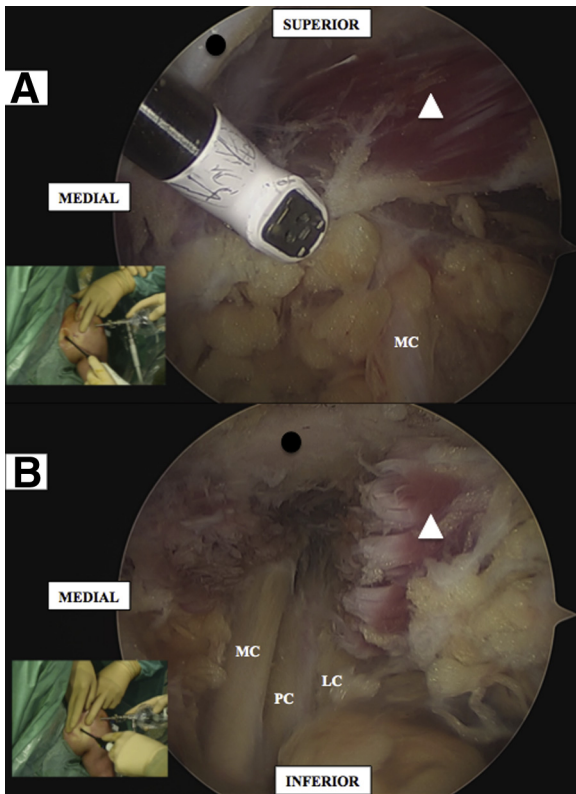


Fig 4. Endoscopic release of brachial plexus (cords) through costoclavicular space. The 3 cords—medial cord (MC), posterior cord (PC), and lateral cord (LC)—are lying underneath the subclavian muscle (white triangles) and the clavicle (black circles) (A) and are freed once the subclavian muscle is detached from the clavicle (B). A left shoulder is shown through portal J.

a subacromial approach, as previously described by Lafosse et al.¹⁰ Portal C is used as a visualization portal and portal D for instrumentation. The anterior border of the supraspinatus muscle is followed until the coracoclavicular ligaments are reached. At this point, perpendicular to the coracoclavicular ligaments, the transverse ligament is identified, under which the SSN lies (Fig 2). Portal TT1 is created under endoscopic control by use of a tracking needle before an incision is made through the trapezius muscle. An endoscopic cutting device is then introduced in this portal toward the suprascapular notch so that the transverse ligament is cut and the SSN is released (Fig 3). We use SSN scissors (Mitek, San Diego, CA), but any endoscopic device allowing for sharp dissection can be used.

Interscalene Space. Portal TT2 is opened under endoscopic control with the use of a tracking needle. The endoscope is switched to portal TT1, and the instrumentation goes through portal TT2, allowing the proximal dissection of the SSN up to the upper trunk. The upper trunk is released from the surrounding

fibrous bands, exposing the middle and lower trunks within the inferior part of the interscalene space. A smooth trocar is used to perform an intraneural dissection, but no scalenectomy, first-rib resection, or root dissection is needed.

Infraclavicular BP

Exposure. Dissection is started from the subacromial area, with the endoscope through portal C and the instruments through portal D (Video 1). Portal E is then opened under endoscopic control with a tracking needle. After the fascia clavipectoralis is opened, the conjoint tendon (CT) and the coracoid process are exposed to enlarge the retropectoral space anteriorly, between the coracoid process and the PM posteriorly and the pectoralis major anteriorly, with a smooth trocar and water flow. Hemostasis is often needed and is performed with radiofrequency assistance. Then, portal I is created under endoscopic control by use of a tracking needle, and portal J is opened at the mid distance from portals D and I. The endoscope is introduced in portal J, facing the

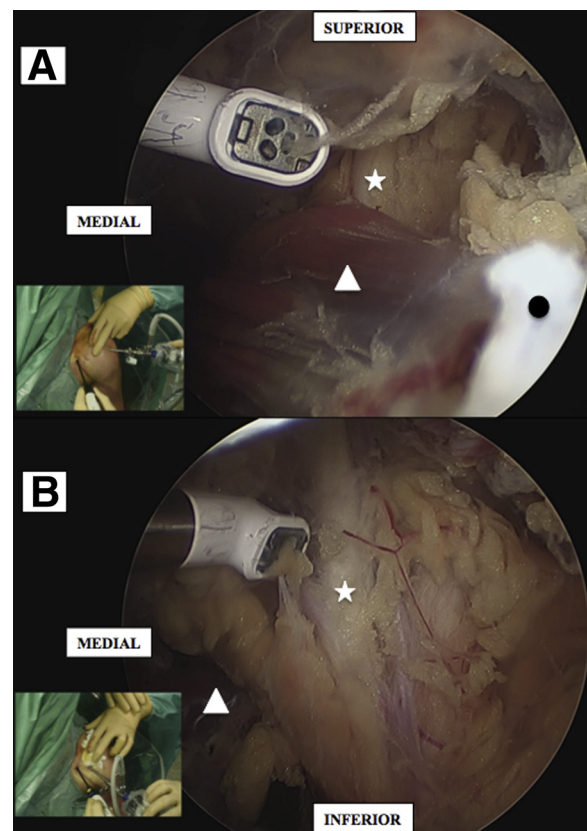


Fig 5. Endoscopic release of brachial plexus (terminal branches) through retropectoralis minor space. The pectoralis minor (white triangles) is first attached on the coracoid process (black circle) (A) and then cut and medially retracted (B), allowing decompression of the musculocutaneous nerve (white stars). A left shoulder is shown through portal E.

coracoid process so that the operator can see the PM muscle and CT very clearly. The limit between the CT and the PM muscle bellies can be difficult to visualize; however, because this is the only way to safely expose the musculocutaneous nerve lying below, it is of primary importance for the operator to identify it. Portal M is finally opened, allowing further proximal dissection, particularly to access the upper border of the PM and the medial border of the coracoid process.

Costoclavicular Space. Following the upper border of the PM tendon, the cords are found under the subclavian muscle (Fig 4). To increase the costoclavicular space, the subclavian muscle is detached from the clavicle, for a distance equal in length to the width of the 3 cords. The latter can thus be exposed and followed toward the supraclavicular space, until the inferior aspect of the interscalene triangle is reached. The ability to complete inferior interscalene neurolysis from the infraclavicular approach is mandatory to ascertain the efficient release of the costoclavicular space.

Retropectoralis Minor Space. Finally, the space between the CT and the PM is opened to visualize the BP terminal branches (Fig 5). Only then can the PM tendon be detached from the coracoid process. The 3

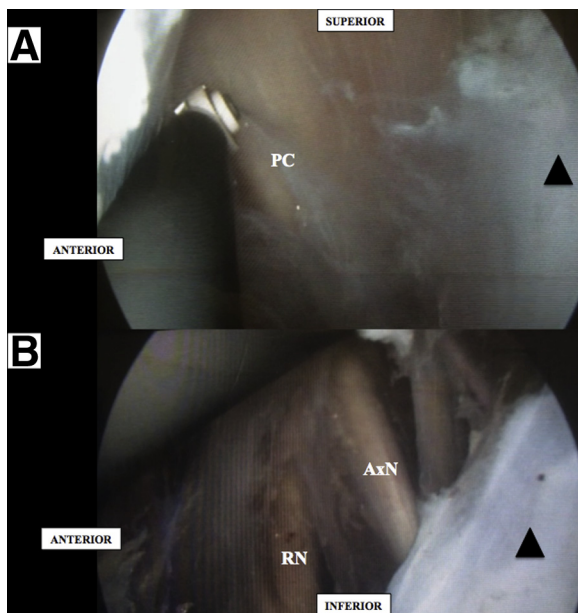


Fig 6. Endoscopic retrocoracoid approach for decompression of posterior cord, found by following anterior border of subscapularis muscle (black triangles). First, the posterior cord (PC) is visualized (A), and then after further dissection, its terminal branches are identified as well, with the axillary nerve (AxN) posteriorly and the radial nerve (RN) anteriorly (B). A left shoulder is shown through portals C and E.

Table 1. Advantages and Risks of Technique

Advantages	
Complete dissection with minimal scar tissue	
Low risk of infection	
Intra-articular control	
Cosmetic	
Risks	
Need to convert to suture if there is neurovascular injury	
Risk of subtotal release	
No capacity for rib resection or scalenectomy	

cords are dissected distally, by carefully cutting the surrounding fibrous bands.

The two terminal divisions of the lateral cord, which are musculocutaneous nerve and the median nerve lateral branch, are the first terminal branches to be visualized. After retracting these two nerves along with the axillary artery, the posterior cord and its two terminal branches—the axillary and radial nerves—are found heading posteriorly to the quadrilateral space. Finally, the medial cord is identified behind the artery medially, with its two terminal divisions, the ulnar nerve and the median medial branch.

Retrocoracoid Approach. The release of the posterior cord and its terminal branches is completed with a posterior approach through portals C and E, following the anterior border of the subscapularis muscle (Fig 6). The dissection is stopped after all branches are identified and released from any fibrous bands.

Table 2. Pearls and Pitfalls

Pearls

- Dissection should be started from the retrocoracoid space to free the posterior cord.
- The artery is more medial than the cords under the clavicle, so the risk is low when the surgeon stays high.
- The surgeon should avoid dissection between the veins and should watch out for the cephalic vein, which is the upper limit of dissection.
- Dissection between the branches should be performed with a blunt instrument such as an arthroscopic trocar.
- The surgeon should dissect the cords and branches from proximal to distal.

Pitfalls

- An ossified coracoid notch implies the use of a Kerrison rongeur to cut the bone and free the suprascapular nerve.
- Recurrence of pain may occur after 6 months because of scar tissue.
- Dissection difficulties may occur in overweight patients with short necks.
- Adhesions may occur between the pectoralis minor and brachial plexus.
- Dissection difficulties may occur in the space between the pectoralis minor and conjoint tendon, with proximity of the musculocutaneous nerve.
- Adhesions may occur between the subscapularis tendon and axillary nerve.

Postoperative Care

Patients undergo observation for 24 hours. No immobilization is needed, and no particular physical therapy is recommended, only self-rehabilitation by daily living activities. Sports involving the shoulder girdle are not authorized for 6 weeks.

Discussion

This article describes an all-endoscopic technique allowing for complete neurolysis of the BP using classic arthroscopic portals and tools. Previous studies reporting BP release had different aims (nerve transfer) and used different means (gas insufflation, da Vinci robot [Intuitive Surgical, Sunnyvale, CA]).¹⁴⁻¹⁶ The advantages of the arthroscopic approach are multifold (Table 1). First, the use of pressurized saline fluid assists dissection by water flow and prevents overheating nerve injuries at the same time.¹⁷ Arthroscopic magnification allows for enhanced BP visualization, both static and dynamic, enabling the operator to protect the BP and its branches during dissection, as well as to ascertain a satisfactory release during final examination. In addition, minimal damage to the skin and surrounding soft tissue is achieved, especially in this technique aiming for a release of all potential compression sites at the same time.

The main limitation of the described technique is the steep learning curve; it is mandatory for the surgeon to avoid iatrogenic BP injury, which is the primary risk when performing this procedure. Such an incident can occur at every step of the procedure, including direct section with the cutting device during SSN release, overheating lesions with extended continuous use of the radiofrequency probe, stretching with external maneuvers, and/or internal dissection. In our experience, this technique seems to be safe and reproducible, although it requires great arthroscopic skills and expert knowledge of the anatomy (Table 2).

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