Robot-Assisted Endoscopic Neurolysis of the Thoracic Segment of the Long Thoracic Nerve

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Abstract

The surgical management of the *scapula alata* is controversial. The most common surgical procedure performed is the neurolysis of the thoracic segment of the long thoracic nerve through a large skin incision of several centimeters. We hereby report the feasibility and the outcomes of an endoscopic robot-assisted neurolysis in a 25-year-old patient. This patient had sustained a thoracic trauma 8 months earlier which had resulted in a *scapula alata*. A minimally invasive neurolysis of the long thoracic nerve was performed through the da Vinci robot. The "crowfoot landmark" was managed through electrocoagulation and the entire thoracic segment of the nerve was released. Eighteen months after the procedure, the patient had fully recovered. The feasibility of the robot-assisted neurolysis of the long thoracic nerve was demonstrated by the uneventfulness of the procedure. With regard to the outcomes, the common disadvantages of an open neurolysis were absent: a cosmetic minimal surgical access was performed, the usual postoperative complications were not noted, and the typical perineural scarring that could lead to recurrence was ideally reduced.

Keywords
► da Vinci
► long thoracic nerve
► neurolysis
► robot
► scapula alata

Introduction

The long thoracic nerve paralysis leads to the paralysis of the *serratus anterior* muscle and causes the detachment of the medial edge of the scapula which disrupts the kinetics of the elevation of the upper limb (*scapula alata*). This is a rare lesion,[1] the incidence of which is unknown.[2] This paralysis may be related to a compression or more rarely to a traumatic injury of two segments of the long thoracic nerve, proximal and/or distal. The proximal compression occurs when the long thoracic nerve crosses the middle scalene muscle according to some authors,[3] or next to the second rib where a fascia causes an angulation of the nerve during the abduction and external rotation of the shoulder, according to other authors.[4-8] The distal compression occurs when the nerve crosses the anterior branch of the thoracodorsal artery (« crowfoot landmark »).[9] The level of compression varies from patient to patient, and must be at least proven by electromyography (EMG) before deciding the indication for surgical management.[2]

Regardless of the level of compression, the surgical release should only be performed after functional treatment with gentle physiotherapy and rest for at least 6 months.[2] When the compression is proximal, the surgical management consists of an extrafascicular neurolysis in the scalene region.[3] When the compression is distal, the surgical management consists of an extrafascicular neurolysis in the « crowfoot landmark » region, frequently associated with the ligation or electrocoagulation of the anterior branch of the thoracodorsal artery.[10] This neurolysis is classically performed through a 10-cm skin incision approximately. The disadvantages of this technique are the risks associated with the open surgery, the duration of the procedure, the general anesthesia, the risk of infection, the cosmetic results, and the perineural scarring and

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adhesions that may lead to recurrence and to the disruption of the nerve regeneration process.[11-13]

We hereby describe the feasibility and the outcomes of the robot-assisted three-dimensional (3D) endoscopic neurolysis of the long thoracic nerve.

Observation

Mr. X, 23-year-old, a right-handed mechanic without a significant past medical history, had sustained a blast injury of his right shoulder due to a high-speed indirect trauma and a direct injury to his sternum due to the projection of a rubber fragment, in the workplace. He had suffered a chest trauma causing a perforation to his pulmonary artery, and multiple fractures of the ribs and of the sternum that were promptly managed surgically though an emergency sternotomy approach.

After the emergency treatment, the patient presented with a *scapula alata* (►**Fig. 1** and ►**Video 1**). The preoperative EMG had shown injuries to the long thoracic nerve, the suprascapular nerve, and the spinal accessory nerve. The suprascapular nerve and the spinal accessory nerve attained full recovery after surgery, whereas the long thoracic nerve paralysis persisted for the following 6 months. A surgical robot-assisted endoscopic neurolysis was scheduled.

Fig. 1 Preoperative clinical aspect of the *scapula alata*.

The procedure was performed under general anesthesia in left lateral decubitus. The « crowfoot landmark » was marked on the skin, drawing the intersection between the midaxillary line and the horizontal line crossing the fourth rib. Three minimally invasive incisions were made to introduce the 3D endoscopic camera and to insert the two instruments of the da Vinci SI robot (Intuitive Surgical, Sunnyvale, California, United States). A fourth incision was made to introduce a further instrument which was controlled by the surgical assistant (►**Fig. 2**). The endoscopic camera access was located on the midaxillary line 4 cm above the right iliac ridge, approximately 15 cm under the « crowfoot landmark ». The incisions made to introduce the instruments were located on either side of the endoscopic camera access, 10 cm anteriorly and posteriorly to the midaxillary line. The four surgical incisions were connected between each other through a cavity which was created through the accurate undermining of the skin and the dissection of the overlying tissues from the subcutaneous tissue with scissors. The cavity volume was maintained by the continuous insufflation of CO_2 at the pressure of 12 mm Hg. The da Vinci SI robot was then positioned cephalad. Thanks to the skin markings, the long thoracic nerve was easily identified through the accurate dissection and electrostimulation, and then released through its entire course along the chest wall (►**Fig. 3** and ►**Video 2**). The anterior branch of the thoracodorsal artery was electrocoagulated. The total duration of the operation was 61 minutes.

Video 1

Preoperative clinical aspect of the *scapula alata*.

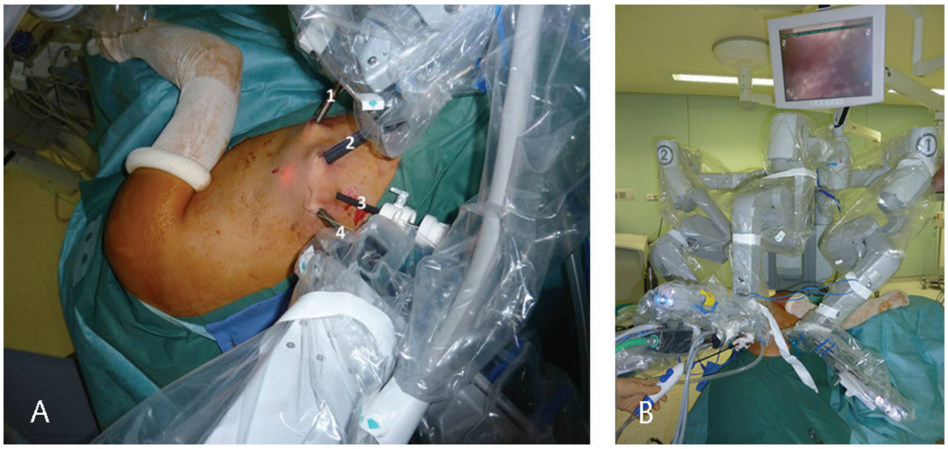

Fig. 2 Installation. (**A**) 1 and 4: instrumental trocars for the robot; 2: robotic camera trocars; 3: trocar for the surgical assistant. (**B**) Patient in left side decubitus, the da Vinci SI robot cephalad.

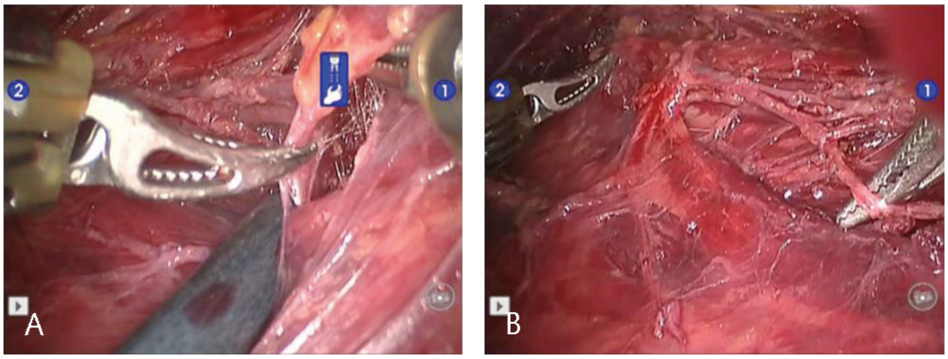

Fig. 3 Intraoperative endoscopic view of the long thoracic nerve neurolysis. (**A**) Electrocoagulation of the “crowfoot landmark.” (**B**) The long thoracic nerve completely released along its thoracic course.

Video 2

Different stages of the robot-assisted neurolysis of the thoracic segment of the long thoracic nerve: nerve dissection, identification through electrostimulation, electrocoagulation of the “crowfoot landmark,” and the entirely neurolysed nerve.

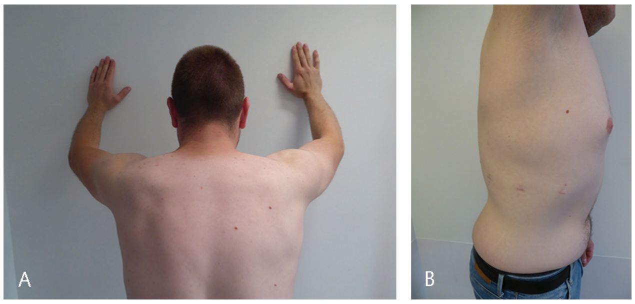

Fig. 4 Clinical results 18 months postoperatively. (**A**) Reduction of scapular winging. (**B**) Surgical incision scars.

Video 3

Postoperative clinical aspect of the *scapula alata*.

The patient was discharged the following day and reported immediate improvement.

On an 18 months’ follow-up, the amyotrophy and the scapular winging had disappeared (►**Fig. 4** and ►**Video 3**). The EMG became normal 6 months postoperatively.

Discussion

The injury of the long thoracic nerve has multiple etiologies: the overuse, the elongation, or the neurological etiology. The etiologies associated with the overuse are the most frequent. They are usually noted in athletes (handball, baseball, water-polo, surf, etc.)[14,15] or manual workers.[16-18] Etiologies by elongation are rare. They often occur under general anesthesia during or after a[14] patient’s installation manoeuver that pulls the upper limb. Neurological etiologies are unusual. However, selected cases of iatrogenic sequelae of radiotherapy[19] and a case of Parsonage–Turner syndrome[20] have been described. The traumatic etiology had never been reported before and our patient is the first case of blast injury being described in current literature. All these etiologies share a common origin which is the mechanical injury to one or multiple anatomical fixity zones along the course of the long thoracic nerve. From proximal to distal, the nerve can be compressed next to the C5-C6-C7 roots at the scalene outlet,[21,22] next to the reflection of the nerve on the second rib,[21,23] next to the upper digitations of the *serratus anterior* muscle, where it can be bent and elongated by the aponeurosis of the muscle during the abduction and lateral rotation movements of the shoulder,[21,22] next to the fourth or fifth rib at the « crowfoot landmark »,[24,25] and even at the tip of the scapula where the nerve is compressed against the *serratus anterior* during the shoulder adduction movements.[14] The only anatomical area where the nerve is constantly fixed is the “crowfoot landmark” which lies on the proximal edge of the distal digitation of the *serratus anterior*. The most common mechanism is probably the repeated traction of the intrathoracic segment of the nerve proximal to its fixed anatomical segment. Therefore, the management of mechanical injuries to the nerve should prioritize the decompression of this area, as confirmed by the satisfactory clinical outcomes noted in more than 90% of cases.[9]

Although the diagnosis is immediate on clinical examination (*scapula alata*), it should always be confirmed through functional complementary exams (EMG), through a morphological study of the nerve (ultrasonography), or a morphological study of the denervated muscle (magnetic resonance imaging [MRI]). Theoretically, a preoperative EMG can be used to identify the level of compression. Practically, it is often inaccurate and fails to give specific information on the level of compression. The high-resolution ultrasonography can identify the long thoracic nerve from its origin in the cervical region to the second digitation of the *serratus anterior* but does not give any information about the cause or the level of compression.[26] When the MRI identifies a denervated *serratus anterior* and a denervated rhomboid muscle, some authors would conclude that the injury is proximal.[27] Should the injury be distal, only the *serratus anterior* would have an abnormal appearance. In our case, the level of injury was clear because of the dynamics of the trauma.

The *serratus anterior* muscle paralysis improves with functional treatment on ranges of motion in a recumbent position.[28] Symptoms usually subside in the following 1 to 24 months according to the authors.[2,4,29-31] However, some authors recommend not to exceed 6 months of functional therapy before deciding to operate, because of the higher risk of failure or recurrence after surgery when the muscle has been denervated for a long time.[25] If the functional therapy fails or if there is a sign of denervation on the EMG, surgical management should be considered. Several techniques have been described: therapeutic (neurolysis) or palliative (muscle transfers, scapulopexy, scapulothoracic arthrodesis). The most effective and the least invasive surgical technique is the long thoracic nerve neurolysis. It should be a first choice in those patients who suffered a traumatic or microtraumatic paralysis, especially when the EMG shows distal compression. This technique usually delivers good functional results.[9] Palliative treatments are only recommended if the neurolysis fails. Their rationale is to stabilize the scapula to the thorax either dynamically through tendon transfers or statically by scapulopexy or scapulothoracic arthrodesis. These procedures are more invasive than the neurolysis. Among the tendon transfer techniques used to compensate for the *serratus anterior* muscle deficit, the most common procedure is the *pectoralis major* tendon transfer.[32,33] Scapulopexy is based on the fixation of the scapula to the thorax using several previously severed ribs. The scapulothoracic arthrodesis is based on the fixation of the scapula to several decorticated ribs through several bone grafts. Muscle transfer delivers better outcomes with regards to shoulder mobility than to muscle strength. This is why scapulothoracic arthrodesis is preferable in heavy manual workers.[18]

The feasibility of the endoscopic robot-assisted neurolysis of the long thoracic nerve was demonstrated by the uneventfulness of the procedure in our patient. With regard to the outcomes, the common disadvantages of an open neurolysis were absent: a cosmetic minimal surgical access was performed, the usual postoperative complications were not noted, and the typical perineural scarring that could lead to recurrence was ideally reduced. The final outcome was satisfactory, leading to a full recovery 18 months postoperatively. These results need to be confirmed by a clinical case series with sufficient follow-up.

Conflict of Interest

P.L. has conflicts of interest with Newclip Technics and Argomedical but none with the present study. P.L. reports grants from Newclip Technics, outside the submitted work. In addition, P.L. has a Argomedical patent pending. None of the other authors have conflicts of interest.

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