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Isolated paralysis of the serratus anterior muscle: Surgical release of the distal segment of the long thoracic nerve in 52 patients

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ABSTRACT

Introduction: Isolated serratus anterior (SA) paralysis is a rare condition that is secondary to direct trauma or overuse. Patients complain of neuropathic pain and/or muscle pain secondary to overexertion of the other shoulder stabilizing muscles. As the long thoracic nerve (LTN) passes along the thorax, it can be compressed by blood vessels and/or fibrotic tissue. The goal of the current study was to evaluate the outcomes of surgical release of the distal segment of the LTN in cases of isolated SA paralysis.
Patients and methods: This was a retrospective study of 52 consecutive cases operated on between 1997 and 2012. The average patient age was 32 years (range 13–70). Patients had been suffering from paralysis for an average of 2 years (range 4–259 months); the paralysis was complete in 52% of cases. Every patient underwent a preoperative electroneuromyography (ENMG) assessment to confirm that only the SA was affected and there were no signs of re-innervation.
Results: Every patient had abnormal intraoperative findings. There were no complications. All patients showed at least partial improvement following the procedure. The improvement was excellent or good in 45 cases (86.7%), moderate in 4 cases (7.7%) and slight in 3 cases (5.6%). In 32 cases (61.5%), the winged scapula was completely corrected; it was less prominent in 19 cases and was unchanged in one case. The best outcomes following surgical release occurred in patients who presented without preoperative or neuropathic pain and were treated within 18 months of paralysis.
Discussion: Isolated SA paralysis due to mechanical injury resembles entrapment neuropathy. We discovered signs of LTN compression or restriction during surgery. Surgical release of the distal segment of the LTN is a simple, effective treatment for pain that provides complete motor recovery when performed within the first 12 months of the paralysis.
Level of evidence: IV.

1. Introduction

The serratus anterior (SA) muscle is innervated by the long thoracic nerve (LTN), which arises from collateral branches of the C5, C6 and C7 nerve roots. After C5 and C6 have joined together, the transverse trunk crosses the middle scalene muscle before being joined by the C7 branch. It goes around the second rib and then descends along the lateral thoracic wall under the SA muscle fascia [1] (Fig. 1). At the proximal edge of the distal SA head, it is joined by a collateral branch of the thoracodorsal artery (serratus anterior branch), which crosses over the LTN before dividing into terminal muscle branches. The nerve can be easily identified at this cross-over point [2].

The main action of the SA is to stabilize the scapula against the thoracic wall. If paralysed, the scapula wings out, especially during forward elevation of the arm. Other scapula-stabilizing muscles (especially the trapezius, rhomboids and levator scapulae) can only partially compensate for this deficit, and can become painful, even go into spasm. If the deficit persists, anterior impingement gradually closes the subacromial space because of the scapular tipping [3,4].

Serratus anterior paralysis was first reported with Parsonage-Turner syndrome (PTS), also known as brachial neuritis [5], a rare condition of unknown aetiology that affects 1.64 out of every 100,000 individuals [6]. PTS is the result of inflammation in the brachial plexus [7]. In a fair number of cases, electroneuromyography (ENMG) studies have found that other muscles are also

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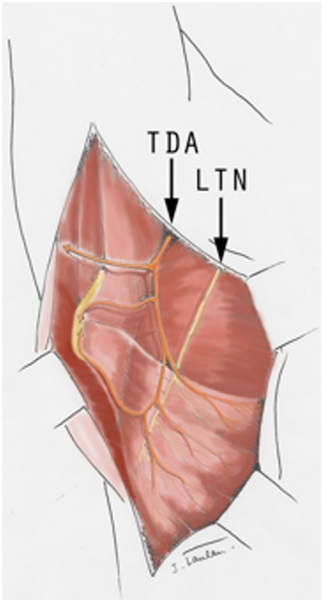

Fig. 1. Position of the distal segment of the long thoracic nerve (LTN) relative to the vascular branches of the thoracodorsal artery (TDA).

partially affected. In this context, the motor deficit is preceded by a few weeks of acute pain, which disappears once paralysis settles in. Typically, the deficit spontaneously resolves itself within a few months [8,9].

Isolated paralysis of the LTN can occur after chest or axillary surgery due to direct nerve injury [10]. In such cases, early repair of the nerve provides the best chance of recovery. LTN injury can also occur after closed direct trauma or when the shoulder and arm are used repeatedly [10,11]. In cases of mechanically-induced paralysis, partial or no spontaneous recovery of activity can be expected [12,13].

Proximal compression, as the nerve passes through the middle scalene muscle [1,14] or goes over the second rib [15], is the most commonly proposed injury mechanism. We have also shown that the LTN can be restricted by the SA fascia or direct vascular branches of the lateral thoracic artery crossing over the nerve [16]. The possibility of distal compression has also been brought up by Manning et al. [17]. In a non-PTS context, non-iatrogenic serratus anterior paralysis has been treated by surgical release of the distal segment of the LTN. The goal of the current study was to evaluate the outcomes of this treatment in our first 52 cases.

2. Patients and methods

From 1997 to 2012, 66 patients were seen in our department for isolated SA paralysis. There were 44 men and 22 women, with an average age of 32 years (range 13–70) at the time of diagnosis. The initial clinical examination was used to determine the patient's dominant arm, injured side, duration of the paralysis, degree of paralysis, mechanism of injury, presence and location of any pain and presence of Tinel's sign over the LTN trajectory. The paralysis was labelled as either complete (entire axial edge of the scapula lifted in neutral position, visible during forward elevation of the arm, without possibility of recruitment when pushing against a wall) or partial (incomplete lifting of the scapula, especially at the tip, mainly visible during forward elevation of the arm, but relieved by pushing against a wall). It seemed to us that there was no way to more precisely defining the deficit. An ENMG study was performed initially and during the postoperative follow-up.

Table 1
Criteria used to assess the clinical outcomes.

Outcome	Clinical criteria		
	Motor recovery		Pain
Excellent	Complete	and	Absent
Good	Almost complete	and/or	Absent or minimal
Fair	Partial	and/or	Minimal
Poor	Minimal	and/or	Residual

The following criteria were used for a surgical indication: partial or complete isolated, non-iatrogenic SA paralysis following a single closed direct trauma or repetitive use during sports or work-related activities, or an abnormal posture, which was present for at least 3 months, with no clinical or ENMG signs of recovery.

Of the 66 eligible patients, 14 were excluded: four paralysis cases were secondary to thoracic surgery; four refused the surgical procedure; one patient presented with chronic complete paralysis, with no pain but complete SA atrophy; one patient had minimal paralysis without prolonged distal motor latency; two patients had fully recovered, one within six months and the other had a relapse that is still being monitored; one patient presented with partial paralysis that partially recovered, in combination with adhesive capsulitis; one patient presented with multiple diseases along with partial SA paralysis, thus functional rehabilitation was determined to be the best course of action.

The procedure was performed with the patient supine and the ipsilateral hemithorax elevated. An 8–10 cm longitudinal incision was performed over the mid-axillary line at the level of the fifth rib. The anterior edge of the latissimus dorsi muscle was reflected backwards. The serratus anterior branch of the thoracodorsal artery was followed distally. Once the LTN was identified, external neurolysis was performed by ligating any blood vessels crossing the nerve, and by opening the SA fascia widely to eliminate any restrictions and sharp bends [18].

Patients were released from the hospital on the day after the surgery, with no immobilization. They returned to the hospital for follow-up at 1 month, 6 months (for the ENMG measurements) and one year. Because several patients did not live near the hospital, not all of them were regularly monitored at the clinic. As a consequence, the ENMG study was performed locally and the results transmitted to us. Patients without recent visits were contacted again by telephone. The results were graded using the criteria outlined in Table 1.

To compare quantitative variables, the non-parametric Mann-Whitney U test was used, with P values less than 0.05 being considered significant. The Kruskal-Wallis test was used to compare two series of quantitative variables. Qualitative variable were compared using the Monte-Carlo test.

3. Results

The cohort consisted of 52 consecutive cases with an average patient age of 32 years (range 13–70). There were 38 men and 14 women with an average age of 32 years (range 13–60) and 36 years (range 15–70), respectively. Forty-one of the patients were right-handed (no information on 8 cases). The right side was paralysed in 45 cases (87%). Six of the seven cases on the left side resulted from a direct blow to the thorax. There were no bilateral cases. The paralysis was present for an average of 2 years (median 1 year, range 4–259 months). The paralysis was complete in 27 cases (52%) and partial in 25 cases (48%) (Fig. 2a).

The injury mechanism in 28 cases was repeated micro-trauma. The injury was sports-related in 13 cases (25%), due to an accident at home in eight cases (15%) and due to a work-related accident in seven cases (13%). A single injury episode was identified as the