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Original article

Isolated paralysis of the serratus anterior muscle successfully treated by surgical release of the distal portion of the long thoracic nerve

Traitement des paralysies isolées du muscle serratus antérieur par neurolyse de la portion distale du nerf thoracique long

J. Laulan [a,*], T. Lascar [b], Y. Saint-Cast [c], M. Chammas [d], D. Le Nen [e]

[a] *Unité de chirurgie de la main, service de chirurgie orthopédique, CHU de Tours, hôpital Trousseau, 37044 Tours cedex, France*
[b] *Centre hospitalier Princesse Grace, 98000 Monaco, France*
[c] *Centre de la main, 49100 Angers, France*
[d] *Service de chirurgie orthopédique 2, CHU de Montpellier, 34295 Montpellier cedex 5, France*
[e] *Service de chirurgie orthopédique, CHU de Brest, 29200 Brest, France*

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Abstract

Objectives. – Isolated paralysis of the serratus anterior (SA) muscle had been reported, especially in athletes. During SA fascial flap dissections, we observed that fascial and vascular structures can mechanically constrain the thoracic portion of the long thoracic nerve (LTN). Here, we assess the results of neurolysis of the thoracic segment of the LTN.
Methods. – A prospective multicenter study was conducted between December 1999 and June 2004. Every case of isolated palsy of the SA was included, after a Parsonage-Turner syndrome has been ruled out. Eighteen consecutive cases underwent such neurolysis. There were 14 men and 4 women. Their mean age was 30 years (17 to 49).
Results. – The operation took place 16.4 months (range, 4-72 months) after the onset of palsy. Pain relief usually occurred during the first postoperative month. At the longest follow-up most patients had recovered completely.
Conclusions. – In the absence of spontaneous recovery from traumatic palsy, surgical release of the distal segment of the LTN is a minimally invasive, safe and efficient procedure. Results were best when surgery was performed within six months of the initial paralysis.

Keywords: Scapular winging; Serratus anterior muscle; Long thoracic nerve; Neurolysis

Résumé

Objectifs. – Des paralysies isolées du muscle Serratus antérieur (SA) sont rapportées dans la littérature, notamment chez les athlètes. Au cours de nos dissections de lambeau du SA, nous avons observé que le fascia et des structures vasculaires pouvaient réaliser un point de fixité voire une compression de la portion thoracique du Nerf Thoracique Long (NTL). Nous rapportons ici les résultats de la neurolyse du NTL dans sa portion thoracique.
Méthodes. – Une étude prospective multicentrique a été réalisée de décembre 1999 à juin 2004. Tous les cas de paralysie isolée du SA, après élimination d'un syndrome de Parsonage-Turner, ont été inclus. Dix-huit cas consécutifs ont été opérés selon la même technique. Il y avait 14 hommes et 4 femmes. Leur âge moyen était de 30 ans (de 17 à 49 ans).
Résultats. – L'opération a été réalisée en moyenne 16,4 mois (de 4 à 72 mois) après le début des troubles. Le plus souvent, la douleur a disparu au cours du premier mois postopératoire. Au plus long recul, la quasi-totalité des patients avait une récupération musculaire complète.
Conclusions. – En l'absence de récupération spontanée d'une paralysie isolée du muscle SA, nous proposons une exoneurolyse de la portion distale du NTL, car c'est une technique peu invasive, et efficace. Les résultats étaient meilleurs si la chirurgie avait été réalisée dans les six mois suivant l'installation de la paralysie.

Mots clés : Scapula alata ; Muscle serratus antérieur ; Nerf thoracique long ; Neurolyse

* Auteur correspondant.
E-mail address: jacky.laulan@orange.fr (J. Laulan).

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1. Introduction

Paralysis of the serratus anterior (SA) muscle may result from Parsonage-Turner syndrome (neuralgic amyotrophy) [1]. This syndrome is characterized by an acute onset of pain followed two or three weeks later by scapular winging. Paralysis usually involves other muscles in the shoulder girdle. The nature of the pathogenic process is still debated [2,3]. Spontaneous recovery generally occurs [4]; therefore treatment is conservative.

A different problem is that of mechanical injuries of the long thoracic nerve (LTN) following repetitive activities or a single trauma. These traumatic cases are characterized by the simultaneity of pain and palsy affecting only the SA muscle. Such compressive or stretching injuries are often associated with sports activities [5–7]. Conservative treatment remains the rule even though spontaneous recovery is frequently partial or absent [8,9]. In such cases SA palsy frequently results in permanent disability [10]. Palliative procedures using muscle transfer have had partial success [11–13]. Concerning the pathophysiology, the injury of the LTN may result from compression or overstretching of the nerve as it passes over the second rib [11], or an entrapment of the LTN as it passes through the scalenus medius muscle [14,15].

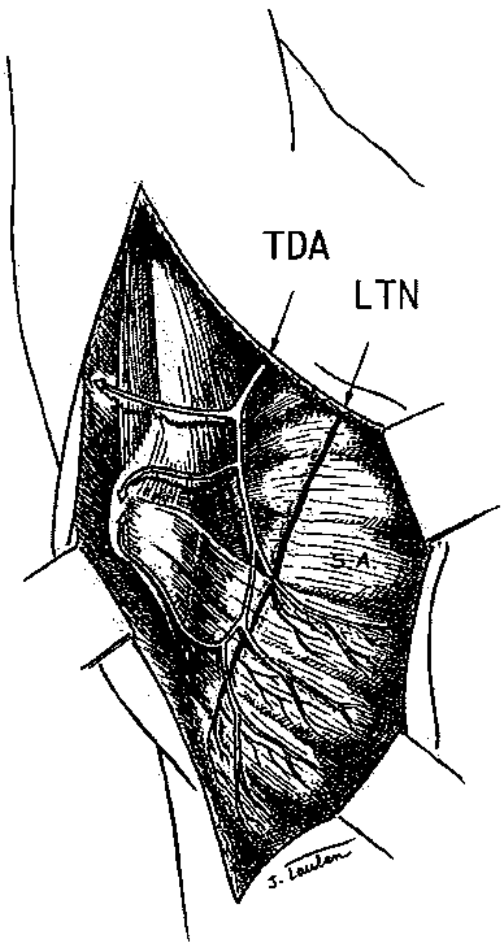

Fig. 1. Position of the thoracic portion of the long thoracic nerve (LTN) relative to the vascular branches of the thoracodorsal artery (TDA). Note that the main arterial branch to the serratus anterior (SA) joins the LTN at the proximal border of the lower serratus.

Our SA fascial flap dissections, demonstrated that fascial and vascular structures may cause mechanical constrains on the thoracic portion of the LTN [16]. Near the fifth rib, at the level of the proximal border of the lower serratus, the LTN passes under the main serratus branch of the thoracodorsal artery as it goes below the fascia of the SA muscle (Fig. 1). At this "crow's foot landmark", the distal portion of the LTN is easily identified [17].

We described the successful treatment of SA paralysis by surgical release of the thoracic portion of the LTN in 2002 [18]. This prospective multicenter study reports the results of this procedure.

2. Patients and methods

This multicenter study includes 18 consecutive patients (14 men and four women) who underwent neurolysis of the thoracic portion of the LTN between December 1999 and June 2004. The demographic details of the patients are shown in Table 1. The mean age of the patients at the time of the operation was 30 years (ranging from 17 to 49 years).

The inclusion criteria were all of the following: an isolated paralysis of the SA muscle of more than three months, associated with acute trauma or excessive use of the shoulder at the onset of palsy; two consecutive electromyographic studies demonstrating persistent SA denervation without abnormalities in the other shoulder girdle muscles. The exclusion criteria were any of the following: pre-existing systemic disorder or surgery (axillary dissection or first rib resection); suspected Parsonage-Turner syndrome (pain occurring few weeks before palsy; absence of a physical activity involving the use of the shoulder or the upper limb, or a specific traumatic event; several muscles affected) or, fascioscapulohumeral muscular dystrophy.

The clinical preoperative assessment included the duration and the cause of the palsy, the presence of pain and its location. The strength of every shoulder girdle muscle was assessed. A pseudo-Tinel's sign was sought for along the thoracic portion of the nerve. Complete paralysis was evidenced by permanent scapular winging, and partial paralysis by a winging of the distal portion of the scapula increased by upper limb elevation.

The surgical technique of the present study was that described by Laulan et al. [18]. A lateral thoracic approach was used, along the anterior border of the latissimus dorsi muscle which was reflected posteriorly. The thoracodorsal bundle was identified and the main artery branch for the SA muscle was followed to the point where it crossed over the LTN. After locating the LTN, any anatomic abnormality was identified and treated. The fascia over the LTN was then opened widely, avoiding the motor branches. The nerve was freed and left without tension or angulation. The main peroperative findings were noted.

Follow-up ended when the condition of the patient became stable, that is when recovery was complete or muscle strength

Table 1
Main characteristics of the series.

N°	Sex	Age	Mechanism	Palsy	Side	Location of the pain	Duration of the palsy (months)	Main cause(s) (associated factor)	Time for alleviation of pain	Time for onset of subjective muscular recovery	Time for optimal muscular recovery (months)
1	M	31	Work (printing office)	Complete	R	Scapular post	13	Fascial fibrosis	Three months	Seven to eight months	11–12; complete
2	F	18	Accordion (lateral strap)	Complete	R	Laterothoracic	4	Fascial fibrosis	One day	Immediate	Two; complete
3	M	30	Acute event (lifting effort)	Complete	R	Scapular	5	Fascial fibrosis	One day	Immediate	Three; complete
4	F	22	Acute event (backpack)	Complete	R	Scapular post	6	Fascial fibrosis (scoliosis)	One day	Immediate	Three; complete
5	M	29	Sport (Javelin)	Incomplete	R	Laterothoracic	72	Vascular branch	One month	Five to six months	12; sub total
6	M	42	Work (horticulturist)	Complete	R	Scapular	9	Fascial fibrosis	One day	Immediate	Three; complete
7	M	34	Trauma (fall from a bike)	Complete	R	Scapular	6	Vascular branch (fascial fibrosis)	One month	Three to four months	Eight to 10; complete
8	M	32	Acute event	Complete	R	Scapular and laterothoracic	7	Vascular branch	One day	Two weeks	Four to five; complete
9	M	23	Sport (judo)	Incomplete	R	Scapular post and laterothoracic	10	Vascular branch	One month	One week	Five; complete
10	M	34	Work (butcher)	Complete	R	Scapular	25	Muscular anomaly and vascular branch	One month	Three to four months	Eight; sub total
11	M	35	Trauma	Complete	R	Scapular	15	Muscular anomaly	Two weeks	Four to five months	Ten; sub total
12	F	49	Acute event	Complete	R	Scapular post and laterothoracic	15	Vascular branch	One month	Six months	Ten to 12; complete
13	M	20	Sport (hand ball)	Incomplete	R	Scapular	60	Vascular branch	Three months	Five months	18; complete
14	F	17	Acute event (traction on the arm)	Complete	R	Scapular post	6	Muscular anomaly and vascular branch	One day	Immediate	Three; complete
15	M	21	Sport (Tennis)	Complete	R	Laterothoracic	7	Vascular branch (fascial fibrosis)	Three weeks	1.5 month	Six; complete
16	M	37	Trauma (thoracic)	Complete	L	Scapular post and laterothoracic	24	Vascular branch	One day	One month	Seven to eight; complete
17	M	31	Trauma (thoracic)	Complete	R	Scapular post and laterothoracic	6	Fascial fibrosis	One day	Two months	Six; complete
18	M	36	Trauma (thoracic)	Complete	R	Laterothoracic	6	Vascular branch (fascial fibrosis)	One day	Two months	Six; complete

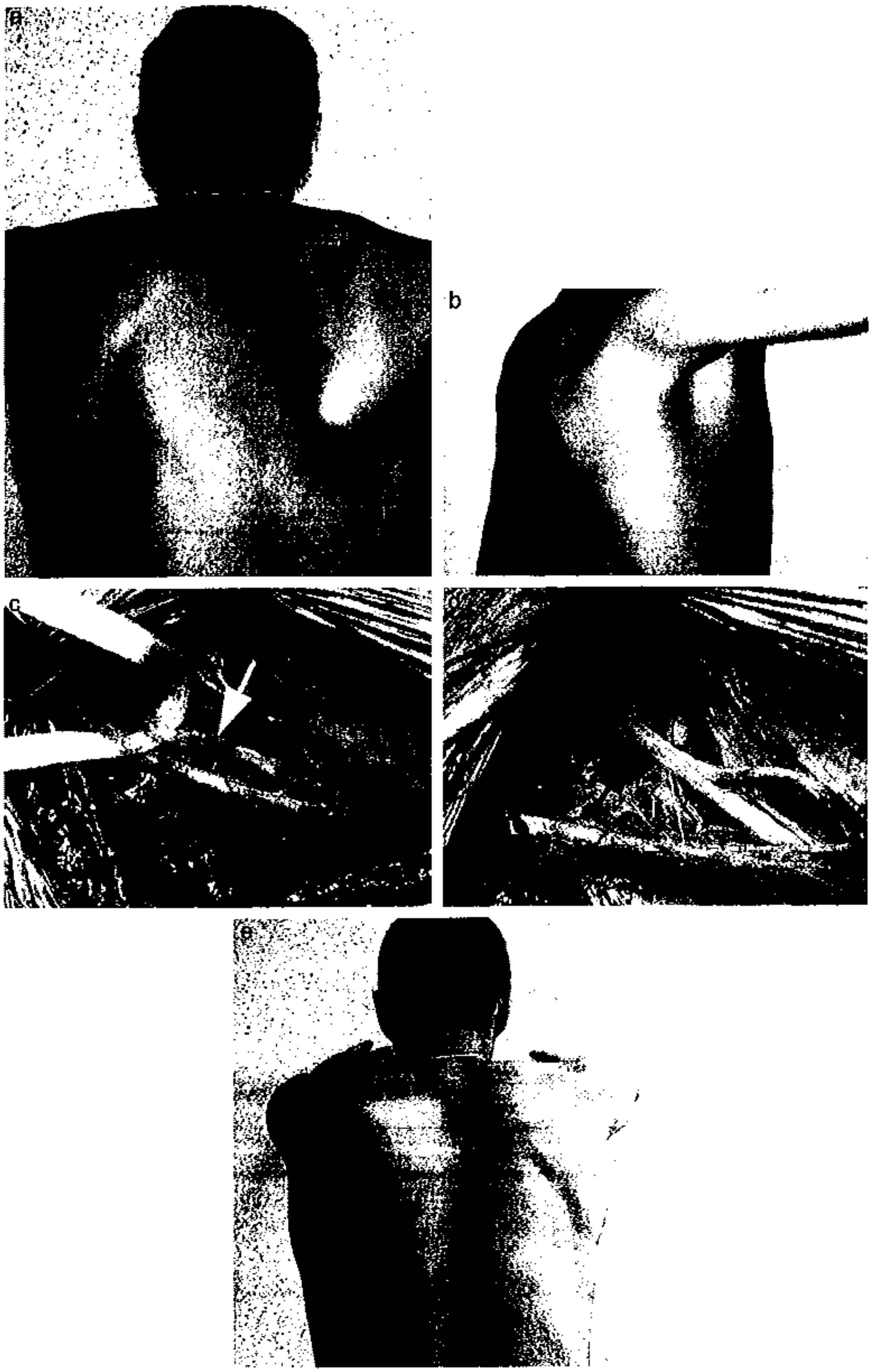

Fig. 2. Clinical and preoperative views of a typical case (case 8): a: a six-month history of scapular winging due to the paralysis of the serratus anterior which occurred after prolonged elevation of the arm; b: the location of the pseudo-Tinel's sign and the incision line are indicated on the skin of the patient. Note the limited elevation of the upper limb; c: peroperative view showing the compression of the LTN by an arterial branch (white arrow); d: peroperative view after neurolysis. Note the pathological aspect of the nerve where it was crossed by the arterial branch (black arrow); e: photo of the patient five months after neurolysis of the LTN. Scapular winging has completely disappeared.

did not increase for two consecutive clinical assessments. Postoperative electrodiagnosis was performed when muscular recovery was slow or incomplete. Complete recovery is evidenced by the disappearance of scapular winging, even during upper limb elevation and wall push-ups. Recovery was considered partial if a slight distal scapular winging persisted when doing wall push-ups.

3. Results

Winging of the scapula of average 16.4 (four to 72) months' duration always involved the dominant side except in one traumatic case (case 16). The cause of paralysis was a single trauma or an acute event in 10 cases: traction of the upper limb twice (cases 12 and 14), prolonged elevation of the arm once (case 8), fall on the shoulder once (case 7), sudden depression of the shoulder girdle once (case 11), carrying a backpac, once (case 4), lifting a heavy object once (case 3), and a direct blow to the lateral chest wall three times (cases 16, 17, 18), of which two were associated with rib fractures. The other eight patients had no definite incident of trauma but were involved in strenuous sports or professional activities with excessive use of the shoulder (Table 1). All patients had scapular or lateral thoracic pain with a neuropathic component and weakness of the shoulder. One patient had been operated on for a subacromial impingement syndrome, but with no benefit (case 16). Pain was the main complaint in three cases (cases 2, 5 and 10).

Initial examination showed limited elevation of the upper limb and scapular winging exacerbated by active forward elevation which was consistent with SA palsy (Fig. 2a). Most patients could not elevate the arm above the shoulder level (Fig. 2b). Paralysis of the SA muscle was complete in 15 cases and marked (M2) in three cases. Two of the three incomplete cases of paralysis were the longest standing (cases 5 and 13). A positive pseudo-Tinel's sign or localized tenderness was found along the course of the LTN near the fifth rib posterior to the midaxillary line (Fig. 2b), except for cases 1 and 4 where this sign was not sought.

All patients underwent two electrodiagnostic studies, with similar findings. These studies demonstrated complete (15 cases) or marked denervation of the SA (three cases). In the three paretic cases, the EMG abnormalities were more severe in the lower than in the middle serratus. The other shoulder girdle muscles were not affected. Motor nerve conduction studies were performed in six patients, and showed a slowing of the conduction velocity in the LTN. The mean distal motor latency was 6.6 ms (between 4.3 and 11.8 ms), whereas the normal value is 3.9 ± 0.6 ms [19]. Case 12, in which distal latency was 4.3 ms in the involved side, had a distal latency of 3.7 ms in the other side.

A local alteration of the LTN was observed except in case 3 where the findings were poor. There was fascial fibrosis in the vicinity of the proximal border of the distal serratus in nine cases and it was the only cause of nerve compression in six of these. A vascular or muscular source of nerve compression was found in the other 12 cases (Fig. 2c and d). There were no complications related to surgery.

The average follow-up was nine months (six months to three years). Pain usually diminished or disappeared within the first postoperative month. At the final review, all patients were pain free at rest and during daily activities. Fifteen patients presented complete muscular recovery (Fig. 2e). Three patients showed slight distal scapular winging during wall push-ups. In two of these cases (5 and 10) the palsy had been present for two years or more before surgery. The third (case 11) presented the most severe nerve stricture of all 18 patients. Complete elevation of the upper limb was restored in all patients.

Postoperative electromyography and motor nerve conduction studies were performed in eight cases. Electromyography demonstrated recovery in five of these eight cases (cases 1, 7, 9, 12 and 13) and a marked improvement in the other three (cases 5, 10, 11). All nerve conduction studies demonstrated a normalisation in the motor distal latency. All patients returned to their former occupations and were very satisfied with the result.

4. Discussion

SA palsy may be observed in Parsonage-Turner syndrome [1]. Spontaneous recovery generally occurs within six months but may take up to five years [1,2,4]. When neuralgic amyotrophy involves an individual peripheral nerve, England and Summer hypothesized that "the selective course of certain nerves selectively exposes them to mild focal trauma that increases their susceptibility to this disease" [3].

Long thoracic mononeuropathy can also occur after an acute injury caused by traction on the arm, by a direct blow to the lateral thoracic wall or sudden depression of the shoulder girdle, or as a result of the excessive use of the shoulder girdle, especially in athletes [5,6,9,11]. A proximal injury of the LTN as it passes through the scalenus medius or over the second rib is generally incriminated [11,14,15].

Our previous observations during SA fascial flap dissections [16] and the results of the present study confirm that the LTN is distally fixed by fascial and vascular structures near the proximal border of the lower SA muscle. The liability of the nerve to be compressed by the fascia of the SA muscle has also been considered by Manning et al. [20]. The LTN is a long thin nerve, which runs along the lateral thoracic wall. This anatomical course makes it especially vulnerable. We agree with Gregg et al. [5] that long thoracic neuropathy is due at least in part to traction injury between two fixed points. Fibrotic involvement of the fascia with fixation and loss of gliding of the thoracic portion of the nerve, associated with movements of the chest wall, submits the nerve to repetitive stretch injuries and may preclude recovery. In one of our patients (case 4), the tethering of the nerve was probably favoured by an associated scoliosis, the palsy being on the convex side of the latter. Pathophysiological and electrodiagnostic studies suggested neurapraxia of the LTN. This may explain rapid recovery when surgery takes place before the onset of muscular degeneration. The present study also shows that the thoracic portion of the

LTN may be compressed by vascular and muscular structures. In 11 cases (Fig. 2c), we found a short arterial branch emerging directly from the thoracodorsal artery (type II branching pattern of the classification of Cuadros et al. [17]). This small branch crossed over the LTN and directly compressed the nerve, especially when the arm was raised. Two patients with this abnormality brought on paralysis through a raised arm position (cases 8 and 12). In three cases we found a muscular abnormality of the last serration of the middle serratus. This modified the course of the LTN before it passed under the fascia of the lower serratus and was associated with a severe constriction of the nerve in case 11.

Spontaneous recovery in traumatic SA palsy is less likely than in cases of Parsonage-Turner syndrome. Complete recovery is observed at best in 50% of patients [11]. At worst, complete recovery is never observed [9]. Muscular recovery must be complete at nine months and usually occurs within the first six months [5,11]. SA paralysis can cause severe long-term disability since the loss of dynamic scapular stabilization affects the function of the whole upper limb [10]. The main type of treatment proposed is a pectoralis major transfer [12,13]. However, this palliative procedure provides only a substitute in scapular stabilization and functional restriction persists [13]. Furthermore, recurrence of scapular winging is possible [11,12]. Recently, two cases of nerve transfers were reported [21,22]. Disa et al reported four cases successfully treated by supraclavicular neurolysis of the LTN within the scalene muscles [14]. However, at least three of these cases had an associated thoracic outlet syndrome. The pathophysiology here is very different from our cases. Furthermore, some authors pointed out that the neural lesion must have been distal to the scalenus medius as the seventh cervical root lies anterior to this muscle [5,11]. Recently, Nath and Melcher reported good results in 13 cases treated by proximal microneurolysis [15].

If neuropathy results from excessive tension of the nerve between two fixed points, neurolysis at one of these points allows recovery of nerve function. In our study, a positive pseudo-Tinel's sign or tenderness along the course of the LTN in the laterothoracic area, near the fifth rib, along with the observation of anatomical abnormalities in this area, as well as the recovery of the SA function in our patients indicated exploration of the thoracic portion of the LTN and distal neurolysis. This relieves distal nerve fixation or persisting nerve entrapment, thus controlling both static and dynamic factors of the LTN neuropathy.

Shoulder pain is a frequent concern in the absence of spontaneous recovery [7,10,12] Shoulder or lateral thoracic pain was constant in our series and was the main complaint in three cases. Sometimes, part of the pain had an anterior location and occurred with arm elevation; a subacromial impingement secondary to scapular winging may be incriminated. Pain can also be due to an overuse of the other shoulder girdle muscles [7,9,12]. We observed a permanent muscular imbalance in several patients. The other muscles involved in stabilization of the scapula especially trapezius, levator scapulae and rhomboid muscles were contracted, resulting in muscular pain. Therefore a decrease in pain is observed after palliative procedures for scapular stabilization. More frequently pain is localized in the lateral chest wall or the lower pole of the scapula [11]. This pain is probably neurogenic and may be due to the entrapment of the LTN. After neurolysis, alleviation of pain occurred very quickly in most patients, and usually before muscular recovery.

5. Conclusion

In cases of isolated scapular winging, spontaneous recovery is uncertain and frequently partial with a residual weakness. When a Parsonage-Turner syndrome is ruled out and a traumatic or microtraumatic origin is suspected, the diagnosis of LTN entrapment must be considered. Patients who do not recover within three to six months can benefit from surgical release of the thoracic portion of the LTN. This procedure is simple, safe and efficient: all 18 patients presented a complete recovery or marked improvement. The speed and quality of recovery mainly depend on the duration of the paralysis before surgery. Results are better when the operation is carried out within six months of the initial complaint. Neurolysis of the thoracic portion of the LTN gives better results than spontaneous evolution. At the longest follow-up all of our patients were pain– free with a functional shoulder.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Acknowledgments

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