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# Thoracic outlet syndrome: influence of personal history and surgical technique on long-term results

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## Abstract

**Objective:** Long-term results after surgery for thoracic outlet syndrome (TOS) are reviewed in terms of personal histories and surgical techniques. **Methods:** Forty-eight operations were performed in 37 patients. In 21 instances, the picture was one of ordinary TOS, in eight TOS was traumatic and in nine the picture was sub-acute. Cervical ribs were excised through a supraclavicular approach (in seven cases), and first ribs through transthoracic, transaxillary or supraclavicular approaches (in 25, 15 or one, respectively). Long-term follow-up was obtained in 41 cases and averaged 11.7 years. **Results:** Surgical decompression was successful in 28 cases (68%), including all patients with traumatic TOS (8/8) and seven with sub-acute symptoms (7/9). Outcome was good in five of seven supraclavicular cervical rib resections, and in 23 of 34 first rib excisions. First rib resections performed transaxillary had shorter post-operative stays, fewer complications. **Conclusion:** Surgical decompression is more successful when TOS is traumatic or sub-acute. When involved, a cervical rib can be resected through a supraclavicular approach, since the procedure is easy and has little morbidity. The transaxillary approach should be preferred for first rib resections because of shorter post-operative stays and fewer complications than after the transthoracic approach. © 1999 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Thoracic outlet syndrome (TOS) refers to a variety of disorders in the upper limb, such as pain, paresthesia and dysesthesia. It is caused by the compression of neural or vascular structures between the scalene muscles, between the first rib and the clavicle, or under the pectoralis minor muscle [1]. Symptoms can be reproduced by compressive and positional maneuvers (Adson's test, hyperabduction and costoclavicular maneuvers). Diagnosis of TOS is difficult, however, because such maneuvers [2] and other diagnostic tests (nerve conduction studies, electromyographs, X-ray films, sensory tests) are not specific [3]. Furthermore other pathologic conditions in the neck and the thoracic outlet may mimic TOS (herniated cervical disk, rotator cuff rupture, tumors or peripheral nerve entrapment) [1,4]. Difficulties in diagnosis and variability in patient selection account for the wide range of results achieved in the surgical management of TOS (from 24 to 100% of symptom relief) [4].

Conservative management is the initial treatment of

choice, since patients with TOS may be cured with postural correction, stretching and strengthening exercises [6–8]. Surgery may be successful when TOS fails to improve with conservative treatment or when patients have symptoms too severe to tolerate conservative management [1]. Selection of patients likely to benefit from surgery on one hand, and timing of surgery on the other hand, are however still debated. Numerous surgical procedures have been described for decompression [1]. Although first rib resection via Roos' transaxillary approach is the most frequently used [9], no clear advantage has been demonstrated for any technique [10], and the choice of a procedure still largely depends on the surgeon's preference.

The purpose of this study is to review the long-term outcome of patients after surgical management of TOS, with special reference to their pre-operative histories and to the surgical technique used.

## 2. Patients and methods

From 1978 to 1997, 37 patients (eight men and 29 women) aged from 16 to 51 years (median 33) were operated for TOS in the Unit of Thoracic Surgery at Geneva

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Table 1  
Clinical pictures of trauma related TOS

	No. of patients
Car crash injuries (seat-belt injuries)	3
Two repeated trauma of the shoulder in high-level athletes (tennis, gymnastics)	2
Overuse of the shoulder in a paraplegic patient in wheelchair	1 (both sides)
Ski trauma (direct anterior trauma of the shoulder)	1

University Hospital. Eleven patients were operated on both sides, amounting to a total of 48 surgical procedures. All patients underwent extensive history taking and physical examination and had chest or cervical X-rays. The following studies were performed prior to admission: upper limb angiography (35/48), electroneuromyography (17/48), Doppler ultrasonography (10/48) and/or phlebography (5/48). None of these studies suggested another diagnosis.

A conservative treatment was always attempted prior to surgery, but proved unsuccessful in all patients. Most (21/37) took painkillers (non-steroidal antiinflammatory drugs, paracetamol), for more than 4 months, and physiotherapy was given for an median period of 7 months (range 1–16). Such conservative management was occasionally felt ineffective from the start, leading to early surgery (in the so-called subacute cases of TOS).

Patients were classified in four groups: neurological (28/48, 59%), arterial (3/48, 6%), arterial and neurological (15/48, 31%), or venous (2/48, 4%) TOS. Symptoms of patients with neurologic TOS were pain (18/28) and paresthesia (14/28) in the neck, shoulder or arm. Adson test was positive in 15 cases (15/28). Hypoesthesia was noted in five patients, paresia in five, brachial plexus tenderness in two, and atrophy of the involved limb in one.

The three patients with arterial TOS had a history of ischemia of the arm, at rest or in abduction. Two had a Raynaud history with a positive Adson test. Angiography showed extrinsic compression of the subclavian artery at rest or in abduction in all three.

Patients with a combination of arterial and neurologic symptoms had pain (10/15), paresthesia (9/15), edema (2/15), or cyanosis (1/15) of the upper limb. The following signs were noted at examination: a positive Adson test (11/15), loss of sensitivity (5/15), loss of strength (4/15), or diminished reflexes (1/15).

Both patients with venous TOS had pain, swelling and cyanosis of the arm. Adson test was positive in both. One had a thrombosis of the axillary vein (Paget-Schroetter syndrome) and had a 3-month anticoagulation therapy prior to surgery.

Median duration of the symptoms before surgery was 21 months (range 1–72). Nine patients (eight women and one man), aged 22–51 (median 41) suffered from subacute TOS. Their symptoms were severe, they could not tolerate conservative management, and surgery took place within 6 months of onset. TOS was of the neurological type in six, neurological and arterial in 2, and arterial in one.

There were eight cases of trauma-related TOS in seven patients (three men and four women, aged 19–45, median 29), five of the neurological type and three neurological and arterial. Trauma took place 7 to 36 months (median 14) prior to decompressive surgery. Three cases involved seat-belt injuries in car accidents and one suffered a direct anterior concussion of the shoulder in a ski accident. The other three occurred in somewhat more chronic fashion (Table 1). None involved a clavicle fracture. Eleven patients had bilateral cervical ribs, five of them presenting with a supraclavicular mass.

Techniques and approaches used for decompression are reviewed in Table 2. In the case of a cervical rib, a resection of this rib through a supraclavicular approach was the technique most often performed. For first rib resections, Roos' transaxillary approach [9] was used in the late period and a transthoracic approach in the early period. The latter procedure was conducted through a classic anterolateral thoracotomy with extraperiosteal resection of the first rib [11].

A median follow-up of 11.7 years (range 1.1–19.2) was obtained in 41 of 48 operated cases (85%). Follow-up was obtained during a clinical visit performed for the purpose of the study in 14 cases, or by phone in 27. Outcome after surgery was graded as 'good' when symptoms improved and when patients were able to return to their pre-illness activities. Outcome after surgery was graded as 'poor' when symptoms did not improve or worsen, or when patients could not return to their usual activities. Surgical outcome was also correlated with pre-operative histories, with the type of TOS, and with the presence of cervical rib. The three surgical approaches used were evaluated in terms of outcome, duration of hospital stay, and morbidity. Student's *t*-test was used for comparison of continuous vari-

Table 2  
Approach and technique used for decompression according to the presence or absence of a cervical rib

Approach	Cervical rib present		No cervical rib	Total
	Cervical rib resection	First rib resection	First rib resection	
Supraclavicular	7	–	1	8
Transaxillary	–	1	14	15
Transthoracic	–	3	22	25
Total	7	4	37	48

Table 3  
Long-term outcome after TOS decompression according to pre-operative history

Post-operative evolution	Good outcome	Poor outcome
Total	28	13
<i>Type of TOS</i>		
Neurologic	11	5
Neurologic and arterial	8	5
Arterial	1	2
Venous	8	1
<i>Particular pre-operative history</i>		
Traumatic TOS <sup>a</sup>	8	0
Acute symptoms <sup>b</sup>	7	2
Presence of a cervical rib	6	6

<sup>a</sup> History of trauma or overuse of the shoulder.

<sup>b</sup> Duration of symptoms <6 months prior to decompression.

ables, and Fisher's exact test for categorical variables. Values of  $P < 0.05$  were considered significant.

### 3. Results

At follow-up, surgery was graded as good in 28 cases (68%): patients were satisfied and would chose surgery again, should TOS symptoms reappear. Pre-illness activity was resumed within 3 months in 27 cases (66%). Six patients did not return to their pre-illness activity or had to change profession. Results for the different groups of TOS are listed in Table 3. Among the 12 cases with a cervical rib, seven had the cervical rib resected through a supra-clavicular approach, with good results in five of them, whereas the remaining five who had their first rib resected (and their cervical rib left in place) by a transthoracic or an axillary route did poorly in four instances.

First rib resections ( $n = 34$ ) were successful in 23 cases, but did not bring any relief in 11. Of the seven cervical rib resections, five were successful. Outcome, duration of post-

operative hospital stay and long-term complications for each surgical approach are reviewed in Table 4. Transitory loss of strength of the involved arm was attributed to a brachial plexus lesion (BPL) and resolved within 18 months with physiotherapy in all cases. When noted, the loss of sensitivity of the inner aspect of the arm or of the breast (LS) persisted years after surgery. Pleural effractions occurring after Roos' approach (pneumothorax in one and effusion in two) were treated by aspiration, whereas pleural drainage was used in all 20 patients who had had a transthoracic decompression. A second operation was needed after a transthoracic decompression because of the painful luxation of a fractured second rib. Two cases of Homer's syndrome occurred, one after a transthoracic decompression which required surgical suspension of the upper eyelid 3 years later, and the other after an axillary procedure.

### 4. Discussion

Diagnosis and management of TOS are still controversial, more than forty years after the initial description by Peet et al. [12]. One explanation is the lack of a reliable paraclinical test, accounting for the absence of clear criteria for surgery. Extensive history taking and clinical examinations should be performed by experienced clinicians, possibly within multidisciplinary groups, in order to achieve a better selection of patients.

Clearly, conservative management should be tried first, since many patients suffer primarily from muscle imbalance and misalignment of their shoulders that cause the compression. Symptoms are frequently relieved by postural correction, stretching and strengthening exercises for the shoulder-girdle muscles [6–8]. Exercises and posture programs should be continued at home to assure long-term success. An operation can be proposed when symptoms are too severe to bear physiotherapy, or after 6–12 months of unsuccessful conservative management.

Good results after surgery are obtained in up to 80% of cases, whatever technique is used [10]. In the present study,

Table 4  
Long-term outcome after TOS decompression according to the surgical approach used

Post-operative evaluation	Supra-clavicular approach	Transaxillary approach (Roos)	Transthoracic approach
Total	8	13	20
Good outcome	5 (63%)	9 (69%)	14 (70%)
Post-operative stay (days)	5	7	8
<i>Complications</i>			
BPL	1	1	1
LS	0	1	6
Pleural lesion	0	3	— <sup>a</sup>
Fractured rib	0	0	1
Homer's syndrome	0	1	1

<sup>a</sup> Transthoracic approach involved pleural drainage in all cases.

two-thirds of operated cases had improvement of their symptoms. These average results may be explained by the long follow-up period (11.7 years), since symptoms of TOS may recur after initially successful surgery [10]. In a study reporting more than 90% of initially successful thoracic outlet decompressions, good outcome decreased to 73–76% and to 69–71% 1–2 years and 3–4 years after surgery, respectively [10]. In the present study, success was defined by the subjective feeling of symptom relief, by the ability to return to work, and by the willingness of patients to undergo the same operation, should TOS symptoms reappear. These criteria of evaluation seem appropriate, since the feeling of well-being is the goal of TOS treatment. However, this type of assessment may result in lower success rates compared to clinical examination alone, since a high proportion of patients with TOS suffer psychological problems or experience difficulties with their insurances, and thus may not fairly appreciate improvement of their symptoms.

History taking and physical examination are the most important criteria for surgical treatment. Various traumatic lesions may lead to TOS: clavicle fractures, acromioclavicular joint dislocations, blows against the anterior aspect of the shoulder and the anterior chest wall [13] and repeated stress of the shoulder in high level-athletes [14]. In the present study, all patients with traumatic TOS had a successful outcome. All these patients had non-work related trauma (results are reported to be 13% better than in a work-related trauma group [15,16]). Patients with sub-acute symptoms (duration of symptoms before surgery < 6 months) also have better results after treatment. The absence of a significant difference may be explained by the small size of this group. As already noted [17], surgery is more gratifying when the clinical picture is that of rapid involvement of the whole brachial plexus. Although the presence of a cervical rib is helpful in making the diagnosis of TOS, surgical outcome is not better in patients with such a morphologic abnormality. These poor results are mainly due to the poor outcome of first rib resections when a cervical rib is present and left in place (1/5). Results of cervical rib resections are similar to overall results (Table 4).

Many surgical procedures have been described for the management of TOS: scalenotomy, scalenectomy, claviclectomy, pectoralis minor release, first rib resection and cervical rib resection [5]. In the present study, as observed by others [10], rates of successful outcome after decompression with first rib or cervical rib resections are similar. Patients with a cervical rib should thus undergo excision of this rib through a supraclavicular approach, since the procedure is easier and has less morbidity than first rib resection. First rib resection, with or without scalenectomy, is the procedure most frequently performed [18]. This technique opens the space under the clavicle and loosens the anterior and middle scalene muscles no longer attached to the first rib [1]. It should be performed in the absence of a cervical rib, when clear symptoms of TOS are present.

These decompression procedures can be achieved by

different approaches: transaxillary, supraclavicular, transthoracic, posterior, subclavicular, or transclavicular [5,15]. In a previous paper, our group proposed a transthoracic approach for first rib resections [11], because it appeared less hazardous for the brachial plexus. With longer follow-up periods, transthoracic and Roos' axillary approaches have similar outcome, but since the latter has shorter post-operative stay and fewer long-term complications, it should be recommended for first rib resections.

Surgical decompression for TOS is a controversial and challenging problem. Emphasis should be put on a better selection of patients eligible for early surgery (traumatic TOS, acute symptoms). The supraclavicular approach should be preferred for cervical rib resections, and Roos' axillary approach for that of the first rib.

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