Long-term functional outcome of neurogenic thoracic outlet syndrome in surgically and conservatively treated patients

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Purpose: **Neurogenic thoracic outlet syndrome (NTOS) in the absence of bony and electrodiagnostic abnormalities, often referred to as *disputed NTOS,* remains enigmatic. Optimal treatment, especially the role of surgery, is controversial. The long-term functional outcome of a cohort of patients undergoing independent medical examination for disputed NTOS with symptoms sufficiently severe to cause inability to work forms the basis for this report.**

Methods: **Patients with disputed NTOS and symptoms sufficiently severe to cause at least temporary inability to work seen for independent medical examinations from 1990-1998 formed the study group. None of the patients were treated by our group. Functional outcome was assessed with information from a standardized telephone interview or patient questionnaire. The patients' ability to return to work and an assessment of their current level of symptoms and symptom progression since the time of onset were determined.**

Results: **Seventy-nine patients were reevaluated at a mean follow-up of 4.2 years (range, 2-7.5 years) after our initial evaluation. Fifteen patients (19%) underwent first rib resection surgery performed by others, whereas 64 (81%) had no surgery. Patients undergoing surgery had missed more work time than those undergoing conservative management (27.6 ± 6.0 months vs 14.9 ± 2.6 months, $P < .04$). Return to work was achieved in nine patients who were operated on (60%) and in 50 patients who were not operated on (78%) (P = not significant [NS]). Among operated patients, current assessment of symptom severity was severe, moderate, mild, and asymptomatic in 7%, 47%, 40% and 7%, respectively. This distribution did not differ significantly from that observed in nonoperated patients (11%, 55%, 30%, 5%; P = NS). When asked about changes in symptomatic status since onset, 7% of the operated group had complete resolution, 27% had marked improvement, 40% had minimal improvement, 13% had no improvement, and 13% were worse. This did not differ significantly from the change in symptoms reported by the nonoperated group (2%, 30%, 22%, 31%, 16%; P = NS).**

Conclusion: **Most patients with disputed NTOS in this nonrandomized series were able to return to work and demonstrated an improvement of symptoms with long-term follow-up. First rib resection did not improve functional outcome in this group. (J Vasc Surg 2001;33:312-9.)**

The diagnosis and management of neurogenic thoracic outlet syndrome (NTOS) remain enigmatic. The diagnostic criteria for "true" NTOS were outlined by Gilliatt et al in 1970.[1] A combination of anatomic and electrodiagnostic findings was necessary to firmly establish this diagnosis. Since the publication of this definitive work, it has become increasingly evident that a minority of patients who have received the diagnosis of NTOS has met the diagnostic criteria of Gilliatt. All vascular specialists are familiar with the group of patients presenting with complaints of upper extremity pain and paresthesias in whom objective diagnostic findings are conspicuously absent. The term *disputed NTOS* was introduced by Wilbourn[2] to apply to this group of patients.

Few would argue that surgical decompression of the thoracic outlet is indicated in patients with objectively diagnosed neurogenic, arterial, or venous thoracic outlet syndrome. It is also clear that these objectively diagnosed entities are rare, and that most thoracic outlet decompression procedures for thoracic outlet syndrome are currently performed for patients with the disputed form of NTOS. Objective critical data on the success of such treatment are conspicuously lacking. Although a number of surgeons have made claims of initial dramatic improvement in patients' symptoms,[3-10] the long-term outcome of these patients is unknown. Outcome data have almost always been reported by the operating surgeon, hardly a disinterested observer. Independent reporting of patient outcomes by those not involved in their care is rare. Several recent reports have focused on the conservative management of patients with symptoms of NTOS,[11-15] and favorable results have been described. Despite broad acceptance by some surgeons for operative therapy of NTOS, the superiority of surgical therapy over conservative management has never been clearly demonstrated.

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Competition of interest: nil.

Presented at the Joint Annual Meeting of the Society for Vascular Surgery and the American Association for Vascular Surgery, Toronto, Ontario, Canada, Jun 11-14, 2000.

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0741-5214/2001/$35.00 + 0 **24/6/112950**
doi:10.1067/mva.2001.112950

Perhaps most important, the natural history of the untreated disease is substantially unknown. Although it is clear that objectively documented brachial plexopathies ultimately lead to chronic axonal loss and muscle wasting,[16] a similar natural history for the disputed form of NTOS has never been demonstrated, a point of considerable interest. In fact, the functional outcome of this group of patients is unknown, surprisingly.

We have evaluated many patients referred with a presumptive diagnosis of NTOS, most of whom have the disputed variant of NTOS. These patients were referred to us by other physicians for evaluation or were referred by workers' compensation insurance companies for independent medical examinations. No patients underwent treatment at our institution. The long-term functional outcome of patients with disputed NTOS in terms of current level of symptoms, improvement of symptoms since their onset, and ability to return to work forms the basis of this report.

METHODS

From 1990-1998, 153 patients with a presenting diagnosis of NTOS were evaluated by the vascular surgery service at the Oregon Health Sciences University. The initial evaluation consisted of each patient providing a complete history and undergoing a physical examination. All patients were also seen by a neurologist and underwent electrodiagnostic testing, including nerve conduction studies and electromyography. Vascular laboratory testing and further imaging studies (plain radiographs, computerized tomography scans, and magnetic resonance imaging) were performed as indicated. All patients were both initially and subsequently treated by other physicians. Conservative and operative management was chosen at the discretion of the patients' physicians.

For the current study, all patients with electrodiagnostic evidence of true NTOS as described by Gilliatt were excluded from analysis. Electrodiagnostic positivity was determined by decreased amplitude of the median motor, ulnar sensory,[1] and often median antebrachial cutaneous action potentials,[17] usually accompanied by electromyographic evidence of denervation of the lower trunk innervated hand muscles, particularly the abductor pollicis brevis. Additionally, only those patients whose symptoms were sufficiently severe to cause at least a temporary inability to work were included.

Follow-up information was obtained from the patients by means of either a standardized mailed questionnaire or standardized telephone interview. All subjects were mailed a questionnaire. An attempt was then made to reach patients not responding to the questionnaire by telephone. The same questionnaire was used in both methods of interrogation. An example of the questionnaire used is included in the Appendix. The interviewing physician did not participate in the patients' initial evaluation. Patients were asked about the severity and frequency of their current level of symptoms. Severity of symptoms was ranked as severe, moderate, minimal, or no symptoms. Patients were asked to estimate their degree of improvement in comparison with their initial presentation. Improvement was classified as complete resolution, marked improvement, minimal improvement, no improvement, or worsening of symptoms. Patients were also asked about methods of treatment they received and the degree of benefit obtained from treatment. Functional status was evaluated by the patients' current ability to perform their work. Patients who underwent thoracic outlet decompressive operations were then compared with those who did not with respect to the previous observations.

All data were entered into a confidential computerized database (Paradox for Windows, Version 5.0; Borland International, Scotts Valley, Calif). Continuous variables were compared with the Student t test. Comparisons of frequencies and proportions were performed with a χ^2 test. Statistical significance was defined as a P value less than .05.

RESULTS

Patient demographics. Of 153 patients evaluated, one was excluded because the patient had electrodiagnostic evidence of true NTOS. Seventeen patients were excluded because they had not lost work time because of their symptoms. Of the remaining 135 patients interrogated, 79 responded to either the mailed questionnaire or phone interview, for a 59% response rate. The inability to locate the remaining patients characterized the nonresponder group. Sixty-four patients had received only nonoperative treatment, whereas 15 underwent operative therapy. Demographic information for these groups is listed in Table I. There were no significant differences between the surgical, nonsurgical, and excluded patients and patients lost to follow-up in sex, race, occupation, and involvement in litigation. Patients undergoing surgery were significantly older than those lost to follow-up (40.5 ± 1.8 years vs 35.0 ± 1.0 years, $P < .05$), but no other age differences between the groups were noted. The mean length of follow-up from the time of our initial evaluation was 4.2 ± 0.5 years (range, 2-7.5) in the patients who were operated on and 4.2 ± 0.2 years (range, 2-7.5) in the patients who were not operated on (P = not significant [NS]).

Symptoms. Patients' symptoms at the time of initial evaluation are listed in Table II. The types of symptoms experienced were the same in both groups. Operated patients had more frequent complaints of neck pain (60% vs 27%, $P < .03$). No other difference in the location of symptoms was noted. Primarily unilateral symptoms were present in 60% of the operated group and 77% of the nonoperated group (P = NS). Sixty-seven percent of the operated group could relate the onset of their symptoms to a specific time or event, whereas 33% thought that their symptoms were of gradual onset. Corresponding percentages in the nonoperated group were 44% and 56% (P = NS). The duration of the patients' symptoms before our initial evaluation was longer in the surgically treated group (4.0 ± 1.2 years) than in the nonsurgically treated group (2.1 ± 0.3 years, $P < .02$).

Table I. Demographic information on patients diagnosed with NTOS

	Survey responders (n = 79)			
Demographic factor	*Surgical (n= 15)*	*Nonsurgical (n = 64)*	*Excluded* (n = 17)*	*LTFU (n = 56)*
Age when first seen (y ± SEM)	40.5 ± 1.8†	37.9 ± 1.1	37.9 ± 2.0	35.0 ± 1.0
Sex (% female)	11 (73%)	36 (56%)	10 (59%)	39 (70%)
Race (% white)	15 (100%)	58 (91%)	16 (94%)	52 (93%)
Occupation				
Manual	8 (53%)	45 (70%)	10 (59%)	39 (70%)
Office/secretarial	4 (27%)	7 (11%)	4 (24%)	6 (11%)
Other	3 (20%)	12 (19%)	3 (18%)	11 (20%)
Involved in litigation (% yes)	9 (60%)	50 (78%)	13 (77%)	48 (86%)
Length of follow-up (y ± SEM)	4.2 ± 0.5	4.2 ± 0.2	NA	NA

*Includes patients whose symptoms were not severe enough to cause work cessation.
†$P < .05$ between patients treated surgically and patients lost to follow up.
LTFU, Lost to follow-up; *NA,* not applicable; *NTOS,* neurogenic thoracic outlet syndrome.

Table II. Nature and site of symptoms in the 79 respondents with NTOS

	Surgical group (n = 15)	*Nonsurgical group (n = 64)*	P *value*
Symptom			
Pain	15 (100%)	56 (88%)	NS
Paresthesias	11 (73%)	55 (86%)	NS
Weakness	3 (20%)	15 (23%)	NS
Swelling	3 (20%)	5 (8%)	NS
Site			
Neck	9 (60%)	17 (27%)	< .03
Shoulder	12 (80%)	44 (69%)	NS
Arm	14 (93%)	52 (81%)	NS
Forearm	15 (100%)	59 (92%)	NS
Hand	14 (93%)	58 (91%)	NS
Fingers	8 (53%)	40 (63%)	NS

Table III. Initial nonoperative management of operated and nonoperated patients

	Operated (n = 15)	*Nonoperated (n = 64)*	P *value*
Total physicians seen	6.7 ± 0.9	4.3 ± 0.3	< .002
Physical therapy	12 (80%)	43 (67%)	NS
Chiropractor	3 (20%)	13 (20%)	NS
Medications prescribed	3.1 ± 0.3	1.9 ± 0.2	< .001
Medication types			
NSAID	13 (87%)	52 (81%)	NS
Narcotics	10 (67%)	19 (30%)	< .01
Muscle relaxants	9 (60%)	17 (27%)	< .01
Antidepressants	8 (53%)	14 (22%)	< .03
NNA	2 (13%)	6 (9%)	NS
other	4 (26%)	10 (16%)	NS

Values are mean ± SEM or number (%).
NNA, Nonnarcotic analgesic; *NSAID,* nonsteroidal anti-inflammatory drug.

Prior assessment and treatment. The initial nonoperative management of all patients is represented in Table III. Patients who underwent surgery had seen more physicians (6.7 ± 0.9) than those treated nonoperatively (4.3 ± 0.3, $P < .002$). There was no difference between surgically and nonsurgically treated patients in treatment by a physical therapist (80% vs 67%, respectively, P = NS) or a chiropractor (20% each group). Those who underwent surgery had been treated with significantly more types of medications than those treated nonoperatively (3.1 ± 0.3 vs 1.9 ± 0.2, $P < .001$). Although most patients in each group had been treated with nonsteroidal anti-inflammatory drugs (NSAIDs), patients undergoing surgery were more likely to also have been treated with narcotic analgesics (67% vs 30%, $P < .01$), muscle relaxants (60% vs 27%, $P < .01$), and antidepressants (53% vs 22%, $P < .01$).

Operative therapy. Fifteen patients underwent operative therapy by other surgeons. Fourteen underwent first rib resections, and one underwent a combined cervical and first rib resection. The duration of conservative management before operative therapy was 3.7 ± 1.0 years. The length of follow-up after surgery was 3.9 ± 0.6 years.

Current level of symptoms. The patients' current level of symptoms is shown in Table IV. In the operated group, 7% currently have severe symptoms, 47% have moderate symptoms, 40% have mild symptoms, and 7% are asymptomatic. Corresponding percentages in the nonoperated group are 11%, 55%, 30%, and 5% (P = NS). With these distributions and power analysis for the χ^2 test,

Table IV. Outcome based on treatment received

	Current level of symptoms in operated and nonoperated patients			
	Severe	*Moderate*	*Minimal*	*Asymptomatic*
Operated (n = 15)	1 (7%)	7 (47%)	6 (40%)	1 (7%)
Nonoperated (n = 64)	7 (11%)	35 (55%)	19 (30%)	3 (5%)

	Progression of symptoms since onset in operated and nonoperated patients				
	Resolved	*Marked improvement*	*Minimal improvement*	*No improvement*	*Worse*
Operated (n = 15)	1 (7%)	4 (27%)	6 (40%)	2 (13%)	2 (13%)
Nonoperated (n = 64)	1 (2%)	19 (30%)	14 (22%)	20 (31%)	10 (16%)

P = NS between the operated and nonoperated group.

we calculated that a sample size of 19,900 subjects would be required to demonstrate a difference between the surgical and nonsurgical groups with power equal to 80%.

Progression of symptoms since onset. The progression of patient symptoms since onset is shown in Table IV. In the surgically treated group, 7% believe that their symptoms are resolved, 27% have had a marked improvement, 40% have had minimal improvement, 13% have had no improvement, and 13% believe that they are worse. Corresponding percentages in the nonoperated patients are 2%, 30%, 22%, 31%, and 16% (*P* = NS). With these distributions and power analysis for the χ^2 test, we calculated that a sample size of 1900 subjects would be required to demonstrate a difference between the surgical and nonsurgical groups with power equal to 80%.

Outcome based on occupation. The patients' current level of symptoms and symptom progression based on occupation is shown in Table V. No differences in outcome were noted.

Ability to return to work. Total work time missed was statistically greater in the operated than in the nonoperated group (27.6 ± 6.0 months vs 14.9 ± 2.6 months, $P < .04$). Nine of the operated patients (60%) have returned to work compared with 50 (78%) of the nonoperated patients (*P* = NS).

Current medication requirements. The current medication requirements of operated and nonoperated patients are listed in Table VI. There were no differences in the long-term medication requirements of operated and nonoperated patients.

DISCUSSION

In this study, we have reported the results of our modest experience with the evaluation and follow-up of patients given a diagnosis of disputed or electronegative NTOS. Follow-up data were attained in 79 patients, of whom 15 had undergone surgical thoracic outlet decompression and 64 received nonoperative therapy. After a mean follow-up in both groups of 4.2 years since our initial evaluation, no significant difference could be detected in the current level of symptoms, disease progression since onset, and ability to return to work. Clearly, there are limitations to these data. Follow-up data were available in only 59% of patients. Patients were not randomized but, rather, were treated at the discretion of their own physicians. One could argue that because the operated patients had a longer duration of symptoms and missed work, as well as seeing more physicians and requiring more medications, that the patients with the most severe disease were the ones who underwent surgery. However, an alternative hypothesis would be that those patients who are persistent in their complaints will ultimately find a surgeon willing to perform thoracic outlet decompression. Regardless of the cause, in this small series, surgical therapy did not have a significant impact on functional outcome. We acknowledge that the small size of the surgical group could be the source of a type II error.

Other limitations in these data are noteworthy. Because patients did not fill out a questionnaire at the time of their initial evaluation, no direct comparison between their initial and subsequent symptoms could be made. Clearly, retrospective questionnaires are not the ideal method of performing outcomes analysis; prospective studies are the gold standard. Also, the questionnaire used has not been validated and, therefore, may be subject to variability. Similar questionnaires have been used in other studies, and we thought that the questions were specific enough so that patients could classify the nature of their symptoms and symptom progression.

Because those who underwent surgery had their operation performed elsewhere, we cannot verify the quality or completeness of resection. However, in another recent report, patient outcome was unrelated to the volume of thoracic outlet surgery performed by individual surgeons.[18]

Although the etiology, diagnosis, and pathophysiology of NTOS remain controversial, opinions regarding optimal treatment are abundant. Numerous surgical case series have been reported that have claimed good to excellent results in 50% to 90% of patients undergoing thoracic outlet decompression.[3-10] The length of follow-up in these studies is variable. There are two noteworthy facts. First,

Table V. Patient outcome based on occupation

	Manual laborers, n = 53	*Nonmanual laborers (office, health care, etc) (n = 26)*
Current level of symptoms		
Severe	6 (11%)	2 (8%)
Moderate	31 (58%)	11 (42%)
Mild	15 (28%)	10 (38%)
None	1 (2%)	3 (12%)
Progression of symptoms		
Resolved	0 (0%)	2 (8%)
Marked improvement	15 (28%)	8 (31%)
Minimal improvement	16 (30%)	4 (15%)
No improvement	14 (26%)	8 (31%)
Worse	8 (15%)	4 (15%)

P = NS between manual and nonmanual laborers,

Table VI. Current medication requirements in operated and nonoperated patients

	Operated patients (n = 15)	*Nonoperated patients (n = 64)*
NSAID	6 (40%)	31 (48%)
Narcotics	4 (27%)	14 (23%)
Muscle relaxants	5 (33%)	9 (14%)
Antidepressants	2 (13%)	10 (16%)
Acetaminophen	2 (13%)	3 (5%)
Aspirin	1 (7%)	7 (11%)
Other	3 (20%)	4 (6%)
None	2 (13%)	9 (14%)

P = NS between operated and nonoperated patients.

the results are reported by the operating surgeon, which potentially introduces bias because functional results can only be reported in subjective terms. Recent articles in which operative results were reviewed by a third party have been slightly less promising. Lepäntalo et al[19] reported follow-up of 75 patients undergoing first rib resections. One month after surgery, 52% of limbs were asymptomatic, and 77% were improved. At a mean follow-up of 6 years, patients were reevaluated by independent examiners. A permanent success rate of the operation of only 37% was reported. The authors emphasized the importance of an unbiased evaluation and long-term follow-up.

The second criticism of heretofore published surgical case series is the distinct lack of a nonsurgical control group for comparison. We are aware of only one other report in which a group of surgically and nonsurgically treated patients was compared. Franklin et al[18] reported the outcome of patients involved in worker's compensation undergoing thoracic outlet surgery. At 1, 2, and 5 years after surgery, the percentage of patients still on disability leave from work was 60%, 40%, and 44%, respectively. In 100 patients followed up for an average of 4.8 years, 63.5% thought that their symptoms were unchanged or worse, and 72.5% thought that they were still "limited a lot" in vigorous activities. In comparison with 95 matched control patients with thoracic outlet syndrome who underwent conservative therapy, patients who underwent surgery had a 50% increase in health care costs and were three to four times more likely to be unable to return to work.

The association between a poor clinical outcome and worker's compensation claims has been previously made. Green et al[20] reported that only 36% of worker's compensation patients compared with 57% of noncompensated patients could return to their preillness function. Good surgical outcomes were reported in 66% of nonlaborers compared with 23% of laborers by Goff et al.[21] Only 30% of laborers were able to return to their previous occupation compared with 65% of nonlaborers. In this study, no differences in outcome were detected on the basis of occupation or involvement in litigation.

Although reports of surgical management of NTOS are abundant, few reports of patient outcome after conservative management have been published. Novak et al[12] reported 1-year follow-up of 42 patients who had undergone a 6-month program of physical therapy for NTOS. Twenty-five patients (60%) thought that their overall symptoms were better than before treatment. Overall, pain relief was thought to be complete in three patients, almost complete in 16, and partial in 19; there was no improvement in four. Overall, 78% of patients were able to resume work. Factors that were significantly associated with a worse outcome were obesity, involvement in a workers' compensation claim, and associated carpal or cubital tunnel syndrome.

Lindgren[11] reported a 2-year follow-up of 119 patients who underwent inpatient rehabilitation for a mean of 11.4 days followed by a home exercise program. At follow-up, 88% were satisfied with the outcome of their treatment, and 73% had returned to work. Kenny et al[15] evaluated eight patients with severe neck and upper extremity range of motion limitations. After 3 weeks of intensive physical therapy, full neck and shoulder range of motion was restored in all patients.

The controversy of surgical versus nonsurgical treatment of disputed NTOS continues. Although each side has its advocates, the only definitive method of resolving this conflict is a randomized, prospective trial comparing the

two modalities. Although such a trial was initially proposed in 1992,[22] to date, no such trial has been performed. It has been our observation that disputed NTOS is virtually never seen in the elderly patient population. This implies that the syndrome runs a self-limiting course. The overall improvement noted in the nonoperated patients in this series supports the assumption that the natural history of disputed NTOS is one of gradual improvement. It is essential that the proponents of surgical treatment of disputed NTOS prove that surgical therapy is superior to conservative management. Until such a time, we will continue to favor conservative therapy of disputed NTOS.

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Submitted June 12, 2000; accepted Nov 8, 2000.

Please see the Web site for the Appendix (www.mosby.com/jvs).

DISCUSSION

Dr Asa Wilbourne (Cleveland, Ohio). This is an interesting and timely article. It adds to a growing list of publications that challenge certain concepts postulated by the proponents of disputed neurologic TOS. It is important for two reasons. First, it demonstrates that a significant number of TOS patients improve with conservative therapy. Second, it shows that after a few years, approximately the same percentage of patients improve regardless of whether they are treated surgically or nonsurgically.

The authors were not the first to demonstrate that conservative therapy is helpful. However, they have provided us with what was lacking previously, namely, some percentages to work with. Thus, it is now possible to explain to patients that regardless of whether they undergo surgery, they have a one in three chance of having their symptoms improve, possibly even disappear, over the next few years.

In regard to TOS treatment, Franklin and coworkers, in an article published in *Neurology* this past March, reported on a 5-year retrospective survey they had performed regarding the outcome of patients with TOS who were treated in the workmen's compensation system in the state of Washington. They compared patients who underwent surgery and those who did not and found the surgical results overall to be dismal. Obviously, these adverse surgical results can be questioned. In the present paper, for example, only 15 patients underwent surgery, whereas more than four times that number did not. Moreover, although it appears that surgical versus nonsurgical management is determined principally by the orientation of the physicians caring for the patient, the contention cannot be refuted that these two groups may not be comparable, because the surgical group consisted of patients with more severe disease.

There is a method, however, for resolving this controversy, by performing a randomized, prospective trial comparing the two types of TOS treatment. If substantial sustained improvement were demonstrated in the surgical group, the evidence would be overwhelming that, first, some disorder actually existed thereby silencing those who are skeptical of this type of TOS and second, that the appropriate therapy was surgical. Although such a trial was proposed in the *Journal of Vascular Surgery* almost a decade ago (1992), none of the proponents to this time, to our knowledge, has initiated such a clinical trial. This is unfortunate because, unlike so many other controversies in medicine, this is one that can be resolved.

Dr Gregory J. Landry. I'd like to thank Dr Wilbourne for his discussion, and I'm sorry that he couldn't be here personally.

We certainly acknowledge the limitations in these data with respect to the small numbers present in the surgical group. Our purpose in presenting this was not to present it as a definitive comparison between these two groups, but rather to suggest that such a comparison needs to be made. As Dr Wilbourne eloquently pointed out in his discussion, to really address this issue further, a randomized, prospective trial is needed.

Dr Alan R. Koslow (Des Moines, Iowa). Very nice paper. I want to ask you for your comments on the paper presented last year at this meeting by the UCLA group at one of the breakfast sessions in which they looked at their results of doing anterior scalene muscle injection CT directed. And they compared their results of operating on patients who had the historical type of workup in which they had about a 60% to 70% success rate with that surgery where they did not do the CT-directed muscle injection. In those patients who had successful relief of that pain with the anterior muscle injection, they had a 90% success rate. And I can attest that since then I've been evaluating my patients that way, and I've done approximately a dozen patients. I have not had a failure of good or excellent relief of symptoms using the CT-directed muscle injection as a preoperative test.

Dr Landry. Certainly the group at UCLA has done excellent work in terms of the management of neurogenic thoracic outlet syndrome, and I think that there may actually be subgroups of patients who may benefit from more aggressive treatment. I think our responsibility is to identify who belongs to those subgroups so that those patients can be more definitively managed.

Dr Stephen J. Annest (Denver, Colo). My group in Denver tends to take only those patients who are failures of physical therapy, so in your paper that would have been 47% nonoperatively managed patients who became worse or who had no benefit from therapy. Looking at that group in our practice over the past 20 months, the first-time operations have a 16% rate of returning to asymptomatic state, 42% had marked improvement, and 42% noted only mild improvement. None of those patients were worse or at the same level as before surgery. Eighty percent of those operated said that they would have the operation again. In the reoperated group who had had scarred brachial plexus from previous operations, 75% experienced marked improvement, only 25% had mild improvement, and no patient was worse. My question to you is, in the 15 who had surgery, what were the selection criteria by which patients were chosen for surgery?

Dr Landry. We were not involved with the treatment of these patients. So in essence, from our standpoint, it was a bit randomized in that we did not have any influence over who was treated surgically and who was not. That decision was made at the discretion of each patient's individual physician. I acknowledge that there may be biases introduced by the opinions of each individual practitioner.

Dr Kaj H. Johansen (Seattle, Wash). Somewhere among all the horse manure that surrounds the issue of thoracic outlet syndrome is a pony. I want to be sure, Dr Landry, that you are actually searching for that pony and not just piling more on.

Specifically, while I agree that your conclusions follow from your analysis of your data, it is your selection criteria that concern me here. Permit me to draw an analogy. A government-sponsored panel of physicians analyzes a group of patients undergoing amputation following bypass graft for limb salvage. The amputation obviously indicates that the procedure failed, and the conclusion is that bypass grafting really doesn't work. The dilemma with your selection process is that is based on subjects selected via the process of independent medical evaluation (IME). The problem is that those who undergo an IME have an implicit conflict or they have failed therapy. You have provided data regarding a series of individuals who have failed therapy, who have an unclear diagnosis, or who are engaged in a dispute with their employers. We do not know the denominator, those patients who underwent a successful surgical decompression of the thoracic outlet without ever undergoing an IME. What you have shown us, it seems to me, is that patients with upper extremity complaints who undergo an IME likely don't have neurogenic thoracic outlet compression. Can you comment on this for us?

Dr Landry. The process of independent medical evaluation is not to evaluate those who have failed therapy, but to evaluate all patients who have a work-related complaint to determine the compensability of their ailment with respect to their occupation. Some of the patients that we evaluated had actually done quite well. Our job was to evaluate whether or not what they had was related to their occupation, not to make an assessment about optimal treatment or to assess whether or not they had failed treatment.

Dr O. William Brown (Southfield, Mich). I'd like to congratulate you for addressing a very difficult problem. I would like to ask you two questions.

First, how many patients in your series developed their thoracic outlet syndrome symptoms secondary to a previous identifiable trauma?

Secondly, when you speak of conservative therapy, was there a specific conservative program protocol you followed, and if so, what did it consist of?

Dr Landry. With respect to your first question, 50% of the patients could relate the onset of their symptoms to an acute event. The severity of that event was quite variable. The other 50% stated that they had a very gradual onset that they couldn't relate to a specific event.

Since we were not involved in the treatment of these patients, I do not know what the extent of their conservative management was. More than two thirds had been treated by a physical therapist, and about 20% had seen a chiropractor, but beyond that I do not know the extent of their conservative management.

Dr Frank C. T. Smith (Bristol, UK). This is a useful paper for those of us who have to counsel patients with potential TOS, and it will help, because we're sometimes under considerable pressure by those patients to perform surgery. My question relates to the disputed and the undisputed diagnosis of TOS in your patients. Did you rely solely on clinical examination, or did you find any specific modalities of investigation useful in determining the nondisputed TOS group?

Dr Landry. The diagnosis of disputed versus undisputed neurogenic thoracic outlet syndrome was based heavily on the evaluation of our neurologists. All of the patients were seen by a neurologist. All of them underwent electrodiagnostic testing. The diagnosis of true neurogenic thoracic outlet syndrome was based on positive electrodiagnostic findings, specifically patients with decreased amplitude of the median motor, ulnar sensory, or frequently the median antebrachial cutaneous action potentials. The findings were supported by abnormal electromyographic findings in the lower plexus nerve distribution.

Dr Julie Ann Freischlag (Los Angeles, Calif). I actually had an opportunity to read your manuscript, as Dr Machleder forwarded that by e-mail to me, and he unfortunately can't be here today. As you all know, he's the father of this, and because of that it's taken three of us at UCLA to take over his practice, because we see quite a bit of neurogenic TOS.

I describe this disease to my patients as similar to alcoholism, in the sense that it never will truly go away and they always will have TOS. And certainly their perception of their disease is very important. We use the scalene block in order for them to understand exactly what will get better, what won't, and whether it gets better at all. And we utilize other people to do the scalene block who will tell us it's positive and then we do the surgery. We're actually using an SF-36 form preoperatively and postoperatively now to try to assess if indeed we're making these patients better, as we tend to see a lot of them, and my nurse practitioner tends to talk to a lot of them both preoperatively and postoperatively.

But I think perception is the big deal. These patients have to understand how much better they can get and that they're never going to be able to go do everything they want and lift and do things the way other people can.

My question to you is, did you use something like the SF-36? Because asking somebody, "Are you okay?" I'm not sure is good enough. In your paper not everyone was able to respond to you. And I would say that most of the people with TOS that decide to talk to you again are usually the ones that aren't so happy. Therefore, did you just ask if you're okay, or did you use a tool that's been recommended in order to assess people's quality of life?

I do agree we need a prospective, randomized study. We'd be glad to participate, because I would love not to operate on half of these people. And therefore, those of us who do a lot of these operations would gladly participate in such a study.

Thanks.

Dr Landry. Thank you for your question. We did not use the SF-36. I think this is an excellent tool to use in prospective trials to compare pretreatment and posttreatment evaluations. Unfortunately, we didn't have the opportunity to distribute a questionnaire prior to our seeing these patients. So these results are all retrospective.

What we did try to do was ask very specific questions relating to their current level of arm function.

Dr John M. Porter. I will make one final observation. We agonize over neurogenic thoracic outlet syndrome as much as any condition that we happen to encounter in vascular surgery.

I make the following observation: Everywhere else in the body, if you have pressure on a nerve, anatomic pressure, causing pain, and no treatment is given, that nerve will eventually malfunction. It will stop conducting impulses. It will stop performing motor functions. By that theory, assuming that there is no way every neurogenic TOS patient in America has been treated with decompression, we ought to have an epidemic of paralyzed arms in our population, which we obviously do not have. It is entirely possible that there is no such thing as disputed neurogenic thoracic outlet syndrome and that what we've been treating is fibromyalgia or some other mystical rheumatologic condition. These are interesting things for thought.