Thoracic Outlet Compression Syndrome

Critique in 1982

W. Andrew Dale, MD

Experienced surgeons recommend different approaches and operations for thoracic outlet compression syndrome. I reviewed my recent 76-patient series (55% had excellent results, 35%, good; and 9%, failure), series reported by others, and the results of a national survey of complications of the transaxillary first-rib resection reporting 273 partial or complete postoperative brachial plexus injuries, 52 of which failed to recover completely. The difficulties with diagnosis, variability of results, and the potential of serious neurologic sequelae suggest reevaluation of indications and techniques of surgical therapy. Operation should be reserved as a last resort. Modern results with scalenectomy (not simple division of the muscle) suggest its use with reservation of first-rib resection for failures.

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Thoracic outlet compression syndrome continues to be a diagnostic problem. Operations for its relief are the subject of debate and their reported results are variable. These problems, along with the frequency of medicolegal disputes generated by them, concern general, neurologic, thoracic, and vascular surgeons.

Some clinicians doubt the existence of the syndrome. Some surgeons do not believe there are any indications for surgical treatment. Others who once had advocated first-rib resection currently have adopted a lesser operation on the soft tissues only. Finally, there are those who advocate first-rib resection by one or another approach. A few surgeons report remarkably high cure rates; others are less optimistic.

Thus, the problem is the source of much disagreement and the cause of numerous therapeutic disappointments.

PATIENTS AND METHODS

Increasing experience with the diagnostic difficulties and dissatisfaction with the overall results of operations for thoracic outlet syndrome have resulted during the past several years in tightening our overall management protocol and adhering to even stricter indications for operations. Every possible conservative nonoperative measure is used and operation has become a procedure of last resort. The plan of management (Figure) is slightly modified from the one advocated in 1974.1

Diagnostic Study

Patients suspected of having thoracic outlet syndrome initially are examined with emphasis on their history of pain, paresthesias, edema, and motor dysfunction. Known aggravating factors such as injury, rib anomalies, and unusual positions at work as well as general health factors are noted. Examination is directed toward tenderness, masses, and changes in the neck along with the production of pain or pulse cutoff by a change in the arm position.

If the diagnosis of thoracic outlet syndrome seems likely, shoulder girdle strengthening exercises are prescribed for three weeks. To interrupt the cycle of nervous and muscular tension tranquilizers often are prescribed along with warm tub baths to promote relaxation of the muscles of the neck and shoulder girdle. Patients' conditions occasionally are made worse by the exercises and they are warned to discontinue them should that occur.

Electromyography is done, roentgenograms of the cervical spine...
Management plan for thoracic outlet syndrome.

Table 1.—Results of 76 Recent Operations for Thoracic Outlet Syndrome With Follow-up of Six Months or Longer

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Excellent</th>
<th>Good</th>
<th>Failure</th>
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<tbody>
<tr>
<td>Transaxillary 1st rib resection</td>
<td>28</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>With clavicle resection</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>With cervical rib resection</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>With carpal ligament repair</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Resection of cervical rib and scalene muscle</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Scalenectomy alone</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>42 (55%)</td>
<td>27 (35%)</td>
<td>7 (9%)</td>
</tr>
<tr>
<td>Carpal lysis alone</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Operative Method

Since Roos\(^2\) introduced the transaxillary approach for resection of the first rib (along with the cervical rib when present) I have used this approach almost exclusively. With the patient in a supine lateral position, the transverse incision just inferior to the axillary hairline is deepened between the pectoralis major and the latissimus dorsi muscles to the chest wall. The sensory nerve that crosses the operative field is recognized and divided since an area of anesthesia on the arm is preferable to postoperative neuralgia.

The shoulder girdle is pulled away from the apex of the chest wall to allow exposure of the first rib. Several methods of traction have been tried, including attachment of the arm to a movable pole for elevation and attachment to an overhead orthopedic traction device. However, the best exposure is obtained by a strong assistant holding the wrist and forearm in a hammerlock and pulling upward by leaning back to lift the neurovascular bundle off the first rib. Assistants are alternated at ten-minute intervals. Approximately 20 minutes of exposure is required for careful dissection and removal of the first rib. Every effort is made to avoid sudden pulls and jerks on the arm.

The first rib is removed as far back as possible, usually reaching its vertebral junction, using a long bone cutter and rongeur.\(^1\)

RESULTS

The last 76 cases with follow-up of six months or longer are summarized in Table 1. The 55% of patients free of any symptoms were classified as having an excellent result. The 35% who improved but still had some pain or paresthesia were classified as having good results. The seven patients (9%) who were not relieved were considered admitted failures.

There were no deaths; the only major complications were brachial plexus injury, which will be discussed, and one injury to the long thoracic nerve. Permanent limitation of shoulder motion occurred in one woman. There has been little change in the statistics since the presentation of our earlier series in 1974.\(^1\)

Three years ago the occurrence of complete paralysis of the upper extremity following a transaxillary resection of the first rib alerted me to this severe complication, which, to my knowledge, has not been reported to date.

REPORT OF A CASE

A 43-year-old woman with a three-month history of pain and paresthesia of the arm and hand had a prominent supraclavicular space with an underlying bruise. The radial pulse was diminished and the oscillometric study of the upper part of the arm showed 25% units while the contralateral side was 7 units, although arteriography did not show any abnormality. Roentgenograms showed no bony anomaly. The electromyogram was normal.

On March 15, 1979 the left first rib was resected via the transaxillary approach. No unusual intraoperative features were noted. The rib segment measured 5.5 cm in length. Postoperatively, the patient was unable to move the entire left upper extremity. Three days later there was some improvement that slowly continued. The neurologic diagnosis was diffuse left brachial plexus injury.

Physical therapy encouraged muscular return and prevented joint contractures. Five weeks following the operation, finger flexion and wrist dorsiflexion were possible but still abnormal. Ten weeks after the operation there was strong dorsiflexion of the wrist and other evidence of complete return of function. Four months...
following operation, there was a complete return of all neurologic function, the preoperative pain had been relieved, and the patient no longer needed medication.

No member of the surgical team could remember any jerk or sudden motion by the arm holder nor any other unusual intraoperative maneuver.

Inquiry locally revealed another such case, also with complete recovery. However, another patient in a distant part of Tennessee did not achieve complete relief and later brought suit for alleged damages. The matter was settled for a considerable sum. Since then other professional liability suits have come to my attention in several other states.

NATIONAL INQUIRY

During the June 1980 meeting of the International Cardiovascular Society, it was learned from a query of the audience (estimated at 500) that similar complications were known to approximately 30 surgeons present. In an effort to learn more concerning this severe neurologic complication of the first rib operation, a questionnaire regarding upper-extremity paralysis or weakness following transaxillary resection of the first rib for thoracic outlet syndrome was mailed to the 920 members of the International Cardiovascular Society in April 1981. The 351 replies constituted 38% of the queries. Ninety-two responding surgeons stated that they did not perform the operation. Among the 259 surgeons who performed the operation, there were 125 (48%) who had never personally observed such a neurologic complication among their own patients or those of their associates. The yearly experience rate of these fortunate surgeons varied from one to 30 with an average of 5.6 such operations yearly. The 134 surgeons (52% of responders) reporting personal or observed neurologic complications indicated an average operation rate of ten per year. Only eight surgeons averaged more than two cases monthly; the procedure was an uncommon one for most.

Complete postoperative paralysis was reported 102 times (33 personal cases and 69 observed); 22 had failed to achieve complete return of function during the follow-up period ranging from a few months to many years. There were an additional 171 instances of partial neurologic deficit (60 personal cases and 111 observed) with 30 instances of failure of complete recovery of function. While percentage values cannot be stated accurately, it is apparent that neurologic complications have been frequent, particularly in view of their gravity.

Responses to the questionnaires reported several other complications including an injury to the subclavian artery with hemorrhage and intraoperative cardiac arrest. Another instance of subclavian artery injury required ligation with later reconstruction.

BRACHIAL PLEXUS INJURY

Survey of the English literature does not disclose any reports of brachial plexus injury with arm paralysis, although there is one suggestion that this might occur. Perhaps the devastating effect of this complication has discouraged publication. It must be recognized now, however, that brachial plexus injury may occur even when the utmost care is taken to prevent direct trauma or excessive traction and is a risk of every transaxillary operation. It is not known whether it is more likely to occur in the heavily muscled patient where more traction is necessary or in the smaller patient where the same pull may be excessive. It is not clear whether any particular method of traction such as attachment to an overhead rack or frame is more or less dangerous than the manual pull with a hammerlock on the forearm.

The long-term outlook for brachial plexus injuries is variable. Eighty percent of the patients described herein recovered completely while the remaining 20% had incomplete return of function. Hoffer and associates recently discussed their experiences with 133 such patients (none, however, due to first-rib resection) and noted that completely recovered patients showed some return of function prior to three months with improvement continuing for as long as 15 months. Clinical examination provided as much information as did either myelography or electromyography. Early and continued stretching exercises, day and night positioning orthoses, and determined follow-up care constituted the optimal treatment program. Hoffer et al recommended that reconstructive tendon and muscle operations be delayed for two years to allow the functional return to plateau.

Professional liability claims following permanent neurologic deficit after thoracic outlet operations have become commonplace. The National Association of Insurance Commissioners summarized a 3½-year study from 1975 to 1978 of 71,782 claims, 546 of which involved thoracic surgeons. Twenty-one percent of the thoracic claims were related to operations for thoracic outlet syndrome. Since the occurrence of a brachial plexus injury is presently unpredictable, patients should be warned of this possibility during the process of obtaining informed consent.

The potential for brachial plexus injury forces consideration of changing the operative procedure. Changing the approach to a supraclavicular one may solve the problem, but plexus injuries and vascular complications also may follow this approach. The posterior approach may be safer but it is a larger procedure and may produce more pain and disability.

COMMENT

Surgeons have been interested in the problem of thoracic outlet syndrome since Coote in 1861 recorded an early attempt to remove the first rib. In 1905 John B. Murphy of Chicago resected a cervical rib that had produced a subclavian aneurysm, and by 1916 William S. Halsted was able to find records of 716 such patients. Telford and Stopford reported relief of vascular symptoms in six patients after resection of the first thoracic rib. The role of the anterior scalene muscle in neurovascular compression was developed further by Naffziger and Grant and by Ochsner et al in 1935. Feet and his associates in 1956 suggested that all of the compression syndromes might be termed thoracic outlet syndrome; the
name was later modified by Rob and Standeven to thoracic outlet compression syndrome.

The substantial failure rate of division of the anterior scalene muscle alone led to efforts to achieve greater decompression such as the wider supraclavicular resection of McCleery et al. and the clavicleectomy advocated by Rosati and Lord in 1961. In 1963 Ciagett directed attention to resection of the first rib via the posterior approach.

The modern transaxillary approach was described by David Roos in 1966. This technique still is practiced by other experienced surgeons such as Kelly and Urschel who believe that it allows decompression of the space without cutting muscle and that it produces few complications and good results.

Presently, there is a wide difference of opinion among surgeons experienced in the management of thoracic outlet syndrome from the position that few, if any, patients require operation to the few who believe that large numbers of patients with pain in the arm may be helped by excision of the first rib.

The diagnostic problem has been expressed by Gilliatt as follows: "Clinical details do not establish a characteristic picture and objective confirmatory tests are also lacking." The existence of some form of pain is invariable. It is often vague and the patient finds description difficult since it is not localized to the shoulder or elbow; this may lead the inexperienced clinician to conclude that it is not real. Approximately 90% of patients have neurologic symptoms and 10% also have arterial or venous problems. Reports of a higher incidence of vascular problems probably reflects a specific referral pattern.

Anterior chest pain may mimic angina pectoris and necessitates coronary arteriography for differentiation. Cervical arthritis and herniated disks may be differentiated by their response to traction or by myelography.

Carpal tunnel syndrome is particularly well differentiated by electromyography, while the value of this examination in detecting thoracic outlet nerve compression is debatable. Nerve conduction studies have been reported to be of considerable diagnostic value by Urschel whose group cited 8,400 examinations in one year with an outcome of 8.5% abnormal results. Stanton and associates similarly supported this test, noting that all of their 25 patients had reversal of an abnormal test result after operation.

Others have not found the test as useful. Cherington found no difference between 213 normal persons and 27 others with thoracic outlet syndrome and advised "caution in diagnosis...on the basis of ulnar nerve conduction velocity." Even the advocates admit difficulties in reproducing their results. An abnormal study in which the nerve conduction time is delayed may be worthwhile but a normal study does not rule out relief of symptoms by operation.

It has been stated that arteriography is unnecessary since only a minority of patients have abnormal findings. Nevertheless, in that minority the arterial changes often are unsuspected and do suggest an operative rather than nonsurgical program to prevent continuing vascular damage. Two-position subclavian arteriograms (with the arm at the side and later elevated) are particularly apt to show arterial lesions in the presence of bony anomalies of the cervical or thoracic ribs.

Routine phlebograms have not been worthwhile and now are limited to those patients exhibiting edema or venous collaterization around the shoulder. Venous pressure studies likewise often are not useful in the absence of the aforementioned symptoms.

Surgeons ordinarily emphasize the results of operative treatment and do not discuss the majority of patients whose symptoms are minor or who respond to nonoperative treatment. J. M. Stallworth, MD, (written communication, May 3, 1982) recently reported operating on only 17% of 1,140 patients who were studied and McGough et al. operated on only 9.4% of their 1,200 treated patients. My own operative rate during the past decade has been 26% of referred patients.

From 1966 until recently I used the transaxillary approach as the procedure of choice for removal of the first rib along with severance of the scalene muscle. The mortality has been zero and the complication rate has been low. There

<table>
<thead>
<tr>
<th>Source, yr</th>
<th>No. of Operations</th>
<th>Preferred Operation</th>
<th>Results, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Stallworth, 1982*</td>
<td>180</td>
<td>Resection of soft tissue</td>
<td>96</td>
</tr>
<tr>
<td>14</td>
<td>1st rib resection</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>McGough et al., 1979</td>
<td>113</td>
<td>Transaxillary 1st rib</td>
<td>80</td>
</tr>
<tr>
<td>Hempel et al., 1981</td>
<td>433</td>
<td>Supraclavicular 1st rib</td>
<td>60</td>
</tr>
<tr>
<td>Sanders, 1982†</td>
<td>239</td>
<td>Scalenectomy</td>
<td>85</td>
</tr>
<tr>
<td>214</td>
<td>Transaxillary 1st rib</td>
<td>85</td>
<td>4</td>
</tr>
<tr>
<td>Kelly, 1979</td>
<td>304</td>
<td>Transaxillary 1st rib</td>
<td>85</td>
</tr>
<tr>
<td>Roos, 1970 in press</td>
<td>566</td>
<td>Transaxillary 1st rib</td>
<td>89</td>
</tr>
<tr>
<td>Urschel, 1970</td>
<td>700</td>
<td>Transaxillary 1st rib</td>
<td>85</td>
</tr>
<tr>
<td>Martinez, 1978</td>
<td>350</td>
<td>Posterior 1st rib</td>
<td>85</td>
</tr>
</tbody>
</table>

*Written communication, May 1982.
†Written communication, May 1982.
always been concerned with the deep, circumscribed field of dissection that produces technical problems for even the experienced surgeon. Other routes to first-rib resection have been advocated by others without the development of a consensus opinion (Table 2). Martinez has developed a wide experience using the posterior parascapular route. This modification of Clagett's old thoracoplasty approach is not well known today, and at present most surgeons restrict its use to secondary procedures where the transaxillary approach was the original one. Munro suggested that if the posterior route is best for recurrences, it also may be preferable for the first-time operation.

Thomas advised the anterior supraclavicular approach to the first rib, citing 92% good to excellent results and 7% failures among 38 operations. He did note the delicate dissection necessary for this deep approach, which in my experience rules against it. Hempel also prefers the supraclavicular approach, citing excellent results in 60% of 358 patients, good results in 39%, and a 2.5% failure rate.

The infraclavicular route proposed by Nelson and Jensen in 1970 was supported by Murphy and associates in 1980 as a simple way to remove the anterior two thirds of the rib. Among 22 operations in 19 patients there were 16 excellent results, four good, and two failures.

Stallworth et al reported 194 operations among 1,140 patients, 180 done by division of the soft tissues with 96% good results; only 43% of the 14 patients having resection of ribs were relieved. He concluded that "only on rare occasion is first rib resection indicated."

Sanders and his associates in 1979 reported 239 scalenectomies and 214 first-rib resections, whereby good to excellent results occurred in 85% and 86%, respectively, fair in 8% and 9%, poor in 7% and 10%, and recurrences in 17% and 16%. These data suggest the lesser procedure.

R. J. Sanders, MD, (written communication, April 12, 1982) more recently reported that he now not only removes both the anterior and middle scalene (Razzuk's warning regarding the anatomic location of the long thoracic nerve in the middle scalene muscle should be noted) muscles via the supraclavicular approach, but also resects the first rib through the same wound, finding this procedure satisfactory in 75 cases.

Roos, who originally described the transaxillary approach, recently modified both his diagnostic considerations and the preferred operation, now proposing scalenectomy for the "upper root" syndrome while continuing to advocate transaxillary first-rib resection for the "lower root" syndrome.

Among those with extensive experience, Urschel et al continue to advocate transaxillary resection of the first rib, reporting only nine recurrences requiring a secondary operation among 700 patients. It is not clear what number of these successes had complete as opposed to partial relief. Similarly McGough et al reported that this approach produced 98% good or excellent results and 7% failure among 113 patients.

Thus, experienced surgeons still disagree on operative indications as well as details of technique, and we hear other unpublished but frequent complaints of poor results from surgeons who do fewer such cases. Therefore, I have come to believe that in the absence of vascular complications or a bony anomaly such as a cervical rib, those patients with neurologic symptoms alone should have prolonged nonsurgical treatment and operative decompression should be a last resort. As Lord recently stated editorially, "conservatism...should be the order of the day."

When all measures fail and the last-resort operation must be undertaken to relieve intractable pain, it seems rational to propose resection (not simple severance) of the anterior scalene muscle. This may be expected to relieve most patients and induce minimal risk. However, it should be understood clearly by patient and physician that some failures will occur and that some patients will require a secondary first-rib resection. Informed consent to the entire program along with understanding of possible complications is necessary.

My further recommendations include use of the supraclavicular route either for removal of a cervical rib or to repair a vascular problem and the posterior route for secondary procedures.

Roos recently listed the 12 "essentials and safeguards" that have produced for him over 90% gratifying relief with only 1% to 2% recurrences. I follow all these recommendations except restriction of use of the shoulder for several weeks. This is apt to result in prolonged reduction of shoulder mobility. No comparative study of these two opposing regimens has been reported yet.

CONCLUDING RECOMMENDATIONS

First, no single test nor group of tests is critical; thus, the diagnosis is one of exclusion. Errors are common. Psychosomatic factors are frequent. Second, frequent less-than-optimal results along with the possibility of severe complications suggest that an operation should be the last resort. Third, cervical rib and/or evidence of vascular compression are associated with a better postoperative result. Fourth, since first-rib resections have not been uniformly successful for neurologic decompression, the lesser procedure of resection of the scalene muscle should be considered as an initial alternative. Last, brachial plexus injury is unpredictable. Patients should be informed specifically of this possibility. Close attention to the degree of shoulder traction during the operation is mandatory.

References


cases with regard to new clinical and electromyographic findings. *Angiology* 1981;32:180-186.

Discussion

Tendinous bands, while four had nerve perforation of the anterior scalene muscles, and 23 had varied soft-tissue problems.

Since the shoulder constitutes the only universal joint in the body, and is controlled by 26 muscles, we should anticipate anomalies, adherent bands, and ligament hypertrophy of the soft tissues.

We try to identify the point of compression accurately by detailed blood flow studies. When the arterial pressure point is found, and if the patient's symptoms are reproduced at the same time at which the change in arterial flow is found, we assume that the closely associated nerves could be involved simultaneously. If all other clinical criteria mentioned by Dr Dale are satisfied, we consider the patient a possible candidate for surgical exploration of the axilla and/or neck.

Using the criteria mentioned, our study showed good results in 96% of patients having soft-tissue operations primarily, whereas only six of 14 patients with bone resection had improved. We have not found it necessary to resect a normal appearing first rib in the past four years.

JOHN O. CLOVER, MD, Indianapolis: Dr Dale's paper calls attention to a serious incidence of nerve injuries after resection of the first rib. Although it is tempting to assume that this finding indicates improper operative technique, I wish to report evidence to the contrary, at least in some cases.

I removed the first rib in a young woman through a transaxillary approach and did a scalenectomy through the usual cervical incision. This patient had severe symptoms that had not improved after vigorous preoperative physical therapy for two months. The woman was slim and small; the operation was routine and it was not necessary to use excessive traction. The nerves were not manipulated in any way. She awoke with numbness and paresthesias in an...
The findings, as well as some weakness of the intrinsic muscles in the hand. She continued vigorous physical therapy and in a few weeks experienced symptomatic hyperactivity that was relieved partially by sympathetic blocks. Symptoms were so disabling that a neurological colleague explored the brachial plexus, found no injury or excess scarring, and stripped the epineurium, using the operative microscope. The patient was not relieved by that procedure, but most of her symptoms have spontaneously resolved after about a year.

Results of the patient’s preoperative studies of the somatosensory evoked potentials were considered within normal limits. Monitoring at Erb’s point after stimulation of the ulnar nerve at the wrist showed a well defined peak. On the other hand, the patient’s postoperative studies, after she was not doing well for a period of time, showed loss of definition of this peak. Studies also were done postoperatively at the elbow to exclude the diagnosis of cubital tunnel syndrome or entrapment of the ulnar nerve at the elbow. From these studies, we can conclude only that nerve injuries such as this are possible even in the absence of excessive manipulation or direct injury to the nerve. Consequently, I agree with Dr Dale that we should include this information in our preoperative discussion of the procedure. Furthermore, the disabling nature of this kind of injury should temper our enthusiasm for recommending operation and help us to suggest longer periods of nonoperative treatment before going to surgery.

On the other hand, there certainly are patients who require operative treatment for relief, and it is imperative that we gather more data to help us understand the condition better. I suspect that dissections on normal asymptomatic patients would disclose a certain incidence of all of the bands and anomalies that have been described in this condition, and the remaining unanswered question is why they cause symptoms in some patients and not in others.

Charles O. Brantigan, MD, Denver: Dr Dale’s presentation gave an accurate idea of my impression of thoracic outlet syndrome when I finished my thoracic surgical training in 1975. My point of view has changed substantially since that time, and I would like to mention to you just how it came to change.

In 1976 I was a young whipper snapper trying to take on all the sacred cows in the surgical world. At that point I met Dr Roos. Dr Roos had a pat answer to thoracic outlet syndrome. It seemed that he understood what it was. He insisted that there were no complications associated with the operation in his hands and his results were uniformly good. Being a basic skeptic, I exercised an opportunity that he generously provided to me. During a period of approximately four months, I had the opportunity of examining every patient that he admitted to the hospital. I scrubbed with him on every surgical procedure that he performed, and I also followed up his patients preoperatively and postoperatively in his office with and without him.

At the conclusion of that four-month period, I decided that he was correct in his approach in every respect. I followed the principles that I learned during that time and I have had the same uniformly good results that he has reported.

From that four-month period, I learned some specific lessons that will be of value to the members of this audience. Dr Roos’ good results have come about primarily due to patient selection. That is a long and cumbersome process. It requires a long time to take an adequate history from one of these patients. Careful examination, including careful neurologic examination on several occasions, is important in figuring out what sort of a syndrome the patient has.

We know that there is no single useful laboratory test that identifies this syndrome, so we must rely on a careful history and physical examination. Dr Roos has a new approach to part of this problem, that is, entrapment of the middle trunk of the brachial plexus. Careful attention to history and physical examination has allowed him to elucidate a syndrome treatable by scalenectomy. This condition is one that he has not attacked surgically by first rib resection in the past, and I think it is important to recognize that this is a different procedure for a different indication. Using scalenectomy to try to treat a standard thoracic outlet syndrome is doomed to failure.

The second thing that I learned from observing Dr Roos’ practice was the importance of physical therapy. It may be that physical therapy just allows the patient’s symptoms to go away while we are trying to figure out what is going on with the patient. On the other hand, physical therapy probably makes many of these patients better, and it is always a mistake to rush into performing one of these operations without an adequate trial of physical therapy. It also allows you to observe the progress of the patient’s disease over time, and in patients who truly need surgery the standard physical therapy for thoracic outlet syndrome will make the condition worse.

The third important aspect of Dr Roos’ success involves meticulous surgery with close attention to details. I had performed this operation during my training and never really was satisfied with the exposure that I was able to obtain. I could see under those circumstances why the procedure was dangerous. After observing Dr Roos do this operation, my ability to achieve the exposure necessary to do the operation with precision was improved dramatically.

In conclusion, I would encourage those of you who are involved in this type of surgery to study carefully the indications for surgery that Dr Roos has proposed, and if you follow his principles I expect that you will achieve the same excellent results.

Larry A. Scher, MD, New York: At Montefiore Hospital in New York, Dr Frank Veith and I have been interested particularly in the problem of arterial lesions associated with thoracic outlet compression, most of which are associated with complete cervical ribs. Our experience encompasses 12 patients with 14 arterial lesions. Because of the potentially disabling nature of this condition and the many therapeutic options available, we have developed a staging system to provide guidelines for surgical management.

Stage 0 lesions have no arterial involvement. Stage 1 lesions have arterial stenosis often with minor poststenotic dilatation of the subclavian artery. These patients require only decompression of the thoracic outlet. Patients with stage 2 lesions have mural damage to the subclavian artery with aneurysm formation and require direct arterial reconstructive surgery as well as thoracic outlet decompression. Patients with stage 3 lesions have distal thromboembolic complications related to the subclavian artery. These patients often require more complex vascular reconstructive procedures. Because of the disabling complications associated with these late stages, we advocate an aggressive approach to arterial compression in the thoracic outlet. Our difficulty has been in the early identification of these patients, but I believe that digital angiography may assume an important role here.

I would like to ask Dr Dale in view of his extensive experience with thoracic outlet syndrome how he thinks arterial lesions can be identified at an early stage, and if perhaps digital angiography should be employed in all patients with a complete cervical rib.

Sam A. Mellick, MD, Brisbane, Australia: I think it would be fair to say that in Australia there is little experience in the “pain group” in the vascular surgical field except for a small number of isolated patients with litigation pending, who undergo surgery because of compensation. The other patients who have arterial and venous lesions requiring treatment are divided into the arterial group, which are correctable because they are diagnosed easily, and the small group with venous lesions that require decompression. The real issue now is where to do the decompression.
I suggest that instead of the transaxillary approach, for those who might be labeled "neck" surgeons, it is easy to expose the root of the neck area as sympathetic nerve surgery has made this approach straightforward. I think it is much easier to use a supraclavicular incision and a small infraclavicular anterior incision to take out the first rib when, in few instances, it needs to be removed.

First, I would like to ask Dr Dale if we are missing out on something as we don't really seem to see those patients who need "decompression" for pain. Second, what does Dr Dale think of a cervicalinfraclavicular approach as opposed to a transaxillary approach?

ROBERT T. SESSIONS, MD, Marietta, Ga: Several years ago I was approached by an internist who said, "I have a severe facial pain. I have had my ethmoid sinuses operated on and my teeth repaired. I have been to the ophthalmologist and to the pain clinic and I still have the pain and I think I have thoracic outlet syndrome." I was trained in scalenotomy at Vanderbilt University (Nashville, Tenn) and I knew that I could do an anterior scalenotomy fairly well, but at that time first-rib resection had become popular and he wanted to undergo the surgery. He knew that I already had done several first-rib resections with good results and without complications. On interview and examination he did have some arm and shoulder pain but the overwhelming and all-encompassing nature of the facial pain overshadowed the more typical symptoms of his thoracic outlet syndrome. Following a first-rib resection he became asymptomatic. However, in three months his facial pain recurred although his arm remained well.

I took him to Denver where Dr Roos operated on him and found that the anterior scalene muscle had reattached to the supraclavicular brachial plexus. Following anterior scalenectomy his face pain disappeared and he has remained asymptomatic since that time. While in Denver, on that trip and subsequent trips, I watched many first-rib resections, and I learned an enormous amount about the techniques of this operation. I confirmed what I already knew, that being a trained thoracic surgeon doesn't really help in first-rib resection; what counts is training in first-rib resection.

During the week before this meeting I talked with the chiefs of service of six major thoracic surgical training programs across the United States, and not a single one thought that their residents were trained adequately in thoracic outlet surgery. They did not see many cases and thought that it was a difficult operation. I talked with one chief resident on a large service, and he thought he was fairly well-trained.

I think the solutions regarding training are twofold. First, the universities need to make a commitment to train physicians to do this surgery if it is to be done, and second, for what Dr Dale refers to as the groundswell of practicing surgeons (men with small numbers of cases but not necessarily without judgment), retraining is a must. Retraining taught me that a "difficult" operation can be made easy and safe.

The axillary procedure is a precise operation. Knowing about the congenital bands helps tremendously and the more you think about them the more you can see. It is possible to retract the arm in such a way that the nerve roots are almost floppy or "on a bend"; they do not have to be pulled tight. In fact, if they are taut it is harder to do the operation.

I believe that with adequate training by people who are willing to train or retrain, and there currently aren't that many in the country, the procedure can be done safely. I don't think that complications are necessarily the fault of the operation.

The practicing surgeon, trained in the days before transaxillary rib resection, needs to retrain himself in proper neurologic examination because that is the crux of the diagnosis. The surgeon must be retrained properly in the anatomy of the thoracic outlet and its variations and he needs to perform the procedure often enough to remain enlightened, comfortable, and capable. I do not think that this is the place for the casual surgeon any more than it would be for the casual surgeon to do a pneumonectomy or a cardiac operation. I think that the occasional surgeon has the best chance of being the unfortunate surgeon or of having the unfortunate patient. Finally, I think Dr Dale's point of a methodical approach to the treatment of thoracic outlet syndrome, especially dragging your feet before you operate, is the main thing we need to keep in mind.

RICHARD J. SANDERS, MD, Denver: I agree that conservative therapy for at least several months is indicated in all patients. If surgery becomes necessary, the patient's history is helpful in localizing the disease. The most common history is that of a hyperextension neck injury followed within a day or two by neck pain and occipital headaches. Hand and arm symptoms develop a few weeks later. This history suggests that the basic disease is in the scalene muscles rather than the first rib.

Recognizing this, the approach I have used for treating patients with the thoracic outlet syndrome is similar to that outlined by Dr Dale. For the first operation, anterior and middle scalenectomy is done. Emphasis is put on removing all of the anterior scalene and as much of the medial portion of the middle scalene as possible. If a cervical rib or one of Dr Roos' congenital bands is present, it will lie in the belly of the middle scalene muscle and easily can be removed supraclavicularly. However, if the patient has a history of arm swelling and reoxygengrams suggest subclavian vein compression, transaxillary first rib resection is indicated. The subclavian vein lies outside of the scalene triangle and, to decompress it, the costoclavicular ligament and anterior portion of the first rib must be removed.

A second operation is indicated only in specific situations. For persistent symptoms in the head and neck, no operation is done. The diagnosis is not thoracic outlet syndrome. However, for persistent hand and arm symptoms, first rib resection may be indicated as outlined by Dr Dale.

Patients with recurrent symptoms are handled a little differently. These patients enjoyed substantial relief of symptoms for the first few months before their symptoms returned. Therefore, the diagnosis was correct. Recurrent symptoms are due to scarring around the brachial plexus. If the first operation was a rib resection, a complete scalenectomy is recommended for the reoperation.

Our results in 30 patients with recurrence after rib resection were 80% good long-term relief. If the first operation was a complete scalenectomy, rib resection is indicated. This can be done by either the transaxillary or the supraclavicular approach. The choice of approach depends on the observation of the position of the first rib at the time of scalenectomy. If most of it lies below the level of the clavicle, the transaxillary approach is easier. But, if the rib lies high, the supraclavicular approach may be easier.

In 246 primary scalenectomies, first rib resection was done as a second operation in 20 patients (8%). Good to excellent long-term results (two to five years) were achieved in 14 patients (70%).

Finally, for recurrent symptoms after both rib resection and scalenectomy have been done, one should proceed cautiously. Only for severe symptoms should more surgery be considered. When indicated, I have performed a supraclavicular brachial plexus neuroplasty and resection of the posterior stump of the first rib.

Of 15 patients, ten still are experiencing good relief of symptoms for seven to 30 months. One of these patients had a second neuroplasty one year after the first, but continues to do well. In the other five patients, no lasting relief resulted.
It must be recognized that whenever surgery is done around major nerve trunks, scar tissue always will form, and will be the cause of recurrent symptoms in a certain percentage of patients. Resection will give temporary relief but the chances of recurrence increases with each reoperation. Therefore, brachial plexus neuroplasties should be reserved for those patients with severe symptoms and with appropriate informed consent, as stressed by Dr. Dale.

DONALD SILVER, MD, Columbia, Mo: Clearly, patients with thoracic outlet compression syndrome do have psychosomatic and numerous neurologic problems that have to be evaluated.

Our indications and results of surgery are similar to those of Dr. Dale. However, we wait four to six months, or even longer, to make sure that the patients comply with the exercise program and weight reduction before considering them for surgery.

I offer two points for Dr Dale's consideration. It appears that it is not necessary to resect the entire cervical rib, if a cervical rib is present. We usually operate through the transaxillary approach, and I find that it is sufficient to take out the first rib, divide the tendons (if any) between the cervical rib and the first rib, and not worry about trying to remove the entire cervical rib. I wonder what Dr Dale does with the cervical rib.

Second, it appears that many of these patients have a hyperabduction component to their syndrome. The hyperabduction component is caused by the vessels and nerves being compressed as they wrap around the pectoralis minor tendon when the arm is hyperabducted. Therefore, when I operate, I usually divide, through the same incision, the pectoralis minor tendon as it attaches to the coracoid process. This addition has thus far been free of complications and has relieved the hyperabduction component. I would like to know whether Dr Dale divides the pectoralis minor tendon.

Dr. Dale: Dr. Shumacker, thank you for recalling the posterior approach. It is particularly valuable for recurrences when operation is necessary.

Dr. Stallworth, we are indebted to you for your information regarding the necessity for conservatism and also for your experience with soft-tissue operations.

Dr. Glover, your paper on evoked potentials two years ago stimulated my interest. Thank you for your update.

Dr. Brantigan, your emphasis on technical skill is well placed. It is, however, a bit difficult for many of us to accept technique alone as the overwhelming difference for an operative procedure that has been used widely for 16 years by numbers of surgeons. Some of us may be less talented, but hardly all. Nevertheless, you represented Dr. Roos' viewpoint well.

Dr. Scher, your discussion of vascular problems prompts no disagreement on my part.

Dr. Mellick, I appreciate the remarks of an eminent Australian surgeon. Facetiously, I will say that the epidemic that started in Denver and spread through Texas has almost ended in Charleston. Perhaps it has not reached Australia, but it's on the way!

Dr. Sessions, thank you for your remarks about residency training. May I point out that Dr. Sessions has written a paper discussing his experiences with 28 operations for recurrent disease.

Dr. Sanders, I appreciate your long-term interest in these matters. I recommend rereading his classic discussion on this subject that was presented before this society two years ago.

Dr. Silver, my understanding of your first question is whether one should take out the cervical rib through the transaxillary approach. Certainly I have done it that way. I also have done it through a supraclavicular approach. In this connection, I frequently prepare the patient both ways so that I can go through the axillary and also use the supraclavicular approach at the same operation.

The preparation of this paper has been difficult. The subject is in a state of chaos, opinions outnumber hard data, and across the land there arises a groundswell of poor opinion of the results of these operations. Indeed, the situation appears to me to parallel that of some forms of back surgery where even the layman views the available procedures with suspicion and physicians urge operation only as a last resort.

My closing comments are, therefore, directed toward strict preoperative screening, the need for careful long-term follow-up studies rather than increasing numbers of operations, and finally, the suggestion that conservatism should now perhaps be the order of the day.

In this city of Boston, the home of many renowned surgeons, it is perhaps appropriate to quote one of them in closing. As John Homans remarked following the discussion of his paper in 1941 by several authorities, "I enjoyed the discussion of my paper, but I wish I had not learned so much from it."