Safety and Efficacy of the Supraclavicular Approach to Thoracic Outlet Decompression

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Background. **Thoracic outlet syndrome (TOS) is a clinical diagnosis encountered by both thoracic and vascular surgeons. The goal of surgical therapy involves relieving compression of the neurovascular structures at the superior thoracic aperture. The traditional approach to thoracic outlet decompression has been transaxillary; however more centers are moving toward a more tailored approach through a supraclavicular incision.**

Methods. **The medical records of 67 patients who underwent surgical decompression between 1993 and 2001 for TOS were retrospectively reviewed. Patient demographics and early outcome were assessed through clinic follow-up.**

Results. **Seventy-two thoracic outlet decompressions were performed on 67 patients with the diagnosis of TOS. Five patients underwent bilateral thoracic outlet decompression. All operations in this time period were safely accomplished through a supraclavicular approach. The syndromes associated with thoracic outlet compression were neurogenic (n = 59), venous (n = 10), and arterial (n = 3). Forty-six of 72 (63.9%) operations resulted in complete resolution of symptoms, 17 cases (23.6%) had partial resolution, and 9 patients (12.5%) had no resolution. There were no deaths and morbidity was minimal with 6 complications (8.3%).**

Conclusions. **The supraclavicular approach is a safe and effective technique in managing all forms of thoracic outlet compression.**

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Thoracic outlet syndrome (TOS) results from compression of the neurovascular structures at the superior thoracic aperture. The syndrome has been attributed to cervical ribs, long transverse processes, first thoracic ribs, compression by the scalene muscles, clavicle fractures, and tumors at the thoracic outlet [1]. Regardless of the etiology, external compression can occur upon the subclavian artery, subclavian vein or brachial plexus and produce myriad symptoms. The various syndromes and presentations of TOS are related to which structure or structures are compressed.

The role of operative intervention for TOS is controversial and not well established. Indications for operative management include both subjective and objective evidence of neurovascular compression at the thoracic outlet. There is also a difference of opinion as to which patients are candidates for operation, with some believing physical therapy is adequate treatment [2–4]. Despite these differences surgery is often performed to treat TOS. The surgical procedure to manage TOS has continued to evolve from a posterior approach [5] to the transaxillary approach [1, 6]. In more recent years the supraclavicular incision and exposure has become a popular technique for thoracic decompression.

For the past decade we have decompressed all forms of TOS using supraclavicular exposure. To assess the safety and efficacy of this approach we reviewed our institutional experience with the surgical management of TOS through a supraclavicular approach.

Patients and Methods

The medical records of patients surgically managed for TOS between June 1993 and June 2001 were retrospectively reviewed. All patients were decompressed through a supraclavicular incision. Early outcomes (14 to 24 months) were assessed through follow-up clinic visits and were categorized as complete response (no residual symptoms, complete range of motion, and able to return to all previous activities without restriction), partial response (some residual symptoms but able to return to most activities), or no response (no change from preoperative state).

Operative Technique

All patients are operated upon using general anesthesia. A supraclavicular incision is made one fingerbreadth above the clavicle extending 5 to 7 cm. The platysma is divided and subplatysmal flaps are created. The omohyoid is divided and the scalene fat pad is dissected and retracted laterally. For all patients with neurogenic or arterial TOS, first rib resection is carried out in the following manner. The phrenic nerve is carefully mobilized and retracted medially. The anterior scalene is divided 1 cm above its insertion onto the first rib. The

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subclavian artery is mobilized and encircled with vessel loops. Any abnormalities in the artery requiring repair mandates further dissection and mobilization of the artery. The brachial plexus is dissected from surrounding tissues medially and laterally and the middle scalene laterally and the first rib medially are identified. The middle scalene is divided lateral to the plexus with care to avoid injury to the long thoracic nerve. The medial and lateral edges of the first rib are palpated and the intercostal muscle attachments are divided bluntly and sharply. The rib is then divided posteriorly with a rongeur just distal to the transverse process. The intercostal muscle attachments are divided from the inferolateral aspect of the rib and the rib is transected anteriorly under the clavicle. This results in a small fragment of the most anterior segment of the first rib remaining. This small segment plays no role in neurogenic or arterial compression and is left in place. Any arterial reconstruction is carried out at this point. Cervical ribs are easily resected through this same incision, and are identified just superior to the posterior aspect of the first thoracic rib.

Patients with venous TOS undergo a more tailored approach. A supraclavicular incision is made as described above. Patients without previous clavicular trauma, and evidence of a normal vein (documented by venogram after thrombolysis), undergo first rib resection as described above. The remaining most anterior segment of the first rib is removed through an infraclavicular incision.

Symptomatic patients with venous TOS requiring more extensive subclavian vein reconstruction may require clavicular resection. This technique decompresses as well as exposes the entire subclavian vein for reconstruction. Once the clavicle is resected the subclavian vein is easily dissected out from the axillary vein and its branches laterally to the junction with the internal jugular vein medially. The vein is then opened, thrombus is removed, and if needed, venous reconstruction is carried out. The venotomy is closed with a vein patch.

Results

This cohort was composed of 67 patients. Five of these patients required bilateral thoracic outlet decompression bringing the total number of cases to 72. There were 41 women (mean age 34.1 years) and 25 men (mean age 37.7 years). Fifty-nine (82%) of the cases were neurogenic in origin, 3 (4.2%) had arterial symptoms, and 10 (13.8%) had venous thrombosis (Fig 1). Complete resolution was obtained in 46 of 72 (63.9%) of cases, partial resolution in 17 (23.6%), and no resolution in 9 (12.5%). The no resolution group was comprised entirely of neurogenic TOS. Sixty-six percent of the no resolution group had previous neck or shoulder injuries. Twenty-two percent of the no resolution cohort had undergone at least one previous surgery to the neck or shoulder girdle or both. Fifty-four percent of our entire cohort were laborers, whereas 78% of the no resolution group were laborers. All patients with arterial or venous compression had at least partial resolution with 75% of them having complete resolution

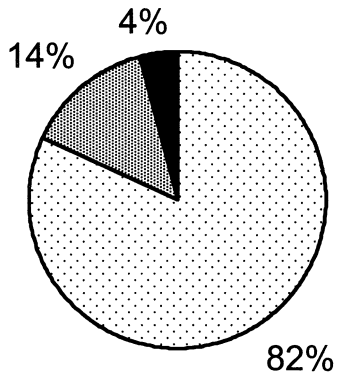

Fig 1. Incidence of compressive syndromes included in the study. Solid section = *arterial;* dotted section = *neurogenic;* shaded section = *venous.*

(Fig 2) Within the entire cohort a supraclavicular incision safely allowed for 14 cervical rib resections, 64 first thoracic rib resections, 5 claviculectomies, and 7 vascular procedures. A supraclavicular incision alone was used in all but 3 cases, and in these 3 cases an infraclavicular counter incision was used to gain access to the most medial aspect of the first rib for completed decompression of the subclavian vein. There were no deaths and morbidity was 8.3%. Complications consisted of 2 pneumothoracies, 2 hematomas, 1 temporary phrenic nerve palsy, and 1 traction injury to the brachial plexus.

Comment

The three clinical entities of TOS arise from neural, venous, or arterial compression. These entities sometimes coexist but more often occur independently. The diagnosis and workup of TOS is fairly straightforward; however the management decisions are not uniform and can be challenging. Surgery is often considered the primary treatment yet the surgical approach has been questioned.

Compression of the subclavian artery represents fewer than 5% TOS and may result in ischemia and aneurysmal dilation and may even be limb threatening. Arterial compression at the thoracic outlet is almost always asso-

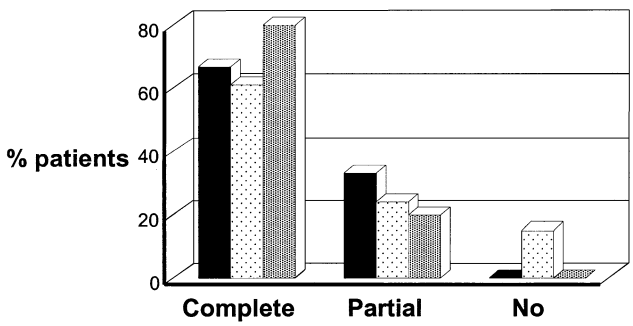

Fig 2. Overall outcome (response to thoracic decompression) of each compressive syndrome. Solid bars = *arterial;* dotted bars = *neurogenic;* shaded bars = *venous.*

ciated with a cervical rib [7]. The 3 patients with arterial compression in this series had bilateral cervical ribs. Longstanding arterial compression leads to stenosis at the thoracic outlet. These changes can cause fibrosis and often manifest as poststenotic dilation. None of our patients manifested any aneurysmal changes; however all had evidence of thrombosis, distal embolization and ischemia. The treatment of arterial complications secondary to compression at the thoracic outlet is surgery. During surgery one must be prepared to address and treat the three anatomic components of this disease process: arterial compression, arterial lesions, and distal emboli. The ideal surgical approach to thoracic decompression with associated arterial disease is one that allows complete exposure for cervical and first rib resection as well as the ability to address associated arterial lesions. We believe the ability to address the key issues associated with arterial compression are more easily accomplished through a supraclavicular rather than the standard transaxillary approach. In our series cervical and first rib resections as well as arterial repairs were safely and successfully accomplished through a supraclavicular approach. All patients had resolution of their arterial symptoms.

Primary axillary-subclavian vein thrombosis or Paget-Schroetter syndrome typically afflicts younger patients and constitutes only 4% to 12% of thoracic outlet symptoms in most reports and only 13.9% of our review [8]. Historically the treatment of subclavian vein thrombosis was rest and anticoagulation. It was not until investigators understood the underlying physiology of primary thrombosis (venous compression at the thoracic outlet) that advances in therapy were made. Today it is well accepted that the optimal treatment of subclavian vein thrombosis requires early restoration of luminal patency and surgical removal of any extrinsic compression, usually a first rib resection [9].

Venous TOS often results from more medial compression, either by the anteromedial portion of the first rib or by the costoclavicular ligament. Extensive first rib resection can not be achieved through a supraclavicula incision alone and the addition of an infraclavicular incision is frequently required. The additional exposure provided by this counter incision allows for complete decompression of the vein through division of the subclavious muscle and costoclavicular ligament as well as complete resection of the most medial aspect of the first rib. Through these two incisions the entire subclavian vein can be decompressed and any external venolysis of adhesions can easily be carried out. Three of the 10 patients with venous disease underwent this operation.

Occasionally patients are encountered who require more extensive subclavian vein reconstruction. This is usually associated with unsuccessful thrombolysis or significant intraluminal defects after lysis. We have found clavicular resection not only decompresses the vein but also provides excellent exposure to the entire subclavian vein for reconstruction. This technique is particularly useful for patients with previous clavicular fractures and bony pannus growth as a cause for their venous obstruction. For these patients, of whom there were 5, the supraclavicular incision was extended laterally and the clavicle was exposed. Medially the clavicle is disarticulated from the manubrium and the lateral dissection is carried out to the acromion. Once the decision is made to remove the clavicle and repair the vein, there is no need for rib resection as the vein is now decompressed. We believe a common mistake is to not remove enough clavicle. All patients in our cohort who had resection of their clavicles ($n = 5$) have returned to their prior employment with no significant disability related to the clavicle resection. Of note is that 1 of these patients is a welder and another is a lumberjack.

Venous compression at the thoracic outlet can be challenging. The flexibility offered by the supraclavicular approach easily allows us to tailor our technique, even intraoperatively, to each patient's needs. Eight of 10 patients (80%) with venous thrombosis had complete resolution of symptoms and 20% had partial resolution. This subgroup of patients has maintained a 100% vein patency rate and no morbidity.

Perhaps no subject generates more controversy in cardiothoracic and vascular surgery circles than the diagnosis and treatment of neurogenic thoracic outlet syndrome. The majority of thoracic outlet cases reported in the literature as well as in our study fall within the disputed neurologic classification. The incidence of neurogenic TOS is controversial. Some authors [10, 11] quote an incidence of 8% of the general population while others [12] doubt its existence entirely. Eighty-two percent of our cohort was classified as having neurogenic TOS.

The affect of blunt chest and shoulder trauma on brachial plexus neuropathies is not well defined. In our series a history of shoulder or neck trauma was noted in 49% of patients surgically managed for neurogenic TOS with 24% of those having at least one previous neck or shoulder surgery or both. Neck and shoulder trauma is the most common predisposing factor for neurogenic TOS with a reported incidence near 80% [13]. In our series previous trauma appears to be a predictor of poor outcome after surgical decompression. Fifty-five percent of previously injured patients in our series had a less than complete response. The symptoms in this subset of patients may be attributed to direct muscle injury, traction injury to nerve roots, or simply arthritic changes and have no component of neurovascular compression at the thoracic outlet. Evaluation of this group of patients may require a more thorough, multidisciplinary approach as well as a more prolonged course of conservative therapy.

In our series the neurogenic subset of patients had the poorest outcome. Seventeen percent of this cohort had no resolution of symptoms. These outcomes are consistent with other similar series evaluating a transaxillary approach [14, 15]. The difference in outcome observed in neurogenic compression compared with vascular forms of TOS is notable. Only 9 patients (12.5%) of our cohort had no resolution of symptoms after thoracic decompression. This subset consisted solely of patients with the preoperative diagnosis of neurogenic TOS. Seven of 9 (78%) were laborers, all but 1 of whom was previously

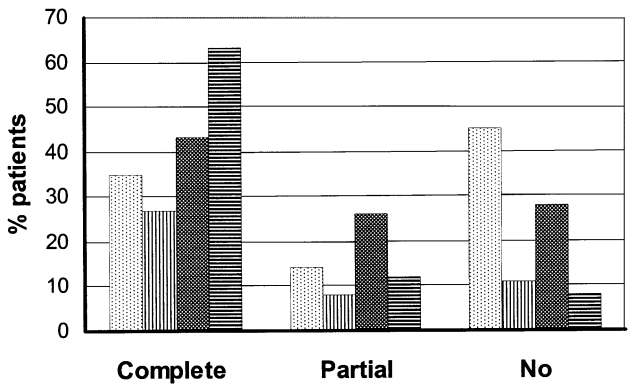

*Fig 3. Response to decompression using a supraclavicular approach compared with similar reports of thoracic decompression using a transaxillary approach. (*Dotted bars = *Leffert;* vertical striped bars = *Sharp;* shaded bars = *Lingren;* horizontal striped bars = *supraclavicular approach.)*

injured and had been unsuccessfully treated for shoulder or neck injuries. Three of these 7 patients had at least one surgery for these injuries before being evaluated for TOS. Despite these results there is an acceptable rate of success from supraclavicular thoracic decompression for neurogenic TOS. Seventy-eight percent of patients surgically treated for neurogenic TOS had improved symptoms, with 56% demonstrating complete resolution. Clearly accurate patient selection is essential for excellent operative outcome and minimal morbidity. When evaluating patients referred with the suspected diagnosis of neurogenic TOS one can not be too cautious. No one protocol or battery of test is appropriate for all patients. Thoroughly considering the patients history (previous shoulder-neck injury or surgery, noninvasive therapy, and previous diagnostics) we tailor our workup to each patients. Understanding that no one diagnostic modality is 100% sensitive and specific for neurogenic compression at the thoracic outlet, these measures are used only to strengthen our clinical diagnosis.

Thoracic outlet syndrome is one of the most controversial symptom complexes in surgery. The surgical approach has been altered over the last several decades with variable results. Our experience with the supraclavicular approach has provided excellent results and outcomes comparable with those of groups using a transaxillary approach (Fig 3). In our experience the exposure provided by this technique is safe and superior to that of other approaches and allows for a wide range of surgical maneuvers required to manage all forms of thoracic outlet syndrome.

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DISCUSSION

DR HAROLD C. URSCHEL, JR (Dallas, TX): I would like to congratulate Dr Maxey on an excellent preparation of his data and clear presentation to us here.

One of the points that he mentioned is that this approach is good for all types of thoracic outlet syndrome. Our principle has always been that anybody operating should know all the approaches technically, be familiar with them, and able to perform them. What he chooses to do is what he is most comfortable with and safest, as you have done here, and I think that is excellent.

I had the opportunity of reading Dr Maxey's paper. The 7 cases that did not respond quite possibly had an error in diagnosis since they did not get better and then get worse, such as with scarring. I would like to ask you what your opinion is of those 7 cases, whether they had carpal tunnel or any other type of compression, a multiple crush syndrome, ala Mackinnon, or what do you think is the reason they did not get a response, because your operations are done very well and anatomically correct as far as I can see?

The total claviculectomy was the operation done when I started in thoracic outlet syndrome by Lord, and we reported actually 40 cases together at one time.

This is a wonderful approach if you are going to patch the vein. If you take the clavicle off, you get wonderful exposure of the vein, which is much more difficult through the transaxillary approach. We do not do any thrombectomies. We have not for about 15 years, so that we are comfortable still through the transaxillary approach. I think this is a much better incision for the thrombectomy or the patching vein procedure.

Finally, I would just like to recognize one of these young guys on my left here who sat through that last paper of Osler Abbott and Tiki. His name is Dr Daughtry. He is one of the founding members of this organization, the eighth president and the oldest living president.

DR MAXEY: Thank you, Dr Urschel, for your comments. I will start with the patients who did not respond to surgical decompression. Those were 7 patients all with neurogenic thoracic outlet syndrome. Using the supraclavicular approach we aim to resect as much of the first rib as possible as well as perform an anterior scalenectomy and neurolysis of the plexus. These patients often have other more distal compressive syndromes, such as ulnar nerve compression and/or carpal tunnel syndrome. We have become much more conservative with patients with the presumed diagnosis of neurogenic compression, and are very attentive to other possible etiologies of their symptoms.

To address the issue of our claviculectomy patients, we had five clavicle resections: four of those patients were men, two of whom were welders and lumberjacks. We had no significant morbidity; similar to the experience you and Lord described several years back. Your point is well taken; however, that a thin, young female requiring claviculectomy may have more of a cosmetic concern than that we typically experience with more muscular males.

DR JOSEPH I. MILLER (Atlanta, GA): Just a couple of comments. In Georgia, to my knowledge there are only three surgeons performing this operation: myself, Dr Mansour, and one of our vascular surgeons. Between Dr Mansour and myself, we have done a few more than 110 cases, not anything like Dr Urschel has previously reported, and that has been in a 29-year period. We have done these all through the transaxillary approach, and our results have essentially been the same as you have reported. We have had two reoperations for bleeding.

My questions concerning the supraclavicular approach are as follows. We have tended to utilize that approach only for the upper plexus syndrome previously reported by Dr Hal Urschel in the *Annals of Thoracic Surgery* and think it works well with that but we have been unable to do a complete resection of the first rib through the supraclavicular approach. It may be due to our inexperience, but also our vascular surgeon, who is pretty well experienced in this, has been unable to excise completely the first rib. But you stated in your talk that you were able to do a complete resection of the first rib.

My questions are, firstly, what percentage of your patients have no objective measurable index and only physical findings of thoracic outlet syndrome that I guess you would call them traumatic, but that is, they have no measurable index either through Doppler, ulnar nerve conduction, EMG or whatever type study, and you are only going on physical findings?

Secondly, how do you manage complete resection of the entire first rib through the supraclavicular approach? At times that I have done that, I have found it quite difficult, and I have previously discussed with Drs Mackinnon and Patterson at Washington University, and they do not feel that they can resect the entire rib, but they resect the pathologic area of involvement, which has been more parallel with our experience.

DR MAXEY: Those are excellent points. As far as first rib resection through the supraclavicular approach, there is no problem whatsoever resecting the most posterior, lateral aspect of the first rib. Gaining access to the most medial portion of the anterior first rib is what provides us difficulty. Leaving a small portion of the most medial aspect of the first rib has no effect whatsoever in patients with neurogenic and arterial disease and the supraclavicular approach is more than adequate. Patients that we do need access to the most medial aspect of that first rib are those patients with Paget-Schroetters. In these circumstances, we use the counterincision, which I described. This incision adds no more morbidity yet provides tremendous exposure to allow us to completely decompress the vein.

As far as patients and their diagnostic workup, certainly arterial and venous diseases are fairly straightforward. We typically rely first on noninvasive studies followed by an angiogram or venogram. These techniques are usually highly sensitive and specific for arterial and venous compression. The controversy arises with the neurogenic patients. These are patients who oftentimes have been worked up to the hilt from their primary care doctors, physical therapists, and chiropractors. Certainly in these complicated patients we do a very detailed history and physical examination, but do not hesitate to get more precise imaging modalities, CT scan, MRI, to rule out any disk disease or cervical stenosis, and I think the role of conduction studies is quite evident from Dr Urschel's published work.

You do, however, need to rule out more distal entrapment syndromes. That is, make sure the ulnar nerve is not entrapped and no evidence of carpal tunnel syndrome is present. I think utilizing all of these modalities decreases one's chances of operative failure from thoracic decompression by allowing one to choose the correct patient most likely to have excellent results.