THE RESULTS OF FIRST RIB RESECTION IN THORACIC OUTLET SYNDROME

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ABSTRACT: Twenty cases of thoracic outlet syndrome in seventeen patients were treated by first rib resections through the transaxillary approach, after conservative therapy failed. The average follow up was twenty-four months. The mean age was thirty-five years with a range of fifteen to fifty-four years. There were fourteen females and three males. The delay in diagnosis averaged four years with the most common mistaken diagnosis being cervical disc disease. Complications included two cases of pneumothorax, one wound infection, and one intraoperative hemorrhage. Fourteen of the patients had complete relief of pain while two of the patients were improved. There was only one patient who was considered a failure because of recurrent pain. It is concluded that this procedure should be considered when conservative measures fail. The orthopaedist is usually the first to see the patient, and therefore, the diagnosis should be considered in all patients with upper extremity pain.

Introduction

Thoracic outlet syndrome is a complex syndrome that is poorly understood. Symptoms are often vague and include pain, numbness, tingling and weakness in the upper extremity. The etiology is believed to be compression of the subclavian artery, vein, and brachial plexus between the first rib and clavicle. This compression can be due to many factors that narrow this space, including cervical rib or its fascial remnants, first rib anomalies, compression between the scalenus anticus and medius, the pseudoarthrosis of the clavicle. There may be other unusual causes of narrowing of this space which are not well documented. The syndrome has been given many names, including Hyperabduction syndrome, Paget-Schroeder syndrome, Scalenus Anticus syndrome, Costoclavicular syndrome, Shoulder-Arm syndrome, and Cervical Rib syndrome. Conservative therapy is successful in most patients. Many different surgical procedures have been utilized in treatment plans. Although many patients are seen by orthopaedic surgeons with symptoms suggestive of this syndrome, it has been infrequently emphasized in the orthopaedic literature. This retrospective study reports the results of first rib resection in patients with the diagnosis of thoracic outlet syndrome after non-operative therapy had failed in order to emphasize the good results which can result from surgical treatment.

Materials and Methods

During the past ten years at University Hospital of Cleveland, we have performed twenty first rib resections through the transaxillary approach in seventeen patients. A retrospective study of these patients was performed including an extensive chart review of private patient office notes and a post-operative evaluation which will be discussed subsequently. The mean age was thirty-five with a range from fifteen years to fifty-four years. There were fourteen females and three males. The patient’s occupations are listed in Table 1. The average follow-up from the time of surgery was twenty-four months with a range from one to nine years. Symptoms included arm pain in all seventeen patients. Fourteen patients complained of numbness and twelve of these were in the ulnar nerve distribution. Fourteen patients also complained of weakness of the entire arm, but the records were too incomplete to determine by examination which, if any, muscles were weak. There was no atrophy noted in any patient
Table 1: Table including age, sex, occupation, complications and results of all patients.

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<th>OCCUPATION</th>
<th>DIAGNOSTIC DELAY</th>
<th>COMPLICATIONS</th>
<th>TRAUMA</th>
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These exercises were closely supervised and continued for a minimum of three months. The aim of these exercises were to prevent narrowing of the thoracic outlet. The inciting activities included benchwork and holding a newspaper with the arms partially abducted. Ten of the patients gave a history of trauma as a predisposing factor, and seven of these were hyperextension injuries of the neck caused by motor vehicle accidents. There is difficulty sometimes differentiating between symptoms arising from the cervical roots as they exit from the neck and from the structures within the thoracic outlet, so that a delay in diagnosis is frequently seen.

In addition, since we are reporting patients from a major referral center, many of these patients were followed by primary care physicians before referring them to our hospital for evaluation. In this study the delay in the diagnosis of thoracic outlet syndrome averaged four years with a range of one to thirteen years. The most common mistaken diagnosis was cervical disc disease in ten patients, followed by carpal tunnel syndrome in four patients. Two of the patients in this study had anterior discectomies and fusions without relieving their symptoms before the correct diagnosis of thoracic outlet syndrome was made.

Preoperative evaluation in each patient included chest and cervical spine roentgenograms, a complete physical and neurological examination as well as an Adson and Allen test of the upper extremities. Some of the patients had specialized diagnostic tests at the discretion of the operating surgeon. These included nerve conduction studies and electromyograms in ten patients, arteriograms in four patients, and myelograms in eight patients. Since, as noted, this was a retrospective study, all tests were not uniformly performed, so that no definite conclusions could be made as to their diagnostic value. There was only one cervical rib seen in this study but no other anomalies of the cervical spine were identified. The indication for surgery in each case was failure of conservative therapy and the continuance of disabling symptoms. No patient was operated upon earlier than six months from the time they were initially seen at our center and ten patients were followed for at least one year before surgery.

Surgical Procedure

The first rib was resected through the transaxillary approach, as outlined by Roos. The advantages of this approach are that it is cosmetic and affords excellent exposure to the first rib. Great care must be taken not to tear the subclavian vein at the time of surgery, since proximal control of the vessel is impossible through this approach. The patient is placed in the supine position with the table elevated 45° and a five pound sandbag placed under the scapula. The entire arm is prepped, draped free and held by an assistant. The third rib is palpated subcutaneously and a slightly curved transverse incision is made over it about three to four inches long. The incision is inferior to the apex of the lymph nodes and vessels and should be carried down directly to the rib cage. Care should be taken not to dissect into the soft fatty tissue but one should find the interval between it and the rib cage.

The intercosto-brachial-cutaneous nerve enters the wound from the second intercostal enroute to the axilla. Care should be taken to preserve it because it provides sensation to the axilla and arm. It may be retracted out of the way without too much difficulty. If it is transected it may lead to a painful neuroma. The arm is now abducted, flexed and externally rotated to gain exposure to the first rib. The assistant holding the arm should place it down by the patient's side every fifteen to twenty minutes to avoid prolonged traction on the brachial plexus.

The brachial plexus, subclavian artery, and subclavian vein can be seen just superior to the first rib from posterior to anterior respectively. Using a pair of
scissors, the insertion of the scalenus medius and anticus are released.

Using a scalpel, a transverse incision through the periosteum of the first rib is made and a sharp periosteal elevator is used to clean the periosteum off circumferentially. The pleura is directly attached to the periosteum so one must stay subperiosteally to avoid injuring the pleura. The rib should be cleaned as far anteriorly as the costal cartilage, and as far posteriorly as the transverse process. Very often fibrous bands from the clavicle anteriorly and the cervical spine posteriorly must be released to gain exposure.

Using an angled rib cutter, the rib is transected anteriorly at the costo-chondral junction, and posteriorly at the transverse process (Fig. 1). Care must be taken to visualize the brachial plexus, subclavian artery and vein and protect them at all times when resecting the rib. If the rib cannot be removed easily in one piece, the posterior portion may be removed with a rongeur. Sometimes it is difficult to remove all the posterior portion of the rib back to the transverse process, but if inspection demonstrates that the brachial plexus is not compressed, then the posterior one centimeter of rib may be left. All sharp spicules of bone should be carefully trimmed with a rongeur. A cervical rib when present can be removed in a similar fashion.

Inspection should now be made to see that there is no impingement upon the entire brachial plexus, subclavian artery and vein. The wound is then filled with irrigating fluid and the lungs hyperinflated to check for a pleural leak. If there is a small tear in the parietal pleura but none in the visceral pleura, a small tube is placed in the pleural cavity attached to suction and the wound is closed and then the tube immediately removed. The subcutaneous tissues are approximated, and the skin is closed. It is not usually necessary to drain the subcutaneous tissue.

**Evaluation**

Fifteen of the patients were personally interviewed and examined. For the two patients where this was not possible, an extensive questionnaire was sent and returned. The evaluation included information about their post-operative symptoms with respect to relief of pain, activity status, including employment and recreational sports, and the performance of a complete physical examination. The questionnaire included the same historical information. The information available was adequate to evaluate the results of the surgical procedure in all patients.

Results were divided into four categories. An excellent result required complete relief of pain and return to full employment and recreational sports. Patients with good results had almost complete relief of pain and returned to employment and some recreational sports. Fair included partial relief of pain and return to employment but with restrictions such that heavy objects could not be lifted overhead. Poor results showed no improvement from their preoperative status.

**Results**

All patients were felt to have compression of the brachial plexus within the thoracic outlet at the time of surgery which was relieved by the first rib resection. Fourteen patients at follow-up were considered to have good or excellent results, two patients fair, and only one patient was considered a failure (Table 1). The one failure was a fifty year old woman who had intermittent symptoms for thirteen years prior to surgery. These symptoms included pain in the right arm and entire hand, paresthesias that awakened her from sleep and weakness of her grip. Conservative measures had included radiant heat to her neck, a soft cervical collar, and exercises as outlined by Britt. All of these were unsuccessful.

Diagnostic evaluation included normal chest and cervical spine roentgenograms, a normal cervical myelogram, ulnar nerve conduction velocity that was slightly decreased from axilla to hand, and an Allen test that reproduced some of her paresthesias. She did return to her employment as a laboratory technician, but had difficulty participating in recreational sports and was unhappy with the procedure because of continued arm pain. The surgeon did feel that the brachial plexus was free after the first rib resection.
Complications included pneumothorax in three patients which responded promptly to post-operative chest tube drainage. This can usually be avoided by carefully dissecting and retracting the pleura with blunt instruments, and staying subperiosteally during the rib dissection. One wound infection occurred in the immediate post-operative period which was successfully treated with drainage and appropriate antibiotics without compromising the outcome of the procedure.

During one procedure the subclavian vein was injured and resulted in profuse hemorrhage which was controlled by direct pressure and a gelfoam pack without recurrence. This was the only patient who was closed over a drain. There was no operative mortality. The direct cause of compression of the neurovascular structures was not specifically noted by the surgeon in the operative notes, but there was always a note pertaining to the freedom of the brachial plexus after the resection.

Discussion

The anatomy of the thoracic outlet predisposes to compression of the subclavian artery, vein, and brachial plexus. These neurovascular structures are bordered by the first rib and clavicle on one plane, and the scalenus anterior and medius on another. (Fig. 1.) Abduction of the arm and backward retraction of the shoulder, as with the military position, narrows the costo-clavicular space. Deep inspirations elevate the first rib thereby further narrowing the space, and in some individuals the normal anterior curvature of the medial two-thirds of the clavicle is diminished causing further compromise. This is why activities such as needlework, typing, benchwork, or sleeping with the arms partially abducted above the head aggravate the symptoms. Ten of our patients gave this type of history.

The neurovascular structures can also be compressed by the pectoralis minor, the costoclavicular membrane, and the costocoracoid ligament. Bony abnormalities such as a cervical rib, a long transverse process from the seventh cervical vertebra, fusion of the first and second ribs, or malunion of a fractured clavicle can also cause compressive symptoms. One of our patients had a cervical rib, but there were no other bony abnormalities. The compression caused by any of these structures can be relieved by first rib resection. If at surgery one finds compression due to only the pectoralis major, then perhaps merely releasing this muscle will alleviate the symptoms. However, we do not think this etiology can be easily diagnosed pre-operatively. Trauma also seemed to be an initiating factor in ten of our patients. In seven of these patients a hyperextension injury caused by a rear end automobile accident resulted in symptoms.

There is a wide spectrum of symptoms which include numbness, tingling, weakness and pain in the hand, arm, shoulder and sometimes chest, scapula, neck and face. The majority of symptoms in our patients was expressed as pain in the shoulder, arm, and ulnar distribution of the hand. Urschel reports that over ninety percent of his patients with the syndrome have symptoms in the ulnar nerve distribution. Besides nerve compression there may be vascular compression, but there were none seen in our study. Venous compression can cause swelling of the entire arm and sometimes thrombosis of the axillary vein. Arterial compression causing blanching of the fingers and an ischemic ulcer in the hand has been reported.

The most helpful sign in establishing the diagnosis in our patients and in other reports was reproduction of symptoms with the Adson or Allen maneuver. The Allen test was the most reliable of the two. It is performed with the arm elevated sideward to ninety degrees and externally rotated. The elbow is bent at a right angle and the head turned toward the contralateral side, while the patient takes a deep inspiration. Obliteration of the pulse alone with this maneuver is seen in many normal subjects and is not reliable but reproduction of the symptoms is important. None of our patients developed swelling of the arm to suggest venous compression, and there were no color changes to suggest severe arterial insufficiency.

Urschel reports 95% improvement of patients treated by first rib resection when ulnar nerve conduction velocities were less than sixty meters per second across the thoracic outlet. Not enough of our patients had nerve conduction velocities to make a judgement as to their reliability, but in the patients tested, decrease in ulnar nerve conduction was a consistent finding. Nerve conduction studies and electromyograms should probably be performed on all patients when the diagnosis is considered because ulnar nerve conduction velocity slowing may aid considerably in making the diagnosis. It may be helpful also to measure ulnar nerve conduction velocities above the thoracic outlet with and without the Allen test. Arteriograms and venograms were individualized for each patient and were performed too
infrequently to make any definite conclusion. They were usually performed when the surgeon felt more information was needed to make the diagnosis.

Our patients were seen first by either internists, rheumatologists, or neurologists and then referred to the orthopedic or thoracic surgeon, which prolonged the diagnostic delay. The differential diagnosis included cervical spine disease ie herniated disc, disc degeneration, osteoarthritis, spinal cord tumors, syringomyelia and demyelinating disease, direct compression of the brachial plexus by a tumor in the superior pulmonary sulcus or trauma, cervical neuritis, carpal tunnel and ulnar nerve entrapment syndromes at the wrist or elbow, and inflammatory processes such as tendonitis. Five of our patients had a large psychological overlay, and this compounded the diagnostic problems. Due to these problems and the confusing symptoms, our diagnostic delay as noted averaged four years, with cervical disc disease being the most mistaken diagnosis. However, the length of diagnostic delay did not appear to affect the ultimate outcome. All of our patients had a trial of non-operative therapy for at least three months as outlined by Britt. The only contraindications to prolonged nonoperative therapy should be severe arterial insufficiency with skin changes and a significant neurological deficit. Two of our patients actually had anterior cervical discectomies and fusions before the correct diagnosis was made. It should be noted that cervical traction seems to exacerbate the pain of thoracic outlet syndrome, which may aid in considering the diagnosis.

It is important to emphasize that in ten years at our Medical Center only seventeen patients were operated upon for thoracic outlet syndrome. We do not know the number of patients where this diagnosis was made and treated conservatively, but one can clearly see that non-operative therapy must be successful in a high percentage of cases. Many surgical procedures have been devised to decompress the structures of the thoracic outlet. Scalenoectomy, clavicle resection, and resection of the first rib through the anterior, posterior, and transaxillary approach have all been utilized. Adson reported eighty percent good to excellent results with scalenectomy. However, only resection of the first rib decompresses the thoracic outlet no matter what the cause. Nelson reported ninety-four percent good to excellent results with first rib resection through the posterior-lateral approach. We found that resection of the first rib through the transaxillary approach decompressed the thoracic outlet regardless of the etiology, however, because of the possible complications, it probably should be performed in conjunction with a thoracic surgeon. Theoretically, removing the rib subperiosteally invites recurrence. We have not found this to be a problem and resecting it extraperiosteally almost certainly will damage the pleura.

The diagnosis of thoracic outlet syndrome should be considered in all patients with upper extremity pain. When the diagnosis is confirmed, and conservative measures fail, in a small number of patients resection of the first rib appears to be helpful in relieving symptoms. Orthopedic surgeons should be aware of this problem because they are usually the ones to first see patients with thoracic outlet syndrome.

References