Thoracic Outlet Syndrome

Current Concepts of Treatment

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The syndrome can be severely disabling but responds to an orderly approach of diagnosis with physiotherapy, operation or both. It is the purpose of this paper to discuss our integrated concept of the current management of TOS in 304 patients operated at Akron City Hospital.

Clinical Material

Three hundred four patients, 198 females and 106 males were operated for TOS during the period 1965 to 1978. The average age of the patients was 38 years. There was a history of trauma in 21% of the patients: 10% had previous surgery related to their symptoms. The duration of symptoms was four weeks to 12 years with an average duration of 18 months. Twelve percent of our patients had subjective symptoms bilaterally when first seen and required a second operation on the contralateral side at a later date. Another 5% of patients subsequently developed TOS on the other side which required surgery.

Signs and Symptoms

The symptoms of TOS vary greatly depending on whether the nerve, artery or vein is being compressed (Fig. 1, modified from Urschel). There may be an overlap of symptoms if more than one structure is involved in the compression.

Compression of the brachial plexus is associated with pain, numbness, paresthesia and weakness. Muscular atrophy of the hand may be present. The pain is usually in the neck and shoulder. Headaches, anterior chest and scapular pain are not infrequently present. Paresthesia and numbness usually along the distribution of the ulnar nerve (C8-T1) to the fourth

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and fifth fingers is extremely common. Any activity which causes abduction of the arm usually initiates or worsens the symptoms.

Arterial symptoms include pain, weakness, coldness and easy fatigability of the arm. The radial pulse may be dampened or completely absent on different arm maneuvers. Raynaud’s phenomenon, ulceration or gangrene of the extremity may be present in advanced cases. The coldness commonly felt by the patients with TOS is usually a reflection of peripheral neuropathy in the presence of strong peripheral pulses.

When venous obstruction is present, the complaint will be an aching tired arm with swelling, cyanosis and edema. Evidence of distended collateral veins around the shoulder and anterior chest may be present. Thrombosis of the subclavian vein (Paget-Schroetter or “effort thrombosis”) is frequently noted.

Two hundred ninety-two patients (96%) in this study presented with predominantly neurological symptoms. The remaining 12 patients (4%) had subclavian vein thrombosis. None of our patients had symptoms due to major arterial vascular occlusion.

The radial pulse could be obliterated upon assuming the 90° abduction position of the affected extremity in 218 patients (72%). Subclavian arteriograms performed in the initial 53 patients revealed subclavian artery compression at the medial border of the first rib in 90% of the patients (Fig. 2). Venography showed venous thrombosis in all 12 patients in which it was employed. Electromyography and nerve conduction times were employed in 60% (182) of cases and proved to be of little benefit in the diagnosis and the selection of patients for surgery.

Bony abnormalities were present in 20% of our patients in the form of cervical rib, long transverse process, clavicular abnormalities, bifid first rib and fusion of first and second ribs.

**Differential Diagnosis**

When TOS is suspected a cooperative and integrated concept of management is utilized employing the aid of the neurologist, orthopedist and occasionally the cardiologist. This flow pattern of management (Fig. 3, modified from Dale) concentrates on ruling out all other causes of radiculopathy, the diagnosis of TOS being made by exclusion. A neurological examination along with electromyography and myelograms, in indicated cases, comprise the main components of the neurological consultation. The orthopedist is concerned mostly with muscular tenderness and bony abnormalities of the shoulder and arm. Cervical spine, shoulder and chest radiography are obtained at this time. Cardiac consultation with stress electrocardiogram is requested if there is a complaint of chest pain.

After the work-up the patient is started on shoulder girdle strengthening exercises for two weeks. If symptoms are not relieved, cervical halter traction is instituted for a few days in those patients suspected of having disc pressure. Carpal ligament lysis may be indicated in some cases.

If the patient experiences relief of symptoms non-operative therapy is continued. Hospital admission is arranged for those patients whose symptoms persist. Subclavian arteriograms, venograms or myelograms

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**Fig. 2.** Arteriogram demonstrating compression of the subclavian artery at the thoracic outlet.
THORACIC OUTLET SYNDROME

FLOW PATTERN: TOS

NEUROLOGICAL CONSULTATION
1) Neurological work-up
2) Electromyograms
3) Cervical spine x-rays

ORTHOPEDIC CONSULTATION
1) Chest x-ray
2) Shoulder x-ray
3) Carpal ligament lysis (in indicated cases)

EXERCISE: SHOULDER GIRDLE
(2 weeks)

CERVICAL HALTER TRACTION
(1 week)

HOSPITAL ADMISSION
1) Subclavian arteriogram
2) Venography
3) Myelograms

OPERATION

92% Good Results

Fig. 3. Flow pattern of management of the thoracic outlet syndrome.

will be performed at this time, in indicated cases. Surgery is then offered to those patients who continue to have symptoms. Utilization of the above pattern of management has produced good to excellent results in over 90% of the operated patients.

Treatment

All patients in this study had removal of the first rib (along with a cervical rib or anomalous band when present) through the transaxillary approach. Figure 4 depicts the regional anatomy adjoing the neuromuscular structures as they pass between the clavicle and first rib. The artery is seen between the subclavius muscle anteriorly and the scalenus anticus muscle posteriorly. The vein and nerve plexus pass posterior to the scalenus anticus. The patient is placed in the lateral position and the arm is draped freely so that the axilla may be opened by applying traction to the arm (Fig. 5). A transverse incision is made just below the axillary hairline and carried down to the third rib. Dissection proceeds cephaled along the chest wall to the first rib. The first rib is dissected extraperiosteally with great care to avoid injury to the adjoining nerve, artery and vein. The anterior scalene muscle is divided at its attachment with the superior border of the rib. The

Fig. 4. Relationship of the neurovascular bundle to the clavicle scalenus muscles and first rib.

dissection is carried out using scissors, periosteal elevator and the surgeon's finger. Finger dissection is sensitive, safe and effective in freeing most of the rib. While it is important to remove as much rib as possible, it is the posterior aspect of the rib which must be removed completely since this is the area where the nerve plexus is compressed. Excision of the first rib removes the floor of the compression compartment and allows the neurovascular bundle to drop downward away from the overlying enclosing structures. Figure 6

Fig. 5. Drawing depicting position of patient and location of axillary incision.
reveals the anatomical structures which are visualized through the axillary incision. The nerves, artery and vein are seen in the background. The pleura rises between the rib and the neurovascular bundle. The scalenus anticus and medius muscles have been divided from the rib and the rib is ready for removal. Subclavian venous thrombectomy was also performed through the same incision in seven of the eight cases with venous thrombosis in this study. Figure 7 reveals the swelling, edema and collateral venous circulation in the right arm of a patient with subclavian venous thrombosis. Figure 8 shows the thrombosis that was removed from the subclavian vein in the patient in Figure 7.

If the parietal pleura is entered the pneumothorax is easily managed by insertion of a chest catheter through the axillary incision. The catheter may be applied to suction and withdrawn as the wound is closed or connected to a water seal and removed the next morning. If the pleura is not entered a Penrose drain is left in place for 24 hours. A cervical rib, if present, can usually be removed through the axillary approach after removal of the first rib. Operative time averages 45-75 minutes; blood loss is 50-100 cc. Figure 9 depicts the decompression of the neurovascular bundle which lies below the clavicle and between the cut edges of the first rib. Finally, Figure 10 demonstrates the healing transaxillary incision at the fifth postoperative day.

Results

The follow-up period, of the 304 operated cases, ranged from six months to five years. All patients were evaluated by re-examination or questionnaire.

Symptoms were completely (85%) or partially (7%) relieved in 92% of the 304 operated patients. Only 8% (16) of patients were not improved and considered as having a poor result. In addition 7% (21) of patients had partial recurrence of symptoms during the follow-up period. It is predictable early as to whom will have a good result since relief of pain, numbness and tingling of the hand is immediate and evident by the first postoperative day. None of the patients were made worse. There were no deaths. Complications consisted of pneumothorax in 22 (11%), long thoracic nerve injury in two, hemorrhage in two and temporary brachial

![Fig. 6. Appearance of the neurovascular bundle through the axillary incision.](image)

![Fig. 7. Swelling of the right arm due to subclavian vein thrombosis.](image)

![Fig. 8. The thrombus removed from the subclavian vein of patient in Fig. 7.](image)
plexus paralysis in one. The average hospital stay was 4.5 days.

Discussion

Thoracic outlet syndrome is not a new entity, yet only recently has it been considered in the differential diagnosis of upper extremity problems. This fact is evidenced by the number of patients receiving inadequate treatment for the syndrome. Most of our earlier patients consulted an average of three physicians before they were referred to the neurologist or orthopedist for their TOS work-up. Many were told by their physicians that their complaints were "not real," "exaggerated" or "in your head." Although the 304 patients in this series were operated during the past 12 years, 50% of the operations were performed in the last four years, indicating that physicians are now recognizing the entity more often than previously.

Electromyography and nerve conduction velocities which have been advocated by Rainer and Sadler\(^8\) and Urschel\(^9\) have not been found to be of benefit in the diagnosis and selection of our patients for surgery. We performed these tests in 182 cases and found in most instances that no abnormality was present, yet the majority of these patients obtained complete relief of pain by surgery. Roos\(^8\) and Daube\(^5\) also feel these tests are of little value in the evaluation of the patient with TOS. Roos\(^8\) gives the following reasons for his beliefs: 1) the normal range of the tests are too wide to rely on a specific nerve velocity to be diagnostic, 2) location of the nerve compression is so central on the plexus that the stimulating electrode cannot be placed proximal to the compression site, and 3) the nerve compression and irritation are intermittent (as suggested by symptoms) and not consistently picked up by the insensitive apparatus. For the above reasons electromyography and nerve conduction velocities are no longer performed in the routine evaluation of our patients.

Although positional obliteration of the radial pulse is commonly present in the syndrome (72% in this study) only rarely are symptoms due to arterial occlusion. We have performed subclavian arteriography in 53 of the cases in this series with 48 patients (90%) showing compression of the artery at the level of the first rib when the arm was hyperabducted. In no instances were there compression of the artery when the arteriogram was performed with the arm in normal unexaggerated positions. Raaf\(^3\) found obliteration of the radial pulse in more than 60% of asymptomatic subjects with the arm in the shoulder-braced position alone. Wright\(^11\) found obliteration of the radial pulse in at least one upper extremity tested in an elevated arm position in 92.6% of 150 asymptomatic normal patients. In the 304 operated patients in this study none had a positive Adson test performed with the arms down on the symptomatic side. These studies indicated that pulse obliteration with the arms and head in various positions is a normal finding in the majority of asymptomatic people and bears no direct relationship to the symptoms of TOS. We no longer perform subclavian arteriography routinely in our patients. They are only done when the patient has definite evidence of arterial insufficiency of the extremity.

With positional evaluation of the radial pulse, subclavian arteriography and nerve conduction velocities proving unreliable and inaccurate, Roos\(^8\) made a valuable contribution by describing the tests that he feels are valuable in establishing the diagnosis of TOS. These tests are: 1) the three minute elevated arm exercise test. The test results in early fatigability and heaviness of the involved arm with gradual onset of numbness

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Fig. 9. Drawing showing decompressed neurovascular bundle with resected first rib.

Fig. 10. Appearance of axillary wound on the fourth post-operative day.
and tingling in the hand, 2) percussion and thumb pressure test. A positive response is tenderness and gradual reproduction of numbness and tingling and pain down the arm, elicited by thumb pressure over the brachial plexus in the supraclavicular fossa, 3) hypesthesia to touch and pinprick skin sensation of the inner forearm and ulnar side of hand and fingers (C8-T1), and 4) weakness of the triceps (C7) or interosseous muscles of the hands (C8-T1).

If patients are thoroughly evaluated by a detailed history, simplistic tests as described by Roos, and appropriate consultations, the diagnosis of TOS can be made with a high degree of accuracy allowing for a gratifying relief of symptoms in over 90% of patients subjected to surgery. Meticulous resection of the first rib (with associated fibrous bands and cervical ribs) through a transaxillary approach, is the treatment of choice. The few patients having no relief will result from an inaccurate diagnosis and lack of technical expertise in performing decompression of the neurovascular bundle.

Summary

The current concepts of treatment of 304 patients with TOS are reviewed. The diagnosis can be made with a high degree of accuracy by utilizing the combination of a detailed history, simple tests of physical examination and appropriate neurological and orthopedic consultations. If patients are highly selected through a thorough evaluation program surgery will result in gratifying relief of symptoms in over 90% of cases. The treatment of choice is meticulous resection of the first rib through a transaxillary approach.

References