REVIEW ARTICLE

Thoracic Outlet Syndrome, Anatomical and Surgical Perspective

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Introduction

The thoracic outlet (TO) is defined as an opening bordered by the first rib laterally, the vertebral column medially, and the claviculomanubrial complex anteriorly (*Fig 1*). (TOS) consists of a group of distinct disorders that affect the nerves in the brachial plexus (nerves that pass into the arms from the neck) and the subclavian artery and vein; blood vessels between the base of the neck and axilla (armpit)(*Fig 2*), What is currently called thoracic outlet syndrome should be renamed the cervicoaxillary syndrome (1).

Thoracic outlet syndrome (TOS) is due to compression/ irritation of brachial plexus elements ("Neurogenic TOS") and/or subclavian vessels ("Vascular TOS") in their passage from the cervical area toward the axilla. The usual site of entrapment is the interscalenic triangle

TOS commonly develops during the 3rd or 4th decade, more often in women, under the combination of a peculiar cervical anatomy and of external factors. Some morphotypes predispose to the syndrome:

- Poor muscular development
- Droop of scapula
- Obesity and breast hypertrophy
- The patient psychological status may sometimes play an important role in the development of the syndrome

-Stress and depression can lead to chronic muscle spasm in the neck region and there to decompensation of a previously asymptomatic predisposing anatomy

- Other precipitating factors are work-related (static work posture)

The thoracic outlet region contains three important structures: the brachial plexus, the subclavian artery, and the subclavian vein. As they travel from the upper mediastinum to the upper extremity, these structures run through three important spaces: the interscalene triangle, the costoclavicular space, and the subpectoral space. Compression can occur in any of these three spaces because of structural anomalies or trauma.Personal evaluation of more than 2,300 patients for possible thoracic outlet syndrome (TOS) and knowledge gained from 980 TOS operations in 766 patients (operative incidence of 33.7 per cent of the patients examined) have shown that most patients with TOS have anomalous fibrous muscular bands near the brachial plexus that predispose them to neurologic irritation or compression involving the plexus. Anatomic analysis during operations for TOS, plus cadaver dissections, have disclosed seven distinct types of fibromuscular bands (2). In addition to this , the less

Risk Factors:

- Exuberant callus after fracture of clavicle or first rib
- Exostosis of clavicle or first rib
- Postural abnormalities (e.g., drooping of shoulders, scoliosis)
- Body building, with increased muscular bulk in thoracic outlet area
- Rapid weight loss combined with vigorous physical exertion and/or exercise

Pathophysiology

The brachial plexus trunks and subclavian vessels are subject to compression or irritation as they course through 3 narrow passageways from the base of the neck toward the axilla and the proximal arm. The most important of these passageways is the interscalene triangle, which is also the most proximal. This triangle is bordered by the anterior scalene muscle anteriorly, the middle scalene muscle posteriorly, and the medial surface of the first rib inferiorly. This area may be small at rest and may become even smaller with certain provocative maneuvers. Anomalous structures, such as fibrous bands, cervical ribs, and anomalous muscles, may constrict this triangle further. Repetitive trauma to the plexus elements, particularly the lower trunk and C8-T1 spinal nerves, is thought to play an important role in the pathogenesis of TOS. Microscopic examination of scalene muscles from the necks of people with TOS demonstrates scar tissue

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throughout the muscle. Presumably, this was caused by a neck injury stretching these muscle fibers. The tight muscles then press against the nerves to the arm (brachial plexus) producing the hand and arm symptoms. Neck pain and headaches in the back of the head may be caused by the tightness in these muscles but also can be the result of stretching muscles and ligaments along the cervical spine of the neck in cases of whiplash injury (3). The second passageway is the costoclavicular triangle, which is bordered anteriorly by the middle third of the clavicle, posteromedially by the first rib, and posterolaterally by the upper border of the scapula.

The last passageway is the subcoracoid space beneath the coracoid process just deep to the pectoralis minor tendon

The following taxonomy of TOS is used in International Classification of Diseases; ICD-9-CM:

Scalenus anticus syndrome (compression on brachial plexus and/or subclavian artery caused by muscle growth) - diagnosed by using Adson's sign with patient's head turned outward

Cervical Rib Syndrome (compression on brachial plexus and/or subclavian artery caused by bone growth) - diagnosed by using Adson's sign with patient's head turned inward

Costoclavicular Syndrome (narrowing between the clavicle and the first rib) -- diagnosed with costoclavicular maneuver.

- Neurologic symptoms occur in 95% of cases (4). The lower 2 nerve roots of the brachial plexus, C8 and T1, are most commonly (90%) involved, producing pain and paresthesias in the ulnar nerve distribution.

-The second most common anatomic pattern involves the upper 3 nerve roots of the brachial plexus, C5, C6, and C7, with symptoms referred to the neck, ear, upper chest, upper back, and outer arm in the radial nerve distribution.

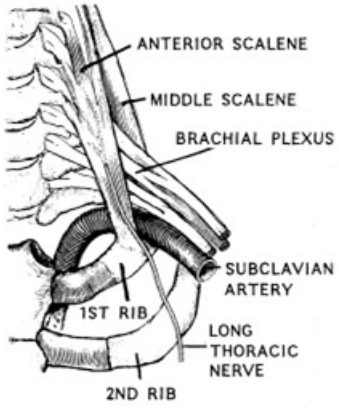


Fig 1. Showing the Boundaries of the Thoracic Outlet

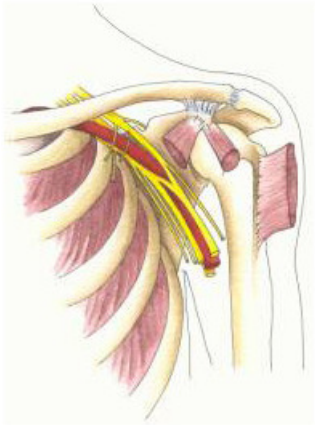
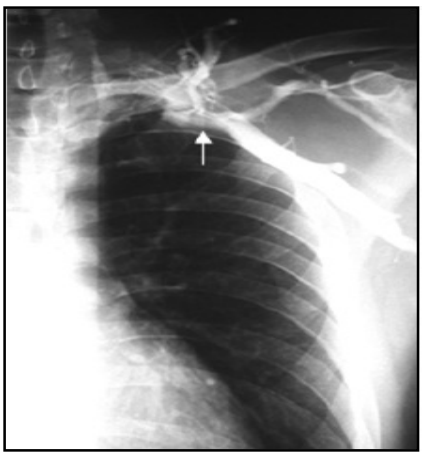


Fig 2. Showing The Neurovascular Bundle Compromising of Subclavian Vessels and Brachial Plexus

Neurogenic TOS has a characteristic sign, called the Gilliatt-Sumner hand, in which there is severe wasting in the fleshy base of the thumb. There may be numbness along the underside of the hand and forearm, or dull aching pain in the neck, shoulder, and armpit (5).

ascular TOS features pallor, a weak or absent pulse in the affected arm, which also may be cool to the touch and appear paler than the unaffected arm. Symptoms may include numbness, tingling, aching, and heaviness.

Vascular symptoms include:	**Neurologic symptoms include:**
1. Swelling or puffiness in the arm or hand	1. Parasthesia along the inside of forearm and the palm (C8, T1 dermatome)
2. Bluish discoloration of the hand	2. Muscle weakness and atrophy of the gripping muscles (long finger flexors) and small muscles of the hand (thenar and intrinsics)
3. Feeling of heaviness in the arm or hand	3. Difficulty with fine motor tasks of the hand
4. Pulsating lump above the clavicle	4. Cramps of the muscles on the inner forearm (long finger flexors)
5. Deep, boring toothache-like pain in the neck and shoulder region which seems to increase at night	5. Pain in the arm and hand
6. Easily fatigued arms and hands	6. Tingling and numbness in the neck, shoulder region, arm and hand
7. Superficial vein distention in the hand	



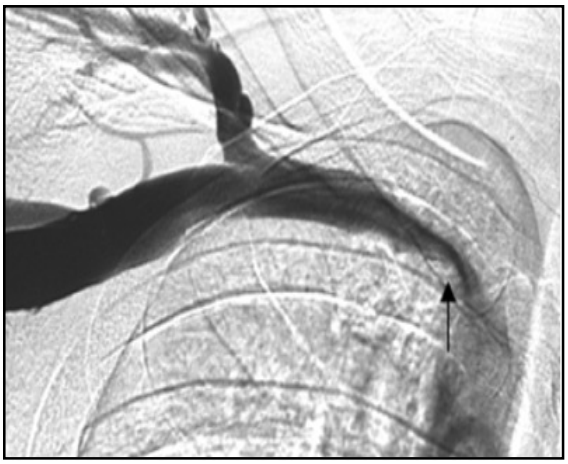


Fig 3 & 4 . Venogram (Showing Complete Occlusion of Subclavian Veins (arrow) where it crosses the First Rib)

Fig 5. Preparation of Thoracic Outlet Area

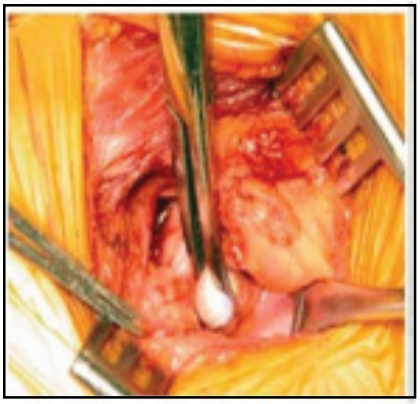


Fig 6. Ist Thoracic Rib Removed to Decompress Neeurovascular Structures of TOS

Non-Specific TOS most prominently features a dull, aching pain in the neck, shoulder, and armpit that gets worse with activity. Non-specific TOS is frequently triggered by a traumatic event such as a car accident or a work related injury. It also occurs in athletes, including weight lifters, swimmers, tennis players, and baseball pitchers.

Diagnosing Thoracic Outlet Syndrome can be difficult because the symptoms and severity of the symptoms can vary greatly among people with the disorder.

Some of the more common provocation tests that can suggest the presence of thoracic outlet syndrome include:

- Adson's maneuver (6).
- Wright test (6).
- Roos stress test (7).

To confirm the diagnosis of thoracic outlet syndrome, the following investigations may be employed;

- X-ray. may reveal an extra rib (cervical rib) .
- Magnetic resonance imaging (MRI) scan. MR imaging appears to be a useful technique to study the thoracic outlet and its contents because of its excellent soft-tissue depiction and its multiplanar capabilities (8).
- Electromyography (EMG). How muscles and nerves are working.
- Nerve conduction study.evaluate possible nerve damage.
- Color Doppler sonography is 92% sensitive and 95% specific for the diagnosis of thoracic outlet syndrome. This preliminary study shows that Doppler sonography has potential in the evaluation of thoracic outlet syndrome (9).

Complications (Vascular): hand ischemia, axillary-subclavian deep venous thrombosis, aneurysms of the subclavian artery, poststenotic dilatation of the subclavian artery were found as well as one thrombosis of the axillary artery and 8 brachial artery embolism, brachial artery embolism (*Fig 3 & 4*)

Differential Diagnosis:

- Cervical disk syndrome

- Carpal tunnel syndrome
- Orthopedic shoulder problems (shoulder strain, rotator cuff injury, tendinitis)
- Cervical spondylitis
- Ulnar nerve compression at the elbow and hand
- Multiple sclerosis
- Spinal cord tumor or disease
- Angina pectoris
- Migraine
- Reflex sympathetic dystrophy
- C8 radiculopathies

Treatment

The objectives of treatment of TOS include: 1) relieve the compression of the nerves and blood vessels in the thoracic outlet region; 2) control and minimize pain and other symptoms to the greatest extent possible; and 3) improve the patient's overall quality of life. The management of TOS requires a multidisciplinary approach with specific treatment for each TOS sub-type.

General Measures:

Conservative

-If no vascular involvement is present and/or if no loss of function or lifestyle is present due to severity of symptoms, conservative therapy may be undertaken for 2-3 months

- Improvement can be expected in 60% of patients
- Exercise program to promote shoulder muscle function
- Physical therapy for postural faults
- Cervical collar, traction
- Weight loss if axillary folds are causing compression

Occupational Therapy

Work simplification & back protection techniques often are helpful.These educational tools are available from the occupational therapist,as well as from physical therapist

Surgical Measures*: (Fig 5 & 6)*

- Operative - if vascular involvement is present and/or if there is loss of function or lifestyle secondary to severity of symptoms and if conservative therapy fails after 2-3 months
- Resection of first rib or cervical ribs (transaxillary, supraclavicular, posterior approaches)
- Excision of adhesive bands via transaxillary approach
- Anterior scalenectomy

First rib resection has been advocated by many surgeons to treat TOS(10). Many also use scalenectomy, in combination with rib removal, or as a second procedure, if the initial surgery is ineffective. Resection of accessory ribs and fibrous bands should be performed, especially if observed to be tethering the plexus.

Patients with acute & chronic venous TOS shoul be maintained on anticoagulation during the perioperative period & may not need thrombolysis prior to surgery.Finally,patients with arterial TOS should undergo cervical or first rib resection with or without arterial reconstruction to alleviate & prevent recurrence f symptoms (11).

The definitions of improvement of the patient are variable and sometimes ambiguous. The data do not provide a rigid guideline for specific management of each condition; rather, the options are presented with their supporting data to permit an individualized approach

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