

THORACIC OUTLET SYNDROME

Essay

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Presented by

Omar Nasser Farouk Moustafa

M.B.,B.Ch.

Ain Shams University

Supervisors

Prof. Dr. Ahmed Anwar El Noory

Professor of Cardiothoracic Surgery

Faculty of Medicine – Ain Shams University

Dr. Hany Hasan El Sayed

Assistant Professor of Cardiothoracic surgery

Faculty of Medicine – Ain Shams University

Dr. Ahmed Mohamed Mostafa

Lecturer of Cardiothoracic Surgery

Faculty of Medicine – Ain Shams University

Faculty of Medicine

Ain Shams University

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Abbreviations

a.	Artery
Ant.	Anterior
BTX	Botulinum Neurotoxin
C	Cervical
CK-MB	Creatinine phosphokinase – MB fraction
CT	Computed Tomography
CRPS	Complex Regional Pain Syndrome
dn TOS	Disputed neurogenic thoracic outlet syndrome
EAST	Elevated Arm Stress Test
EMG	Electromyography
LAC	Lateral Antebrachial Cutaneous Nerve
LMNL	Lower Motor Neuron Lesion
m.	Muscle
MAC	Medial Antebrachial Cutaneous Nerves
Med.	Medius
mm.	Minimus
MNCS	Motor Nerve Conduction Study
MR	Magnetic Resonance
MRA	Magnetic Resonance Angiography
MRI	Magnetic Resonance Image
MRN	Magnetic Resonance Neurography
NCS	Nerve Conduction Study
nTOS	Neurogenic Thoracic Outlet Syndrome
Post.	Posterior
PSV	Peak Systolic Velocity
PTT	Partial Thromboplastin Time
SCA	Subclavian Artery
SNCS	Sensory Nerve Conduction Study
SNAP	Sensory Nerve Action Potential
SSEPs	Somatosensory Evoked Potentials
T	Thoracic
TENS	Transcutaneous Electrical Nerve Stimulation
TOS	Thoracic Outlet Syndrome
UMNL	Upper Motor Neuron Lesion
v.	Vein
vTOS	Vascular Thoracic Outlet Syndrome

Abstract

Background: Thoracic outlet syndrome (TOS) is a clinical entity characterized by compression of the neurovascular bundle of the upper limb as it passes from the upper thoracic aperture to the axilla. Although thrombosis of the axillosubclavian vein was first reported by Paget in 1875 and Von Schroetter in 1884, and was coined “Paget-Schroetter syndrome” by Hughes in 1949, the term “Thoracic Outlet Syndrome” was coined in the 1950s to reflect the fact that TOS has many variants, ranging from vascular involvement of the subclavian artery (SCA) or vein (SCV) to the more common neurogenic form with compression of the brachial plexus .

Aim of work: Is to review the historical background, surgical anatomy, aetiology, clinical picture, investigations, differential diagnosis and treatment of the thoracic outlet syndrome.

Methodology: Patients with severe vascular compression and brachial plexus compression with intrinsic muscle atrophy likely will require surgical intervention. However, in the patients with brachial plexus nerve compression and no muscle atrophy, operation should be recommended only for the few patients whose symptoms are not relieved with an appropriate program of physical therapy that addresses posture, neural mobility, and cervicoscapular muscle imbalance.

Conclusion: Thoracic outlet syndrome results from mechanical compression of various structures of the thoracic outlet. It remains controversial in both diagnosis and treatment, particularly in patients with brachial plexus nerve compression and no muscle atrophy. The diagnosis of TOS is a clinical diagnosis based on reproduction of patient symptoms with provocation testing (arm elevation) and exclusion of other conditions that can cause similar symptoms.

Keywords: Thoracic Outlet Syndrome, anatomy, aetiology, clinical picture, investigations

Introduction:

Thoracic outlet syndrome (TOS) is a clinical entity characterized by compression of the neurovascular bundle of the upper limb as it passes from the upper thoracic aperture to the axilla. Although thrombosis of the axillosubclavian vein was first reported by Paget in 1875 and Von Schroetter in 1884, and was coined “Paget-Schroetter syndrome” by Hughes in 1949, the term “Thoracic Outlet Syndrome” was coined in the 1950s to reflect the fact that TOS has many variants, ranging from vascular involvement of the subclavian artery (SCA) or vein (SCV) to the more common neurogenic form with compression of the brachial plexus .(*Moriarty et al, 2015*)

Thoracic outlet syndrome (TOS) denotes compression of the subclavian vessels and nerves of the brachial plexus in the region of the thoracic inlet (*Lukanich et al, 2001*). The name itself is confusing and misrepresentative because anatomically the area of compression between the scalene muscles and the first rib is termed correctly the thoracic inlet (*Mackinnon & Novak, 2002*).

Although it was Galen in AD 170 who first mentioned the occurrence of cervical rib, not until 1821 was it noted by Sir Astley Cooper that pressure of a cervical rib on the nearby subclavian artery could produce vascular symptoms. In 1861, the first resection of a cervical rib was undertaken at St. Bartholomew’s Hospital, London (*Mercer et al., 1998*).

The neurovascular bundle, that contains the brachial plexus trunks and the subclavian vessels, courses through three narrow passageways from the base of the neck toward the axilla and the proximal arm. The most important of these passageways clinically is the most proximal, the interscalene triangle, which is bordered by the anterior scalene muscle anteriorly, the middle scalene muscle posteriorly, and the medial surface of the first rib inferiorly. This triangle contains the trunks of the brachial plexus and the subclavian artery. The subclavian vein crosses anterior to the anterior scalene muscle. Just distal to the interscalene triangle, the neurovascular bundle enters 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. Finally, the neurovascular bundle enters the subcoracoid space beneath the coracoid process just deep to the pectoralis minor tendon (*Huang & Zager, 2004*).

Causes of TOS can be divided into osseous and soft tissue factors. Anomalous fibrous bands, cervical rib and trauma are the most common causes of TOS (*Huang & Zager, 2004*).

Patients with TOS can be divided into three groups: 1) those with compression of the brachial plexus, also called neurogenic TOS; 2) those with compression of the subclavian vessels (either artery or vein), also called vascular TOS; and 3) those with nonspecific-type TOS, sometimes referred to as the

disputed or common type of TOS, consisting poorly defined chronic pain syndrome with features suggestive of brachial plexus involvement. Occasionally, the neurological and vascular components may coexist in the same patient (**Huang & Zager, 2004**).

Radiological evaluation includes chest X-ray and cervical spine films. CT scan, MRI or cervical myelograms are sometimes helpful to rule out narrowing of the intervertebral foramina or cervical disc pathology. Doppler studies or vascular imaging (angiogram / venogram) may be indicated if the extent of vascular impairment cannot be determined clinically or if aneurysm or venous thrombosis is suspected. Nerve conduction velocities are very useful in differentiating the causes of neurological symptoms reported by the patient. By varying the points of stimulation along a specific nerve from the supraclavicular fossa to the wrist, the site of compression can be identified (**Lukanich et al., 2001**).

Differential diagnosis of TOS includes cervical disc or osteophyte, Pancoast tumor, nerve sheath tumor, ulnar and/or median nerve entrapment, brachial plexitis, syrinx or spinal cord tumors, shoulder pathology, fibromyalgia, multiple sclerosis, Raynaud's disease, acute coronary syndrome, vasculitis, vasospastic disorder and complex regional pain syndrome (**Huang & Zager, 2004**).

Conservative management includes modification of behaviours to avoid provocative activities, in addition to individually tailored physical therapy programs that strengthen the muscles of the pectoral girdle and help to restore normal posture

(Huang & Zager, 2004). Appropriate analgesia and non-steroidal anti-inflammatory drugs may provide a measure of comfort **(Mercer et al., 1998).**

There are three possible open surgical approaches to the thoracic outlet: supraclavicular, transaxillary and posterior approach in addition to VATS resection of first rib **(Tindall, 2000).**

Aim of work:

Is to review the historical background, surgical anatomy, aetiology, clinical picture, investigations, differential diagnosis and treatment of the thoracic outlet syndrome.

Historical background:

Cervical rib was first described by Galen and Vesalius in the second century (*Davidovic et al., 2003*). Sir Astley Cooper in 1818 described a woman with arm ischemia resulting from a projection of the lower cervical vertebrae towards the clavicle (*Mackinnon & Novak, 2002*). In 1821, he was the first to note that pressure of a cervical rib on the nearby subclavian artery could produce vascular symptoms (*Mercer et al., 1998*).

In 1860, Dr. Willshire described a case of supernumerary rib arising above the first rib in twenty one years old girl. That rib was presenting with a pulsating lump in the subclavian triangle (*Willshire, 1860*).

In 1861, excision of exostosis of the transverse process of the seventh cervical vertebra was done by Coote in St. Bartholomew's Hospital in London. Coote said "The operation was undertaken with the purpose of removing a bony growth, which had pressed forwards the subclavian artery, and pushed upwards the axillary plexus of nerves, thereby producing disturbance of circulation and loss of sensation in the corresponding upper extremity " (*Coote, 1861*).

The first classification of cervical ribs was suggested by Gruber in 1869. The diagnosis of cervical ribs was much facilitated by the advent of X-ray in 1895. It was soon realized that they are often asymptomatic and symptoms could occur without a cervical rib (*Schenker & Kay, 2001*).

At the turn of the century, the possibility of brachial plexus compression by a persistent cervical rib was first recognized in 1903 when Thomas and Cushing described a patient with a cervical rib who presented with hand atrophy (**Villavicencio & Friedman, 1999**). In 1905, Murphy performed a successful resection of the cervical rib in a patient with TOS and subclavian artery aneurysm (**Davidovic et al., 2003**). Murphy was the first to remove the first rib in a patient with TOS via the supraclavicular approach in 1910 to relieve the symptoms associated with TOS (**Robicsek & Eastman, 1997**).

Adson in 1927 described the "scalenus anticus syndrome", meaning neurovascular compression by a hypertrophied or abnormally inserted anterior scalene muscle (**Schenker & Kay, 2001**). In the same year, Adson and Coffey introduced the scalenotomy, which was the most frequently used operative procedure for decompression of the neurovascular structures at the cervico-thoracic junction for many years until its poor long term results became obvious in the early 1960s (**Atasoy, 2004**).

In 1947, Adson described the "Adson test" as provocative maneuver and considered it a pathognomonic sign of scalenus anticus syndrome (**Mackinnon & Novak, 2002**).

In 1953, Lord introduced claviclectomy as a new procedure. This was a rather disfiguring operation and has never gained popularity (**Atasoy, 2004**).

The term "Thoracic outlet syndrome" was first used by Peet in 1956 to indicate compression of one or more of the neurovascular structures traversing the thoracic outlet (*Samarasam et al., 2004*).

Clagett introduced the first rib resection using a posterior approach in 1962. This was a rather traumatic and bloody procedure that is reserved now for recurrent cases only (*Atasoy, 2004*). In the same year, Falconer and Li noted good relief of symptoms in 12 of 13 cases using a supraclavicular first rib resection approach (*Mackinnon & Novak, 2002*).

The transaxillary approach for the first rib resection was described by Roos in 1966. It was much less traumatic procedure and has been used more frequently (*Atasoy, 2004*).

In 1996, Atasoy first introduced a different combined approach. It consisted of a transaxillary first rib resection followed immediately by a transcervical anterior and medial scalenectomy (first performed in 1989). The combination of these procedures achieved total decompression of the thoracic outlet region (*Atasoy, 2004*).

Surgical Anatomy:

There is much confusion and controversy regarding the region termed by clinicians, the thoracic outlet. Anatomists refer to the thoracic outlet as the inferior thoracic aperture, which is the opening into the abdominal area and not the region between scalene muscles and the first rib. Anatomically the area between the scalene muscles and the first rib is termed the thoracic inlet (*Mackinnon & Novak, 2002*).

The thoracic inlet is reniform, about 5 cm anteroposteriorly, and about 10 cm transversely. Its plane slopes down and forwards, bounded by the first thoracic vertebral body behind, the superior border of manubrium sterni anteriorly and the first rib and costal cartilage laterally (*Cooke, 2003*). The middle and anterior scalene muscles, the five primary nerves and three trunks that comprise the brachial plexus, the phrenic nerve, the stellate ganglion, the subclavian artery and vein, the thoracic duct, scalene lymph nodes and the apex of the lung are found in this anatomical area (*Han et al., 2003*).

Compression may occur at three distinct points in the thoracic outlet: the interscalene triangle, the costoclavicular space, and the retropectoralis minor space (Figure 1). The interscalene triangle consists of the anterior scalene muscle, the middle scalene muscle, and the first rib, and it contains the subclavian artery and the upper, middle, and lower trunks of the brachial plexus. The costoclavicular space is made up anteriorly by the clavicle, the subclavius muscle, and the costocoracoid ligament,