THORACIC OUTLET COMPRESSION SYNDROME A REVIEW ARTICLE*

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ABSTRACT

Thoracic outlet compression syndrome is the complex of signs and symptoms because of the compression of the neurovascular structures in the thoracic outlet region. In this article, this syndrome is reviewed in terms of historical cronology, anatomy, etiology, histopathology, clinical and radiological evaluation, and discussed among the conservative and surgical treatment.

Key words:

INTRODUCTION

Thoracic outlet compression syndrome (TOCS) is the complex of signs and symptoms resulted because of the compression of the vital neurovascular structures in the thoracic outlet region. The structures underwent compression are brachial plexus, subclavian vein and artery. The reasons of the disease in most cases are congenital and acquired changes in the surrounding fibroosseous and fibromuscular structures (2).

HISTORICAL CRONOLOGY (2, 20):

Galen 150: Cervical rib was defined.

Hunald 1742: First description of the cervical rib cases.

Gruber 1842: First modern classification of cervical rib with four types.

Coote 1861: First resection of an exostosis of the seventh cervical transverse process.

Paget 1875: First clinical description of subclavian vein thrombosis, introducing the venous type of TOCS.

Bramwell 1903: Description of the compression due to anatomically normal first rib.

Keen 1907: First complete clinical definition and surgical treatment of cervical rib.

Murphy 1908: Resection of the normal first rib.

Law 1920: Description of the ligaments originating from the seventh cervical vertebra and compressing the brachial plexus.

Adson and Coffey 1927: Division of the anterior scalene muscle without removal of the cervical rib.

DeBakey 1935: Introduction of the term "Scalenus Anticus Syndrome".

Peet 1956: Introduction of the term "Thoracic outlet syndrome" and description of an exercise program.

Rob and Standevan 1958: Using of the term "Thoracic outlet compression syndrome".

Clagett 1962: Description of the posterior periscapular approach for first and cervical rib resection.

Roos 1966: Description of the transaxillary approach for first rib resection.

Gol 1968: Description of the infraclavicular approach.

Jebsen 1968: First objective neuroelectric studies of patients with TOCS.

Glover 1981: First experience with somatosensory evoked potentials in TOCS.

ANATOMY

The anatomic limit of thoracic outlet region is the area from the outer edge of the first rib to the upper mediastinum medially and cephalad to the level of the fifth cervical nerve. The thoracic outlet forms the communicating region at the root of the neck for the passage of great vessels and the nerves from the mediastinum and the neck to the axilla (12). The structures included are brachial plexus, subclavian artery and vein, the anterior and middle scalene muscles, the phrenic, long thoracic and dorsal scapular nerves, the stellate ganglion, the thoracic duct, scalene lymph nodes and the cupola of the lung.

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The subclavian artery begins at the upper mediastinum, courses behind the anterior scalene muscle, arches over the first rib, passes through the interscalene triangle. The brachial plexus lies lateral, posterior and superior to the subclavian artery. Especially, its lower roots have a close relationship with subclavian artery (2). The subclavian vein passes in front of the anterior scalene muscle, just inferior and lateral to the costoclavicular ligament and over the first rib. Then these structures follow a course, passing under the clavicle and subclavian muscle, then entering the axilla beneath the pectoralis minor muscle near its insertion into the coracoid process (2).

COMPRESSION AREAS:

There are three possible areas for neurovascular compression in the thoracic outlet region:

1. Interscalene triangle
2. Costoclavicular space
3. Subpectoralis minor space

INTERSCALENE TRIANGLE:

This area is limited by the anterior scalene muscle anteriorly, the middle scalene muscle posteriorly, and the first rib inferiorly. The structures leading compression here are the anterior, middle and minimus scalene muscles, anomalies of the first rib, cervical rib, prominent transverse process of seventh cervical vertebra, fibrous bands, tumors and narrow interscalene triangle.

The scalene muscles:

Anterior and middle scalene muscles are the secondary respiratory muscles. They act to raise the first rib and rotate and bend the neck. Their insertions may overlap and make a "V" shape and create a narrow space leading brachial plexus and subclavian artery to be in a high position (Figure 1). In some cases, the middle scalene muscle inserts into the entire length of the first rib narrowing the space much more. This formation is usually observed in cervical rib cases. Sometimes, the scalene muscles form a "U" shape making pressure on the vital structures from below.

Attention to anterior scalene muscle was first called by Adson in 1925 during the operation of a patient with cervical rib. He had observed that with each inspiration of the patient, the anterior scalene muscle was bulging and becoming tense collapsing the subclavian artery (1).

In the study of Sanders and co. (21), anterior and middle scalene muscles from the patients with traumatic TOCS were evaluated microscopically by means of histochemical stains applied after freezing of the muscles. They have resulted a consistent abnormal histologic pattern with a significant increase in connective tissue. They have concluded that following neck injuries, the changes in the anterior and middle scalene muscles are competible with trauma, suggesting that fibrotic scalene muscles are an important cause of symptoms in traumatic TOCS.

Cervical rib:

As the most known cause of thoracic outlet compression syndrome, the cervical rib incidence in general population is 0.5%. It is observed bilaterally in 50-80% of the cases. Female-male ratio is 2:1. In 10-20% of the cases, symptoms and signs may develop. The cervical rib is seen mostly on the left side of the body (2) (Figure 2).

The cervical rib is mostly originated from the seventh and rarely sixth or fifth cervical vertebra (Figure 3). It can be identified as rudimentary or complete. Lying anteriorly, it connects usually with the first rib and rarely with the sternum. In some patients, the chondral structure beginning from the tip of the rudimentary rib inserts near to the scalene process transforming to a fibrous band. Therefore, brachial plexus and subclavian vessels have to pass from a high obstacle on their way and they are hung up. This situation increases the pressure on these structures (Figure 4). Especially, by lifting something heavy, the symptoms may appear. Mostly, the distal fascicles are affected. The symptoms arise by aging. In most cases, the reason of neurovascular compression is the pressure from the tip of the cervical rib and fibrous band which are usually connected to the first rib. This can cause a subclavian artery stenosis and poststenotic aneurysmal dilatation. In the advanced cases, thrombosis with distal emboli can be seen and the patient can loose one or more digits.

Fibrous bands:

In thoracic outlet region, 12 different types of fibrous bands have been described, 9 by Roos and 3 by Poitevin.

Type 1: A fibrous ligament attaching an incomplete cervical rib to the middle third of the first rib, passing under the T1 nerve.

Type 2: It is like type 1, but lies more vertically. The cervical rib is shorter.

Type 3: A small extra muscle attaching to the first rib between the T1 nerve and subclavian artery.

Type 4: A large middle scalene muscle attaching farther on the first rib than normal. T1 nerve is displaced from its usual passage. The anterior edge of this muscle abuts against the T1 nerve. This is the most common fibrous band anomaly.

Type 5: The scalenus minimus muscle is located between T1 and C8 nerves and the subclavian artery like a ribbon.

Type 6: The same muscle attaches to the Sibson's fascia, the reflection of endothoracic fascia covering the cupola of the lung.

Type 7: A long fibromuscular band arising from the lower part of the middle scalene muscle and passing anteriorly under the T1 nerve, subclavian artery and vein.

Type 8: A fibromuscular band arising from the anterior scalene muscle, passing directly under the subclavian vein to attach to the costocartilage. Subclavian vein thrombosis is common.

Type 9: A thin, sharp-edged band filling the posterior inner curve of the first rib and lies against the T1 nerve.

Type 10: Vertebra–Septocostal ligament.

Type 11: Transverse–Septocostal ligament.

Type 12: Costo–Septocostal ligament.

Pathologies of the first rib:

1. Stretching of the brachial plexus against the first rib in the people having droopy shoulders.

2. Bifid first rib,

3. Fused first and second ribs.

4. Excessive callus formation after a fracture of the first rib.

5. Exostosis of the first rib.

Tumors:

Tumors are very rare in the thoracic outlet region. In the literature, only 2 cases of Schwannoma were reported (2).

COSTOCLAVICULAR SPACE:

This triangular space is surrounded anteriorly by the inner half of the clavicle and the costoclavicular ligament, posteromedially by the first rib and insertion of both the anterior and middle scalene muscles, and posterolaterally by the superior border of the scapula. The pathologies responsible of neurovascular compression here are:

1. Congenital or acquired structural changes of clavicle and the first rib.

2. Structural changes of subclavius muscle and costoclavicular ligament.

3. Changes in the shoulder's position (saggy shoulder): The symptoms associated with the descent of the shoulder girdle begins in the early adult life. The sagging of the shoulders add sufficient traction on the brachial cords to precipitate symptoms (2).

4. Trauma (fractures of the first rib and clavicle, formation of haematoma and excessive callus): In some cases of malunion or non-union of the clavicle may give rise to pressure on the brachial plexus or the axillary vessels in the neck. The clavicle may also impinge where drooping of the shoulders and pressing upon the plexus is produced by carrying heavy packs (12).

5. Hyperabduction of the shoulder (by moving of the coracoid and scapula downward and creating traction on the costoclavicular ligament and pressure on the neurovascular bundle).

SUBPECTORALIS MINOR SPACE:

During hyperabduction, the neurovascular structures may undergo compression beneath the taut pectoralis minor muscle below its insertion. This is called "hyperabduction syndrome" and first described by Wright in 1945. It is seen usually in short, muscular young men who work with their arms and hands above their shoulders and head. With hyperabduction, the clavicle moves upward and backward narrowing the costoclavicular space and increasing the hand and arm symptoms (2). The other reason of this syndrome is the habit of sleeping with the arms over the head (12).

REASONS OF TOCS:

The reasons of TOCS can be classified in 2 groups:

1. Osseous reasons
   a) Cervical rib
   b) Anomalies of the first rib
   c) Fractures and excessive callus formation of the first rib and clavicle
   d) Prolonged transverse process of C7 vertebra
2. Soft tissue reasons
   a) Congenital bands and ligaments
   b) Congenital or acquired scalene muscle changes
   c) Subclavian muscle and costoclavicular ligament
   d) Pectoralis minor muscle

Altough cervical rib is the most reported cause of TOCS, today trauma of the neck region is appearing as a rising cause in the population. In regard to trauma, Sanders and co. (21) have made another classification system for TOCS:

I. OSSEOUS TOCS

A. Traumatic
1. Fractures of the clavicle
2. Fractures of the first rib

B. Non-traumatic
1. Cervical rib
2. Anomalies of the first rib

II. NON–OSSEOUS TOCS

A. Traumatic
1. Scalenus anticus syndrome
2. Scalenus medius syndrome

B. Non-traumatic
1. Congenital bands and ligaments
2. Anomalies of scalene muscles insertions
3. Scalenus minimus muscle
4. Non-thrombotic subclavian vein occlusion
5. Pectoralis minor (Hyperabduction) syndrome
6. Inflammation
7. Tumors
8. Muscular dystrophies
9. Possible osseous compression syndromes with normal roentgenogram
   a. Costoclavicular syndrome
   b. Normal first rib syndrome
   c. Saggy shoulders
   d. Rucksack paralysis

III. SHORTENED PRACTICAL CLASSIFICATION

1. Osseous TOCS
2. Traumatic non-osseous TOCS
3. Non-traumatic non-osseous TOCS

HISTOPATHOLOGY:

An important component of TOCS is the brachial plexus compression. Most of TOCS patients have associated carpal and cubital tunnel syndromes. Therefore, to understand the pathogenesis of TOCS, it is indispensible to know that of chronic nerve compression.

The first change in chronic nerve compression is the break-down of the blood–nerve barrier, followed by subperineural and endoneural edema. With compression, fibrosis in the external and internal epineurium occurs. Then, segmental demyelination and then diffuse segmental demyelination and finally Wallerian degeneration occur. Typically with chronic nerve compression, some fascicles in the nerve are more affected than the others. This situation determines the symptoms of the patient (9).

On the sensory side, the patient initially complains of intermittent paresthesias, then persistent paresthesias and finally numbness. On the motor side, he or she complains of aching in the muscle distribution initially, and later gradually increasing muscle wekness and atrophy.

DOUBLE CRUSH SYNDROME:

This theory was first introduced by Upton and McComas in 1973. According to them, a proximal level of nerve compression can cause more distal sites to be more susceptible to compression. Thus, in the patients having the symptoms of TOCS, carpal or cubital tunnel syndromes can be observed. They concluded that multiple levels of minor compression can result in alteration in subsequent pathology and increase in the symptoms (9). Wood and Ellison have stated that TOCS may present with only median nerve compression symptoms. And one should bear in mind that patients with median nerve symptoms not relieved by carpal tunnel release may be suffering from thoracic outlet compression (26).

REVERSE DOUBLE CRUSH SYNDROME:

Distal nerve compression causes morphologic changes in the nerve cells by blocking the retrograde axonal conduction. Therefore, the nerve cells cannot realize the anterograde axonal conduction and the proximal part of the nerve gets susceptible to compression. The improvement of the proximal compression after the carpal tunnel release explains this theory (2).

MUSCLE IMBALANCE:

This theory was introduced by White and Sharmann in 1994.

Normally, a muscle fiber produces its maximum tension at its normal resting length. However, muscles can change their resting length and these changes affect their functions. In the shortened position, the overlap between the actin and myosin filaments increases, and in the lengthened position it decreases. In both situations, the amount of tension and force of the muscle is reduced. Muscle injuries most often occur when they are lengthening and contracting. Activated muscles those are shortening when they contract don't induce particular injury but get weak. The comfortable posture causes muscles to adapt to resting lengths. This is different than the normal ideal resting length. Muscles adapt to this situation by increasing the numbers of their sarcomeres and decreasing the sarcomere lengths, but putting abnormal stress on the tendons, muscles and joints (9).

In some postures, the muscles can be abnormally shortened or lengthened; this is related with overuse of some muscle groups and minimally using of the others. The shortened muscles are painful when they are stretched and make compression on the brachial plexus. These muscles are scalene and pectoralis minor muscles.

In the position with the head in front of the body, there are thoracic flexion, increasing of the cervical lordosis, scapular abduction and internal rotation of the shoulder. In this position, scalene, sternocleidomastoid, suboccipital, upper trapezius, pectoral, serratus anterior and levator scapula muscles are stretched and middle and inner trapezius muscles are lengthened. This position destructs the muscle imbalance.

CUMULATIVE TRAUMA DISORDER:

This theory was introduced in the United States and Canada to the terminology of TOCS. Patients typically complain of pain in the subscapular, scapular and cervical regions with associated occipital headaches. Paresthesias and numbness can be observed with the elevation of the arms. Majority of the patients show multiple levels of minor nerve compression sites and muscle imbalance in the neck, shoulder and upper back (9).

EVALUATION OF TOCS PATIENTS:

The diagnosis of TOCS is based largely on subjective complaints of upper extremity paresthesias and pain. Many clinical, radiographical and electrodiagnostic tests have ben described. But none of them was regarded as the gold standard. So, clinical evaluation remains the most available component of the diagnosis (8, 15).

Typically the patients complain of pain in the subscapular, interscapular and cervical regions radiating to the upper extremity and paresthesias on the medial side of the hand and forearm. The most common involvement appears to be in the lower nerves of the plexus (C8-T1). These patients complain of pain in the supra- and infraclavicular fossa, the back of the neck, rhomboid areas, the axilla and the inner arm, with numbness radiating through the ulnar nerve distribution from the axilla to the ring and small fingers (2, 8, 19).

With involvement of the upper part of the plexus (C5-6-7), the patients complain of pain in the anterolateral aspect of the neck and in the region of the brachial plexus just behind the sternocleidomastoid muscle. Pain radiates to the mandible and ear, to the scapula and upper chest, laterally top of the shoulder and down to the outer aspect of the arm in the C5-6-7 nerve distribution (2, 19).

Usually, lower and combined plexus involvement are seen. In the combined cases, usually breathing and swallowing is hard and because of these symptoms, the patients can be consultated with psychiatrists (2).

In the long standing cases, orbital and occipital headaches are often described. Facial pain and numbness and anterior chest wall pain or complaints simulating angina pectoris called as "pseudoangina" are the rare symptoms (9, 15).

Weakness and fatigue of the upper arm and hand are common; but intrinsic muscle atrophy is rare.

Usually, there is no reason for the onset of the symptoms. But it is mostly related with the sleeping postures of the patients in which the arms are positioned above the head and elbows are flexed. Mostly, the progress of the disease is very slow (8).

In chronic cases, thickening and curling of the nails, hair loss on the fingers and swelling of the hands and fingers can be seen (2).

In general, TOCS has 2 different types (2):

1. Neurogenic (90%)
2. Vascular (10%)

Neurogenic type is classified in 2 groups:

A. True neurogenic
B. Dispute neurogenic

In the true neurogenic type, with the compression of C8-T1 roots, there is pain and paresthesia in their distribution areas, deep pain in the arm, anterior and posterior chest wall, weakness in the hand and muscle atrophy. In the dispute neurogenic type, there is no objective sign and this is the most observed type.

VENOUS TOCS:

Venous TOCS symptoms are seen more often than the arterial TOCS symptoms. These are swelling and cyanosis of the extremity, pain, heavy feeling and venous distension in the upper arm and shoulder region. Subclavian vein thrombosis is caused frequently by TOCS and called as "effort" thrombosis of the axillary-subclavian vein (**Paget–Schroetter syndrome**). It is usually secondary to excessive use of the arm in addition to the presence of one or more compressive elements in the thoracic outlet (24).

ARTERIAL TOCS:

It is very rare. The symptoms include extremity weakness, coldness and pain caused by ischemic neuritis of the plexus. In the severe cases, subclavian artery thrombosis with peripheral emboli can be seen (2). Gangrene and loss of some fingers can also be seen in some patients (18). In the study of Carty et al., among 32 patients operated because of TOCS, arteriography has demonstrated abnormal findings in 11 (4).

ASSOCIATED PATHOLOGIES WITH TOCS:

1. Distal nerve compression
2. Myofascitis
3. Rotator cuff tendinitis
4. Epicondylitis

PHYSICAL EVALUATION:

According to many authors, it is not difficult to diagnose venous or arterial TOCS because of the objective findings like swelling and discoloration of the arm. But it is still controversial to diagnose the neurogenic TOCS because of lack of its objective symptoms. In the physical evaluation of neurogenic TOCS, some positional provocative tests are described (1, 2, 8, 13, 14). They mostly evaluate the vascular integrity.

1. ADSON TEST (=SCALENE TEST):

"This test indicates whether or not the volume of the pulse has been altered, suggesting that the subclavian artery has or has not been compressed" says Adson in 1947 (1). While checking the patient's radial pulse when his or her arm is down, the patient elevates his or her chin and turns it to the affected side and inhales deeply. An alteration or obliteration of the radial pulse is a pathognomonic sign of TOCS. This test may be positive in healthy individuals (2, 8).

2. REVERSE ADSON TEST (=NECK TILTING TEST):

In this test the patient tilts his or her head away from the affected side. This position produces neck and arm pain, discomfort and heaviness, with numbness in the arm and fingers in the involved side (2).

3. HALSTED TEST (=COSTOCLAVICULAR COMPRESSION TEST):

In this test, the patient holds the shoulders backward and downward and this maneuver narrows the costoclavicular space. Obliteration of the radial pulse and reproduction of the symptoms are the positive results (2, 8). And also, with the oscultation of the infraclavicular space, a bruit can be observed. If the compression is complete, then the bruit dissapears.

4. WRIGHT TEST (=HYPERABDUCTION TEST):

The shoulder is hyperabducted to 180 degrees and the elbow is flexed. The radial pulse is absent and paresthesia and muscle fatique can be seen. This test is positive in 50% of the healthy individuals (2, 8). Mackinnon and co. have modified it to maintain the elbow in an extended position not to produce associated cubital tunnel syndrome symptoms (8).

5. ROOS TEST (=INTERMITTENT CLAUDICATION TEST):

In this test, the shoulder is abducted to 90 degrees, externally rotated and the elbow is flexed for three minutes associated with rapid closing and openning of the hand. Reproduction of the symptoms is positive for TOCS (8).

The duration of the first 4 tests must be 1 minute.

Spurling test: In all cases of suspected TOCS, this test must be performed to determine the status of the nerve roots at the spinal canal. In this test, the examiner compresses the patient's head and turns and flexes the neck toward the symptomatic side. Any radiating pain and paresthesia to a particular part of the extremity increases the possibility of nerve root compression (2).

RADIOLOGICAL EXAMINATION:

In the cases suspected of TOCS, cervical spine and chest radiograms are useful to detect the bony abnormalities like cervical rib, large transverse process of C7 vertebra, degenerative changes and clavicular abnormalities (2, 8, 15). An apical lordotic chest roentgenogram can rule out the presence of a Pancoast tumor (2).

Computed Tomography: CT was used and recommended for the cases suspected of TOCS and observed normal with the radiograms. In the study of Mackinnon and co. (8), among 50 patients with TOCS, they have found that only 32% with compressive abnormalities were determined by CT scan. According to the authors, radiographic evaluation remains the most useful to identify other pathologies that may produce the symptoms rather than establishing the diagnosis. Therefore, CT may demonstrate abnormal fibrous bands in the thoracic outlet (18). In the study of Bilbey and co. (3), they have reviewed 27 patients with TOCS and 21 normal subjects. They have observed that 15 patients with TOCS had osseous abnormalities identifiable on plain radiograms and CT didn't provide further information in these patients. 8 of 12 patients with normal plain radiograms had abnormal findings on CT scans. They concluded that CT may be useful in patients with symptoms suggestive of TOCS and no osseous abnormalities on plain radiograms.

ELECTRODIAGNOSTIC TESTS:

In the evaluation of TOCS, some electrodiagnostic tests were described. These are nerve conduction velocity studies, F-waves and somatosensory evoked potentials. Nerve conduction velocity studies are most useful in the differential diagnosis of distal nerve entrapment syndromes (8).

In the patients diagnosed clinically as having TOCS, positive electrodiagnostic test only confirms the diagnosis; negative test does not exclude the presence of TOCS (2).

SCALENE INJECTION:

This test has been used as a diagnostic tool since 1938. In this test, 5-7 ml. of 0.5% bupivacaine and 1 ml. of betamethasone are injected inside the anterior scalene muscle. If the injection is successfull, the symptoms are relieved for a period ranging from a few hours to several weeks. Rarely, full recovery is observed. The absence of pain relief does not exclude the presence of TOCS (2, 22).

ANALGESIC CERVICAL DISK PUNCTURE:

The purpose of this test is to differentiate the symptoms of TOCS from diskogenic causes. Kofoed and co. (7) have performed it in 9 cases at the levels of C5-6, C6-7, C7-T1 under image intensifier with 0.5-1 ml. of 2% Tetracaine. The positive result is to be free of symptoms for more than two hours and this is the evidence of a diskogenic cause for the patient's complaints. Among these cases those were operated by the resection of the first rib because of suspected TOCS, in the ones who had positive test, the symptoms remained unchanged after the operation while in those who had a negative test, late postoperative results were excellent in 100%. According to Kofoed and co., this test may be a valuable diagnostic test in cases of suspected TOCS.

PERIPHERAL ANGIOGRAPHY:

In the cases with the presence of a supraclavicular or infraclavicular bruit, absent radial pulse or pulsating paraclavicular mass, peripheral angiography may be useful. Antegrade or retrograde arteriograms can be used in localizing the pathology in the subclavian and brachial arteries. In the cases of suspected venous obstruction, phlebograms may be used to evaluate the degree of thrombosis (8, 15).

TREATMENT:

As a concept in TOCS, the initial treatment method is conservative therapy. The surgical treatment must be the last alternative. The advocaters of conservative therapy say that many patients have suffered serious and irreversible complications like brachial plexopathy and injury to the subclavian artery after surgery (5).

In the patients suspected of TOCS, a concept of management must be utilized with the aid of a neurologist, orthopedist, thoracic surgeon and occasionally a cardiologist (23). After the diagnosis of TOCS with the aid of the diagnostic tools, initial treatment must begin with patient education regarding the postures and positions that may exacerbate symptoms (16) (Figure 5). The conservative treatment methods can be classified like this (2):

1. Excersises
   A. Postural education
   B. Muscle relaxing
   C. Muscle strengthening
2. Myorelaxer and anti-inflammatory drugs
3. Moist heat (in chronic cases)
4. Ultrasonography with phonophoresis or iontophoresis
5. Moist ice and cold spray (in acute cases)
6. Transcutaneous electrical nerve stimulation (TENS)
7. Scalene injection
8. Oscillating massagers
9. Low dose narcotic agents

For the individuals having sleep disturbances caused by irritating postures, they should be instructed to rest and protect the cervical spine at night. Novak and co. have found soft cervical rolls to be successfull in decreasing the night symptoms (15).

Good posture requires a balance between the muscular and skeletal systems. Forward flexion posture in TOCS cause pain in the region. Some orthosis have been used by some authors and they are strapped anteriorly over the pectoral region. The disadvantage of these orthosis is the intoleration of them by most patients. The straps of the orthosis may increase the pressure on the brachial plexus and may place the patient in an extremely upright position. Nakatsuchi and co. (11) have developed a strapping device to correct the shoulder position and used it in 86 TOCS patients with a mean age of 27 for a period of 119 days in average. They have stated that the device was more effective in patients with distal symptoms and it could conterbalance downward traction on the brachial plexus and reduce the tension on it.

The wrong posture causes some muscles to act in a shortened position and others in an elongated position. In TOCS, the pectoral muscles, scalene muscles, sternocleidomastoid, upper trapezius, levator scapulae, suboccipitalis should be evaluated for tightness, weakness, spasm and trigger points. The aim of treatment should be regaining the normal muscle length, motion and strength. Stretching excersises should be directed toward the upper trapezius, levator scapula, scalenes, sternocleidomastoid, suboccipitalis and pectorals (8, 15). These excersises should be continued for a minimum of 2 to 6 weeks (23). Kenny and co. (6) have used a simple treatment program for 8 patients with a mean age of 45 with TOCS. This program have included graduated resisted shoulder elevation excersises for 3 weeks and all of the patients were symptom free after this program.

Oscillating massagers are applied manually to the difficult-to-reach myofascial trigger points on the neck (2).

Moist heat and TENS may be useful in decreasing pain and spasm but should be used with effective stretching program (16).

The other recommendations in the conservative therapy of TOCS are to provide weight loss, job modification, home behaviour modification and lowering of the keyboard in computer workers (2, 15, 16).

SURGICAL TREATMENT:

Although satisfactory results have been obtained with conservative treatment methods in most TOCS patients, sometimes surgical treatment may be acquired. The indications of surgical treatment can summarized so (25):

1. Poor results with minimally 6 months of conservative treatment program, repetitive symptoms and inability of the patient to do his or her daily works.

2. Presence of ischemic symptoms

3. Presence of obstuctive lesion in angiography

4. Poststenotic arterial dilatation

5. Emboli in the distal arteries

6. Complete thrombotic occlusion in great vessels

7. Presence of a spesific compressive structure like mal-union of the clavicle

8. Severe neurologic and abnormal electrodiagnostic findings

9. Atypic chest pain not improved with conservative treatment

10. Hypersympathetic activity

According to Urschel, the initial operation for TOCS must include complete removal of the first rib and this alone is satisfactory for upper as well as lower plexus involvement (25).

In surgical management of TOCS, the mostly utilized procedures are (10):

1. Resection of the cervical rib and/or the first rib with transaxillary approach.

2. Anterior and midscalenectomy and/or the resection of the cervical and the first rib.

Sanders has stated that although the presence of a cervical rib is helpful in making diagnosis of TOCS, the results of surgical treatment of patients with cervical ribs are no better than those of without cervical ribs (22).

The surgeon must choose the one with which he feels more comfortable. Major complication have been reported with both procedures. Cherington have stated that many of the surgeons have seen patients who continue to complain of symptoms even after surgery (5). According to Novak and Mackinnon, decompression of the brachial plexus is best achieved by the supraclavicular approach, permitting release of the scalene muscles and excision of the first rib (15). Mackinnon and Patterson recommended first rib resection and anterior and middle scalenectomies prefering supraclavicular approach (10).

Atasoy have stated that first rib resection was recommended mainly for the lower type of TOCS and scalenectomy was the preferred method for the upper type of TOCS. Obese and muscular patients are also the candidates for supraclavicular approach, because transaxillary approach is very difficult for these patients (2). Qvarfordt and co. have combined supraclavicular radical scalenectomy with neurolysis of the brachial plexus and transaxillary resection of the first rib (17). They have reached excellent and good results in 99% of their operations. They have reported 94.7% excellent result with combined operation, 80% with supraclavicular approach and 72.2% with transaxillary approach. Wood and Ellison have concluded that first rib resection achieved equally good results both in patients with only upper plexus symptoms and with only lower plexus symptoms (26). According to Sellke and Kelly, transaxillary removal of the first rib, and cervical rib, if present, must be the operation of choice (23).

SUPRACLAVICULAR APPROACH:

Supraclavicular approach has some advantages and disadvantages. It mostly allows the surgeon to visualize the neurovascular elements and remove the first and/or cervical ribs. According to Mackinnon and Patterson, under direct vision, the most posterior aspects of the first rib can be easily visualized (10). According to Qvarfordt and co., with this approach, the entire thoracic outlet can be viewed from above (17). They also accompany the technique of openning the pleura to allow drainage into the pleural cavity rather than around the brachial plexus and its benefit is decreasing of the postoperative scarring around the neural elements.

To minimize scar formation around the brachial plexus, postoperative early movement of the head and the neck should be encouraged.

The complications after the procedure are mostly damage to the major neurovascular structures. Smaller nerves like phrenic and long thoracic nerves are rarely damaged. The other complications are neck haematoma, chylus drainage, dyspnea (caused by phrenic nerve irritation), mild Horner syndrome. Dyspnea and Horner syndrome usually improve spontaneously (2, 10).

TRANSAXILLARY APPROACH:

This approach is recommended by many surgeons. Urschel has preferred this approach and stated that its advantage over the supraclavicular approach was that the rib could be removed, the muscles divided and resected if necessary, and all constricting structures decompressed with minimal risk to the critical neurovascular structures (25). In the supraclavicular approach, the neurovascular structures must be retracted and therefore the complication rate is higher. According to Carty et al., the supraclavicular approach takes about twice as long to perform and phrenic nerve paralysis takes about 7% of the cases (4).

The complications of the transaxillary approach are recurrence due to hyperscarring or keloid formation and failure to remove the rib completely, damage to the neurovascular structures, transient paresthesia due to the traction on the 2. and 3. intercostal brachial nerve (25). In the series of Sellke and Kelly (23), the complications included one death due to hemorrhage because of necrotizing wound infection, 11 pneumothorax, 2 long thoracic nerve injury, one temporary brachial plexus paralysis among 473 cases.

According to Atasoy, in a muscular person suspected of hyperabduction syndrome, pectoralis minor division should be carried out in addition to first rib resection (2).

DORSAL SYMPATHECTOMY:

Sympathectomy may be added to the procedure for the treatment of hyperhydrosis, reflex sympathetic dystrophy, Reynaud's phenomenon. It can be performed from both approaches and also posterior approach. Urschel has recommended posterior approach for the reoperation for recurrence of TOCS (25).

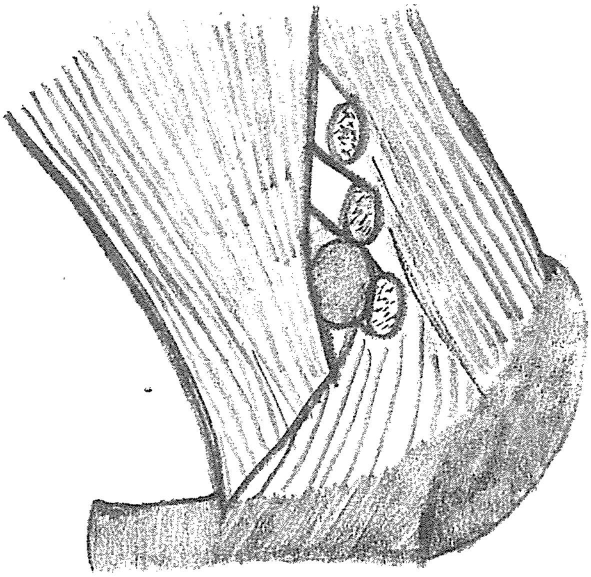

Fig. 1. The overlapping of the insertions of anterior and middle scalene muscles creating a V shaped narrow space for brachial plexus and subclavian vessels.

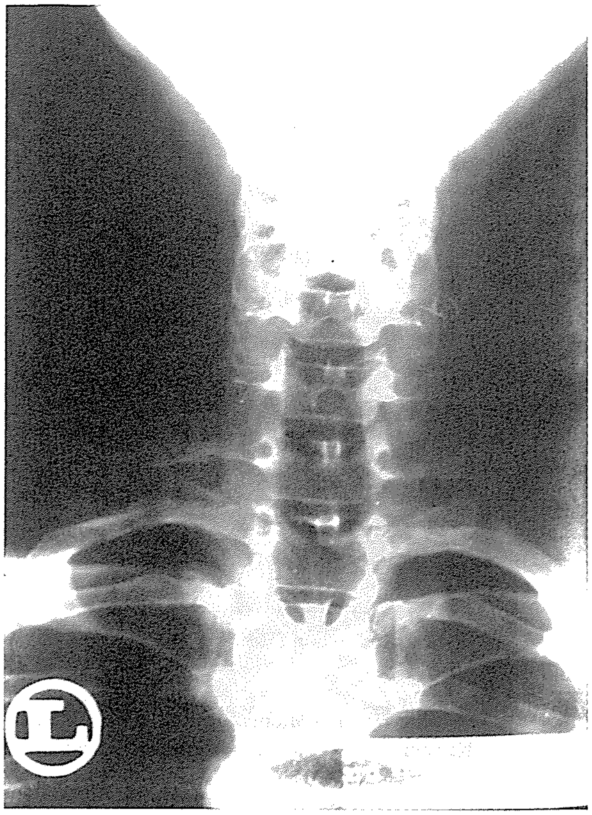

Fig. 2. The roentgenogram of a patient with cervical rib on the left side and prominent transverse process of the seventh cervical vertebra on the right side.

Fig. 3. A cervical rib with the articulation of the first rib resected from a patient by the authors.

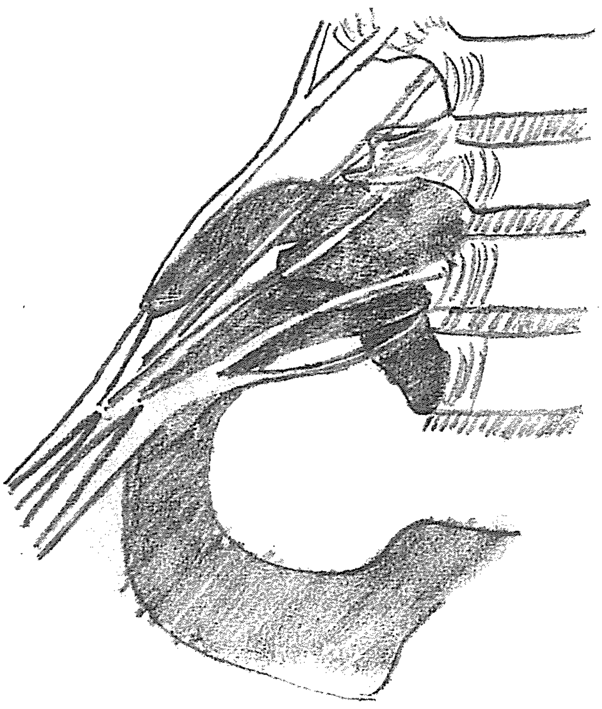

Fig. 4. A cervical rib diagram making a high obstacle on the way of the neurovascular structures in the thoracic outlet region.

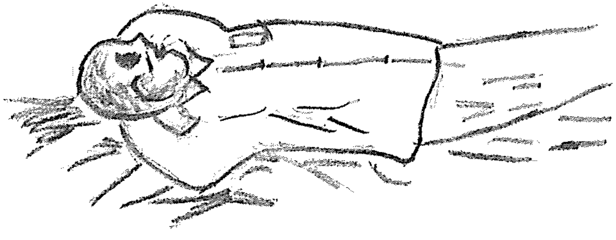

Fig. 5a) The wrong sleeping posture of the patient with TOCS.

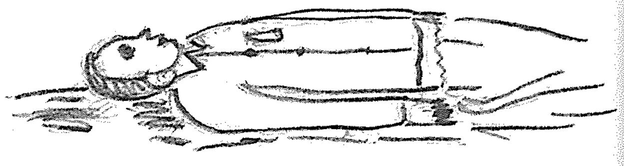

Fig. 5b) The corrected posture habit of sleeping after the education of the same patient.

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