Risk factors and prevention strategies for thoracic outlet syndrome (TOS) are very difficult to access for a number of reasons. Since its introduction as a diagnostic term in 1956 (1) the diagnosis itself has remained controversial with some doubting the clinical entity even exists (2). Thoracic outlet syndrome has become an umbrella diagnosis that includes scalenus anticus syndrome, cervical rib syndrome, costo-clavicular syndrome and hyperabduction syndrome, to name just a few (3). Additionally the diagnosis is primarily a clinical diagnosis since examination, electrodiagnostic and imaging findings have low specificity and sensitivity (4). Finally few clinical trials have examined efficacy of TOS interventions, much less prevention strategies. As a result risk factors and prevention strategies identified are based on weak evidence and are largely expert opinion.

The reported incidence of TOS covers a broad range, from 0.3% to 8%, and is reflective of the uncertainty of the diagnosis (5).

RISK FACTORS AND PREVENTION STRATEGIES

1. Biomechanical factors (C):
   a. Posture: Head forward posture is often implicated as a risk factor for TOS. Muscle imbalance and thickening of muscle groups may compromise the thoracic outlet. Decreased length of the scalene, pectoralis minor, sternocleidomastoid and serratus anterior concomitant with weakening and lengthening of the mid and lower trapezius may impede passage through the thoracic outlet and result in TOS (6). Pascarelli et al consider posture to be key in the development of TOS (7).
   b. Structural abnormalities (C): Anomalous fibro-muscular bands which could result in TOS were reported in 1/3 of cadavers examined in a study by Roos (8). Sheth et al consider fibrous bands the most common structural abnormality leading to TOS. Interestingly cervical ribs, which seemingly receive the most attention, are present, at most in 1.5% of the population and only 5 to 10% of those with cervical ribs will develop TOS (9). A case series of 98 cervical cadaver dissections found only 37% had completely normal anatomy and led the authors to speculate that this predisposes many individuals to TOS when injury occurs (10).
   c. Heavy breasts: Bra straps of heavy breasted women exert a downward pressure on the clavicle causing possible impingement between the clavicle and first rib. Using broad bra straps should provide a more even distribution of pressure and lessen the risk of
TOS (11). Other activities which depress the clavicle such as carrying heavy luggage also have been mentioned as risk factors (9).

2. **Occupational/recreational risk (C):** Several occupational activities have been reported as increasing risk for TOS. Hagberg et al stated repetitive short cycle arm movements increase the risk for TOS by a factor of 4 based on the pooled results of 4 studies. The occupations they specifically identified were assembly line workers, slaughterhouse workers and cash register operators (12). A separate study reported working with the hands at or above shoulder height also increased risk for TOS (3). Thoracic outlet syndrome has been reported athletes in several studies. One case series of 12 professional athletes found moderate to severe hypertrophy of the anterior scalene muscle which resulted in TOS. All of these subjects exhibited head forward posture and most had been emphasizing pectoralis major and deltoid strengthening exercises (13). Other athletes at increased risk for TOS include tennis players (14), swimmers (15) and throwing athletes (16). At least 2 studies have identified musicians as having a high incidence of TOS. The most effected groups are violin and viola players followed by keyboard and woodwind players (17;18).

3. **Neck trauma (C):** A review of TOS the stated 86% of patients have a history of neck trauma based on 660 histories. Overall 32% are the result of rear end automobile accidents and 24% the result of other automobile accidents (19). Nichols in his article on diagnosis and management report the most common form of TOS is primarily neurological and often follows a hyperextension injury to the neck. Delayed onset of symptoms are common with this type etiology (20).

A primary theme is in literature relating to the risk factor for TOS is the need to reduce compression on the thoracic outlet. Prevention strategies should address this factor. For example, anecdotal evidence suggests avoidance of sleeping with the arm in an abducted position can reduce the risk of developing TOS. This and other similar strategies may reduce the overall incidence of TOS.

Reference List


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Thoracic outlet syndrome is the center of a raging controversy in the healthcare field. Vanti et al stated “Thoracic outlet syndrome (TOS) has been one of the most debated clinical topics over the last 120 years” (1). Some experts feel it is over-diagnosed (2) while others think it is under-diagnosed (3). The fact that 120 TOS surgeries were performed at the Mayo Clinic over a 34 year period while in less than half of that time a single Colorado thoracic surgeon performed 1400 TOS surgeries is indicative of the controversy relating to TOS (4). Cherington in an editorial states the disputed form of TOS “in which no objective clinical, radiologic or electrodiagnostic abnormalities are documented, is the most commonly diagnosed and surgically treated form of TOS” (5). This form of TOS represents 85% (1) to 95% (6) of all TOS cases. Based on a large majority of opinions TOS is almost always a clinical diagnosis without confirming objective evidence.

Thoracic outlet syndrome (TOS) results from compression of the neurovascular structures as they pass through the thoracic outlet, primarily the interscalene triangle, the costoclavicular space and the subpectoral tunnel. Some authors also include the area anterior to the humeral head, passageway for the median nerve roots and the axilla (1). Thoracic outlet syndrome is usually categorized as follows (7):

1. **Neurogenic TOS**: Represents up to 95% of all TOS cases and has two subcategories.
   a. **True Neurogenic TOS**: Patients present with subjective symptoms which can be confirmed by objective testing. According to Burke this form is “as rare as rocking-horse manure” (8)
   b. **Disputed Neurogenic TOS**: Patients present with subjective complaints which cannot be objectively confirmed, The subjective symptoms often include upper extremity heaviness, fatigability, neck, face and shoulder pain and extremity paresthesias. These cases represent up to 99% of neurogenic TOS.

2. **Venous TOS**: These cases are characterized by swelling of the upper extremity, heaviness, pain with activity and paresthesias. They represent 2 to 3% of TOS cases.

3. **Arterial TOS**: This is the least common form and represents less than 1% of TOS patients. Pain, paresthesias, cyanosis, fatigability, coldness and color changes are common presentations. Arterial TOS is often asymptomatic until an embolism occurs.

The difficulty in diagnosis of TOS by provocative tests is demonstrated in the high number of positive results in asymptomatic populations. Rayan et al found 91% of normal volunteers had a positive response to at least one of three provocative tests (hyperabduction, Adson’s and costoclavicular tests) (9). A 1980 photoplethysmographic study found 60% of a normal population, when tested with provocative maneuvers, had arterial obstruction (10).
The reader should be aware that generally less than 5% of patients with TOS can be identified with provocative testing. The overwhelming majority must be diagnosed based on history and complaints after ruling out other causes. Thoracic outlet syndrome is primarily an exclusion diagnosis. It should be noted that carpal tunnel syndrome (CTS) often manifests similar symptoms as TOS. Nord et al found that many of the TOS tests also test positive in patients with CTS. This results in a high false positive rate for TOS in many patients with CTS (11). This is troublesome since the first step in the diagnostic process is often to rule out CTS (12;13).

The typical TOS patient is female, between 20 and 50 years old, has a history of neck trauma and complains of arm pain and paresthesias (14).

**CLINICAL TESTING**

1. **Clinical tests (C):** Many of the provocative TOS tests are meant to assist in the diagnosis of vascular TOS although the vast majority of TOS cases are neurological in nature. Some authors argue if pressure is sufficient to compress the subclavian artery, the brachial plexus would also be compressed (15). Unfortunately many of the studies investigating the diagnostic value of specific tests do not specify which form of TOS is being investigated. As a result some of the results may be misleading. An additional shortcoming of studies assessing the diagnostic value of tests for TOS is that the tests themselves are often used to arrive at the final diagnosis in the study. This limitation was well stated in the study by Gillard et al (16).
   a. **Adson’s test:** Adson’s test has high specificity (91%) in normal subjects when evaluating for vascular TOS. Unfortunately when testing a population of patients with CTS for TOS the number of false positives rises significantly and specificity drops to 58% (11). Consequently when you have a patient with arm pain and paresthesias the test has limited value in distinguishing the two conditions. Gillard et al reported specificity at 76% for Adson’s test which improved to 94% when used in combination with Wright’s test for pulse obliteration (16). Sanders et al stated Adson’s test is not reliable for diagnosis of neurogenic TOS using pulse obliteration as a standard (17). However it may be of value when pain and paresthesias are reproduced to support the diagnosis TOS (6).
   b. **Hyperabduction test (AKA Wright’s test, Wright’s hyperabduction test):** Rayan et al reported 78% of a normal population had positive pulse obliteration when performing the hyperabduction test and 28% had neurological responses. The authors suggested modification of the test to extend the elbow to preclude compression of the ulnar nerve at the elbow (9). Muizelaar et al and Gillard et al reported sensitivity of 52% to 90% and specificity of 29% to 90% in their studies (16;18).
   c. **Roos Test (AKA Elevated Arm Stress Test):** Two separate studies have found unacceptably high false positive rates in normal populations ranging from 47% to 74% (11;19). Gillard et al reported sensitivity of 84% and specificity of 30% for this test (16). Nord et al questions the role of the Roos test in diagnosing TOS (11).
   d. **Costoclavicular maneuver (CCM) (AKA: military position):** Warrens et al found the CCM to have the highest degree of false positives in a normal
population of all the tests they investigated (20). Rayand et al and Gillard et al confirmed these findings in their studies (9;16). Forty eight per cent of patients with CTS tested positive to the CCM in a study of 62 arms (11). Marx concluded there is “insufficient evidence for use in clinical practice (21).

e. **Supraclavicular pressure (AKA Morley’s test):** As with many of the provocative tests this test is positive in 45% of patients with CTS (15). In healthy volunteers 15% were positive for paresthesias (22). Sensitivity range for this test range is from 57% to 79% (12;18).

f. **Other tests:** Many other tests have been identified in the literature or are used in practice which have scant or no evidence relating to usefulness in the diagnosis of TOS. These include but are not limited to Eden’s test, Allen’s test, Bikle’s sign, Spurling’s sign, Tinel’s test and the Upper Limb Tension Test (of Elvey).

2. **Signs and symptoms(C):** The most common symptoms of TOS include:
   a. Paresthesias: Different studies have reported paresthesias occur in 75% (18) to 99% (23) of TOS patients. Sanders states in 46% of cases with paresthesias all fingers are included (6).
   b. Arm pain: Arm pain occurs in 80% (5) to 94% (23) of patients.
   c. Neck pain: Neck pain is a common finding in 62% (18) to 96% (23) of patients.
   d. Shoulder pain: Shoulder pain is reported to be present in 70% of patients (6).
   e. Disturbed sleep: Disturbed sleep is less common but still affects up to 28% of patients (18).
   f. Headache: Although the evidence is very limited Raskin et al reported in a case series of 30 individuals that 26 reported chronic recurring headache (24).
   g. Blood pressure difference: Some authors consider a blood pressure difference between arms of 20 mm Hg to be an indicator of vascular TOS (14;25).

Figure 1: Common distribution of pain and paresthesias in TOS
3. Imaging: The reader is reminded that the large majority of TOS is of the disputed neurological type. No form of imaging is of diagnostic value in disputed TOS except to rule out other pathology. However imaging may be of value in evaluation of the vascular and true neurogenic types of TOS. This section addresses imaging in relation to these forms of TOS.
   a. X-ray (C): X-ray assessment has limited value in the diagnosis of either true neurological or vascular TOS except to determine the presence of a cervical rib or to rule out other pathology. Cervical ribs are present in approximately 1.5% of the population based on a study of 30000 radiographs (26). Symptoms of TOS only develop in approximately 10% of individuals with cervical ribs which reduces the diagnostic value even more (27).
   b. CT angiography (C): Demondion et al reported in their 2006 review that “arterial compression is well assessed with CT angiography” but the diagnostic value is reduced due to the high incidence of compression of structures in the asymptomatic patient (28).
   c. Magnetic resonance imaging (C): In another study by Demondion et al the value of MRI was demonstrated for arterial and neurological TOS. They concluded MRI “appeared helpful” in the diagnosis of these conditions. An evidence based review of magnetic resonance angiography (MRA) found “at present there can be no firm evidence-based grounds to support the use of MRA is a valid diagnostic tool for TOS (29). Most studies of MRI in the diagnosis of TOS state use of the elevated arm position is essential for maximum diagnostic value (30;31).
   d. Ultrasonography (C): All forms of ultrasonography experience the same limitations in the diagnosis of TOS as do other imaging techniques. Namely the common response of asymptomatic subjects with no past history of TOS symptoms to provocative maneuvers of the shoulder (32;33). Gillard et al does note ultrasonography can be helpful when used in conjunction with examination findings and provocative testing for vascular TOS (16).

4. Electrodiagnostic studies (C): With the exception of establishing the diagnosis of true neurological TOS, electrodiagnostic testing is of limited value in diagnosing the much more common forms of TOS (34). (34). Most experts consider the value of electrodiagnostic studies are limited to their use as a tool in the differential diagnosis for TOS (35-37).

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As discussed in the thoracic outlet syndrome (TOS) prevention and diagnosis monographs, TOS is a very controversial topic in the medical literature. Disagreements over methods to arrive at a diagnosis, whether it is under-diagnosed or over-diagnosed or even exists at all have resulted in a gross lack of evidence related to treatment. A recent Cochrane Review (1) could only locate 1 randomized clinical trial (RCT) on treatment. That study was small, highly suspect of bias and compared 2 surgical protocols (2). For the practitioner who desires to practice in a non-evidence based environment, TOS is the perfect diagnosis. Outside of a handful of case series and case reports, virtually all the evidence on treatment is based on expert opinion or is anecdotal.

Most studies combine a variety of approaches in treatment. Most include strengthening, stretching, postural training, manipulation/mobilization and breathing exercises. The reader should note although the different treatment protocols have been broken down into separate groups, almost all protocols include a mixture of interventions. Success rates vary with the study but generally 62% to 88% of patients experience improvements or are satisfied with treatment (3;4). Several authors have stated early intervention is important to success in the treatment of TOS as delayed treatment may lead to intraneural scarring and chronicity (5;6).

Most studies recommend 10 to 12 treatment sessions over a month’s time with most protocols recommending long term home exercise programs (7). Improvement should become apparent within the first 6 to 8 treatments or it is unlikely improvement will occur according to Ingesson et al. (8).

A very interesting study was published in 2001 in the Journal of Vascular Surgery by Landry et al. They found there were no statistical differences in outcomes between 79 disputed TOS patients who were treated with either conservative care or surgical care at an average follow-up of 4.2 years. The authors of this study concluded that “it is essential that proponents of surgical treatment of disputed TOS prove that surgical therapy is superior to conservative management” and until then “we will continue to favor conservative therapy” (9).

Up to 95% of TOS cases fall into the neurological TOS category (true and disputed) (10). Although it is uncommon, venous TOS can result in a potentially life threatening upper extremity venous thrombosis. The physician must have the knowledge and skill to recognize the different forms of TOS in order to minimize risk to his/her patient. Most cases of TOS can be initially treated with conservative means. Patients that do not respond or worsen may, due to the severity of symptoms, have no other option other than surgical intervention.

CONSERVATIVE TREATMENT OPTIONS
1. **Exercise (C):** Exercise is a common component of most treatment protocols for TOS. Strengthening of the upper trapezius (3;11), serratus anterior (4;11), levator scapula (3;12) and general shoulder girdle elevators (4;12;13) are often recommended. Home exercises appear as effective as guided exercises (14). If exercises aggravate the condition they should be stopped (12).

2. **Stretching (C):** Most experts agree stretching combined with strengthening exercises is necessary to correct postural imbalances. Specific muscle groups that often require stretching include the scalenes, upper trapezius, levator scapula, pectorals, and sternocleidomastoid (3;4;11;15). Chin retraction exercises are also recommended (11). Post isometric relaxation, gentle stretching and spray and stretch have been suggested as effective methods for lengthening functionally shortened muscles while massage and trigger point therapy may reduce hypertonicity (12).

3. **Spinal manipulation (C):** Although spinal manipulation is commonly used to treat TOS only a few case reports supporting the intervention have been published in the chiropractic and osteopathic literature (16-20). Some authors speculate the mechanism by which manipulative therapies positively impact TOS may be related to the “double crush syndrome” which hypothesizes proximal compression of a nerve may worsen distal compression syndromes (21;22).

3. **Postural training (C):** In conjunction with strengthening and stretching, posture training is considered by most experts an essential component of treatment. Patient education and postural awareness are recommended (7;23)

4. **Breathing exercises (C):** A part of most treatment protocols is to insure the patient is breathing properly. Paradoxical breathing is thought to contribute to TOS. Several authors include diaphragmatic breathing exercises in their treatment regimens (11;23;24).

6. **Orthosis (C):** A strapping devise that forced elevation of a slumping shoulder was tested in a case series of 86 TOS patients for an average duration of 4 months. Patients wore the brace during waking hours. At the completion of the study pain had disappeared or improved in 67% of patients. Treatment was more effective in patients with distal symptoms (25).

8. **Other (C):** Several other interventions have been mentioned as adjunctive therapies in the treatment of TOS with minimal support in the scientific literature. These include nerve gliding exercises (pain should be avoided) (26), heat (27), transcutaneous nerve stimulation (12) and 2400 mg of omega-3 fatty acids (28).
With the exception of arterial TOS with complications, a consensus of opinion as to the
need for surgical intervention is lacking in the literature (29). It is difficult to access the
literature relating to the effectiveness of surgical intervention for TOS since, with the
exception of 1 small randomized controlled trial, the studies are essentially case series and
most are written by the authors performing the surgery.

1. Surgery (C): A review by Sanders et al reported varying failure rates (1% to 55%) in
different 6 studies consisting of 4991 surgical procedures. The studies reporting
high success rates are dampened when reading a Washington state workers’
compensation study investigating the results of surgical intervention in for TOS.
The study reported 50% higher costs for surgical cases and 3 to 4 times greater
likelihood of being disabled when compared to conservatively treated patients (30).
Jamieson et al reported excellent or good results in 75% of patients with arterial
TOS, 100% in patients with venous TOS and 53% with neurological TOS (31).

2. Drug therapy (C): The evidence in the scientific literature for use of drug therapy
is very limited. Use of muscle relaxants and anti-inflammatory medications have
been reported in studies discussing treatment protocols (32;33) but no studies were
located that examined effectiveness.

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