

## Research

# Clinical Brief: Neurogenic Thoracic Outlet Syndrome

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## Abstract

Thoracic outlet syndrome (TOS) is a frequently overlooked and misunderstood syndrome which is most often of neurogenic origin. A thorough clinical examination is essential in properly diagnosing TOS, differentiating neurogenic TOS from vascular (arterial or venous) TOS, and effectively managing patients suffering from this condition.

## Introduction

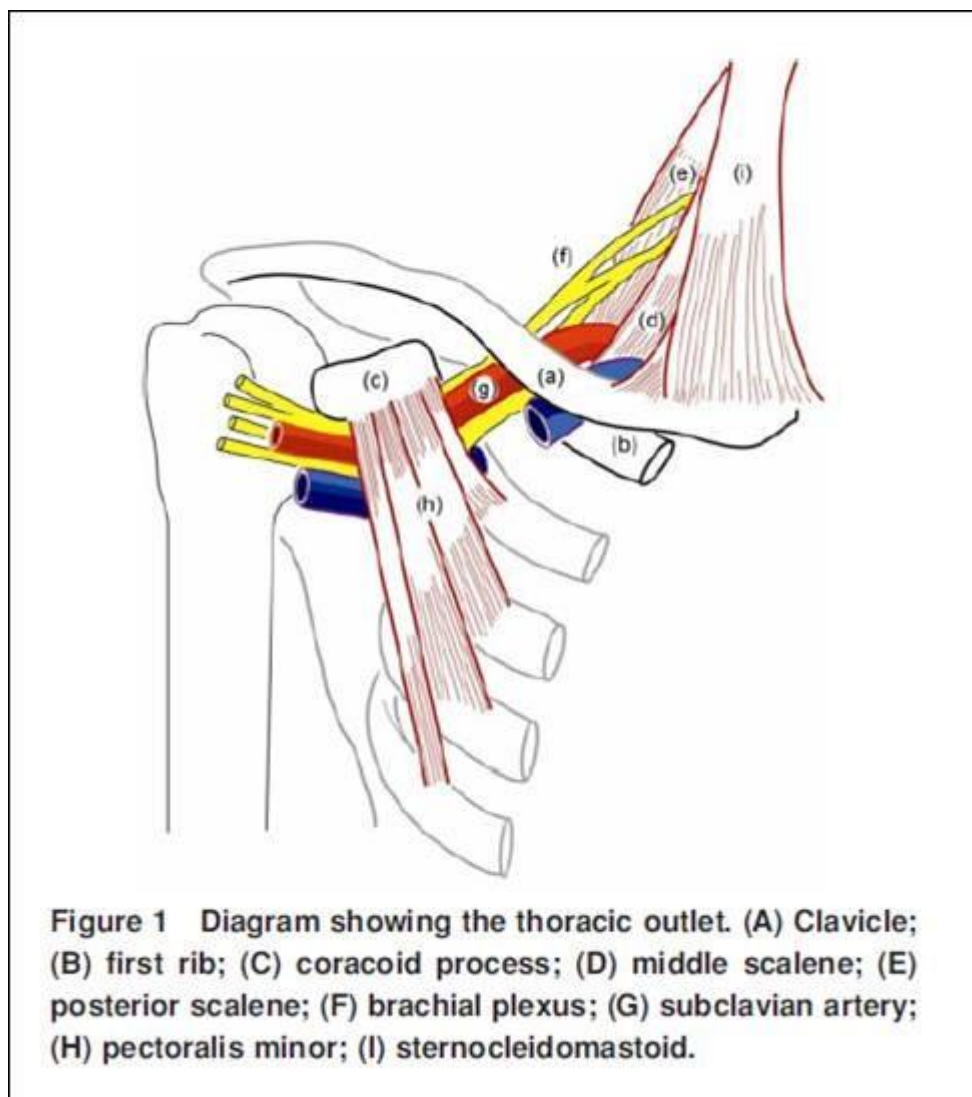
Thoracic outlet syndrome (TOS) remains a challenging, controversial, and often misunderstood and misdiagnosed upper extremity disorder.<sup>1-5</sup> The term “TOS” was first described by Peet in 1956, describing a compression of neurovascular structures contained in the thoracic outlet.<sup>6,7</sup> Nearly all aspects of TOS have served as a point of controversy since Peet’s original introduction, including definition, incidence, proper diagnosis and treatment.<sup>3,8,9</sup>

Although TOS symptoms can be initiated by compromise of both neural and vascular structures, over 90 percent of all TOS cases are of neurogenic origin.<sup>10-14</sup> Optimum recognition, diagnosis and management of neurogenic thoracic outlet syndrome (NTOS) must begin with an understanding of the underlying cause(s) of the neural compression or tension. Thoracic outlet syndrome characteristically develops from abnormalities or changes that produce constriction at one of three specific anatomical locations: interscalene triangle, costoclavicular space, and coracopectoral tunnel.<sup>3,15-17</sup>

The interscalene triangle is bordered anteriorly by the posterior edge of the anterior scalene muscle, posteriorly by the anterior portion of the middle scalene muscle, and inferiorly by the superior aspect of

the first rib, between the insertion sites for the anterior and middle scalene muscles (**figure 1**).<sup>18</sup> The anterior rami of the third, fourth, and fifth cervical spinal nerves and the superior, middle and inferior trunks of the brachial plexus are located within the interscalene triangle. Several types of bony, fibrous and muscular abnormalities make this site susceptible to neurogenic compression.<sup>3, 19</sup>

**Figure 1.** Anatomical compression sites of thoracic outlet include the interscalene triangle, costoclavicular space, and coracopectoral tunnel. Reproduced with permission from Hooper et al, 'Thoracic outlet syndrome: a controversial clinical condition. Part 1: anatomy, and clinical examination/diagnosis', *Journal of Manual & Manipulative Therapy*, Volume 18, Issue no.2, 2010, pp. 74-83(10), Figure 1.



The same neural components continue to travel through the costoclavicular space in route to the upper extremity. The costoclavicular space is described as the interval between the first rib and clavicle.<sup>17</sup> According to magnetic resonance imaging and computed tomographic studies, of the three potential locations for TOS related compression, the costoclavicular space is the most susceptible.<sup>18, 20, 21</sup>

The coracopectoral tunnel is defined as the space deep to the pectoralis minor muscle and its insertion to the coracoid process. As these neural components traverse into the upper limb, potential exists for compression at this site.

## Clinical Presentation

Thoracic outlet syndrome is seen more commonly in women and occurs most often between 20-50 years of age.<sup>22-24</sup> Many patients suffering from TOS have a long history of pain and disability.<sup>3</sup> Classic symptoms of NTOS include: neck and shoulder discomfort, headache, and paresthesia and/or weakness of the upper extremity. Paresthesia, particularly at night, is common and symptoms are usually more pronounced with the arm in an elevated or overhead position. Sensory abnormalities will characteristically involve the ulnar aspect of the hand or the medial portion of the forearm.<sup>10,</sup>

<sup>22</sup> Raynaud's phenomenon is a sympathetic response also frequently seen concurrently with NTOS and may be a consequence of an overactive sympathetic nervous system involving the nerve roots of C8, T1, and the lower trunk portion of the brachial plexus.<sup>10, 23</sup> As neural compression occurs at these sites, stimulation of sympathetic fibers occur, generating Raynaud's phenomenon.<sup>10</sup>

## Clinical Examination

A comprehensive physical examination is a fundamental practice that should be completed to accurately recognize and diagnose thoracic outlet syndrome. Evaluation should include assessment of posture, visual inspection, examination of the cervical spine and shoulder, provocative testing, and local joint palpation. The provider must be mindful that TOS diagnosis is usually confirmed by elimination of other causes with similar clinical presentation, particularly differential diagnosis of cervical radiculopathies and upper extremity entrapment neuropathies.<sup>25</sup> A description of the cervical spine, shoulder and peripheral nerve examinations are beyond the scope of this discussion and are described elsewhere.<sup>26-28</sup>

Postural assessment is important to determine the position of the patient's head, shoulders, scapulae and arms in the seated and standing positions. The examiner should pay attention to the presence of rounded shoulders, forward head position, and downward rotation of the scapulae. These postures tend to increase tension loading on the brachial plexus.<sup>29</sup> Visual inspection of the upper limbs includes observing for cyanosis and edema in case of venous compromise, atrophy in the hand region, and fullness of the supraclavicular fossa. If the patient has a cervical rib or an elevated first rib, the supraclavicular fossa may appear full.<sup>30</sup>

No valid standard diagnostic test or diagnostic criteria is available for NTOS, resulting in controversies in the frequency of diagnosis.<sup>1, 2, 31</sup> Commonly, nerve conduction velocities and electromyography are negative for disputed NTOS. Thus the examiner must rely on a thorough history and a cluster of clinical TOS provocation test findings (**Table 1**).<sup>3</sup>

**Table 1. Provocative Testing in TOS Evaluation<sup>3,10</sup>**

<b>Provocative Maneuver</b>	<b>Description</b>	<b>Positive Results</b>
Supraclavicular Pressure Test	<ul style="list-style-type: none"> <li>▪ Patient seated with arms at side</li> <li>▪ Examiner places fingers on upper trapezius and thumb on anterior scalene near the first rib</li> <li>▪ Examiner squeezes fingers and thumb together for 30 seconds</li> </ul>	Reproduction of pain or paresthesia
Adson's Test	<ul style="list-style-type: none"> <li>▪ Patient seated with arms at side</li> <li>▪ Examiner palpates the radial pulse</li> <li>▪ Patient inhales deeply and holds the breath, extends and rotates the neck toward the side of testing</li> </ul>	Change in radial pulse and/or reproduction of pain or paresthesia
Costoclavicular Maneuver	<ul style="list-style-type: none"> <li>▪ Patient seated with arms at side</li> <li>▪ Examiner assesses the radial pulse</li> <li>▪ Patient retracts and depresses shoulders with chest protruded for up to 1 minute</li> </ul>	Change in radial pulse and/or reproduction of pain or paresthesia
Wright's Test	<ul style="list-style-type: none"> <li>▪ Patient seated with arms at side</li> <li>▪ Examiner palpates the radial pulse</li> <li>▪ Examiner places the patient's shoulder into abduction above the head</li> <li>▪ The position is held for 1-2 minutes</li> </ul>	Change in radial pulse and/or reproduction of symptoms
Elevated Arm Stress Test	<ul style="list-style-type: none"> <li>▪ Patient is seated with arms at 90 degrees of abduction and full external rotation with head in neutral position</li> <li>▪ Patient opens and closes hands into fists while holding the elevated position for 3 minutes</li> </ul>	Pain and/or paresthesia and discontinuation with dropping of arms for relief of pain
Upper Limb Tension Test	<ul style="list-style-type: none"> <li>▪ Patient is supine</li> <li>▪ Examiner stands on side to be tested</li> <li>▪ Examiner depresses the shoulder girdle and abducts the shoulder to 110 degrees with slight extension and elbow flexion to 90 degrees. The forearm is then maximally supinated, elbow extension is applied, and the neck is side bent to the contralateral side</li> <li>▪ Testing is stopped following any symptom reproduction</li> </ul>	Reproduction of symptoms with the distal movement or neck movement and/or restricted elbow extension range of motion

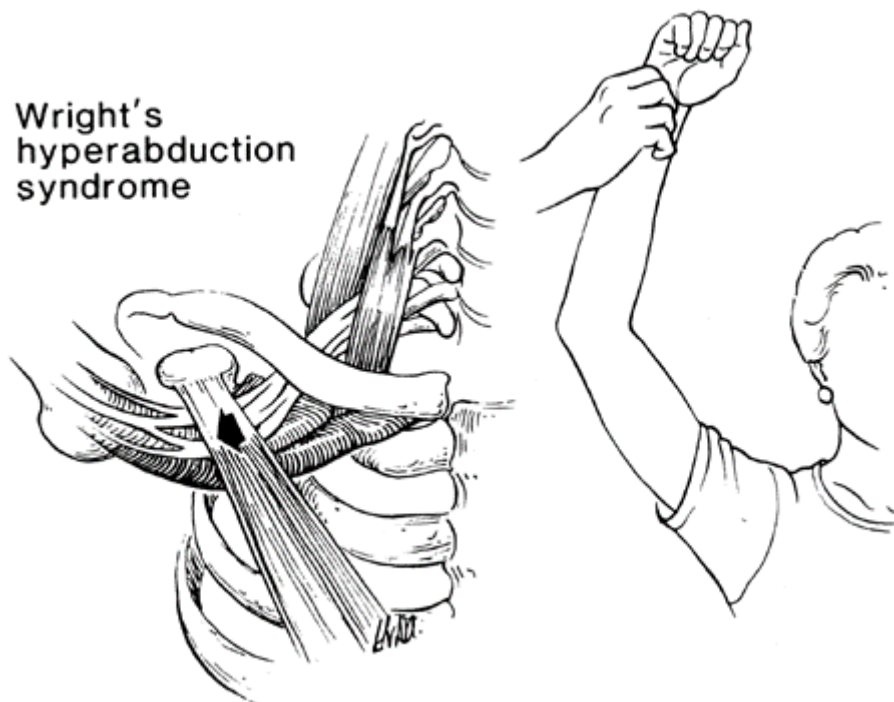
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Cervical Rotation	▪ Patient is seated	Decreased neck flexion with
Lateral Flexion	▪ Examiner passively rotates the head away from affected side and flexes the neck forward to end range, moving the ear to the chest	bony hard end feel and/or reproduction of pain and paresthesia on the contralateral side

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Provocative clinical testing with the supraclavicular pressure test and the Adson's test more specifically address compromise of the plexus through the interscalene triangle.<sup>32</sup> The costoclavicular maneuver evaluates provocation produced by costoclavicular space narrowing, while Wright's test examines neural compromise at the coracopectoral tunnel (**figure 2**).<sup>32</sup> The elevated arm stress test examines the result of loading the plexus throughout the TOS container, and the upper limb tension test examines provocation to the neural tissue passing through the thoracic outlet container while under a tension load.<sup>3</sup> Adson's test and costoclavicular maneuver display a fairly large percentage of false positives when a change in radial pulse is considered as a positive test.<sup>3, 33, 34</sup> Therefore, the clinician should only use these test positions for provocation and not as a test of radial pulse change.<sup>3</sup> Wright's test and elevated arm stress test appear to display the greatest sensitivity for neurogenic and vascular TOS, whereas the upper limb tension testing is sensitive for irritation of the neural tissue including cervical roots, brachial plexus, peripheral nerves, and arm pain syndromes.<sup>35-37</sup> The upper limb tension test (ULTT) is not specific to one area, and is recommended only as a part of the examination and for its usefulness in treatment that includes neural mobilization.<sup>38</sup> NTOS can be differentiated from vascular TOS, particularly arterial TOS, upon physical examination, primarily through provocative testing.<sup>10</sup> NTOS regularly demonstrates tenderness to palpation of the scalene musculature. Additionally NTOS often reveals replication of symptoms upon performing the following provocative maneuvers: 1. Cervical rotation lateral flexion, which produces symptoms of pain and paresthesia on the contralateral side; 2. Elevated arm stress testing, which elicits symptoms within 60 seconds and usually, in less than 30 seconds; 3. Upper limb tension testing. It is noteworthy that a positive ULTT is not pathognomonic of NTOS. However, it suggests irritation or compression of neural tissue within the thoracic outlet, the pectoralis minor space, or the cervical spine.<sup>10</sup>

**Figure 2.** Wright's hyperabduction test compresses the brachial plexus as it passes through the coracopectoral tunnel. Reproduced with permission from the article published in *Orthop Clin North Am*, 27, Atasoy E, Thoracic outlet compression syndrome, p. 276, Copyright Elsevier 1996.



Provocative clinical testing for TOS has been reported to display high rates of false positive findings and are themselves nonspecific.<sup>28</sup> Due to the poor validity of any single provocative maneuver, the tests must be clustered for diagnosis. A cluster of two positive provocative tests shows the highest sensitivity (90%), while a cluster of five positive tests showed the highest specificity (84%).<sup>34</sup>

Lastly, local joint mobility should be assessed for contribution to TOS. Specifically the provider should assess the elevation of the first rib, thoracic spine extension, glenohumeral end-range mobility, and motion of the clavicle with arm elevation.

Hypomobility of any of these areas can lead to dysfunction in the movement of the clavicle and shoulder girdle, thus crowding the thoracic outlet container through which the brachial plexus courses.<sup>32</sup> This assessment should be accompanied by appraisal of the length of the scalene muscles. Shortening of these muscles can lead to non-compliance of the thoracic outlet container through its gates.<sup>10, 39</sup>

## Conservative Management

Generally, the initial approach to NTOS should consist of non-surgical treatments, as the majority of patients improve with conservative therapies.<sup>4, 8, 23, 40-43</sup> Conservative treatments, which may include behavioral modification, ergonomic modifications, postural training, relaxation, massage, mobilization, manipulation, biofeedback, non-steroidal anti-inflammatory drugs, injections and/or cervical traction appear to be effective at reducing symptoms, improving function, and facilitating return to work;

although proper conservative treatment strategies remain controversial.<sup>8</sup> The primary emphasis in early treatments is to minimize symptoms. Non-steroidal anti-inflammatory drugs, injection of botulinum toxin, cervical traction with a hot pack and exercise program, patient education, and modification of behaviors that result in symptom aggravation have all been shown to reduce symptoms.<sup>4, 8, 44-47</sup> Once symptom control has been achieved, treatment should focus upon correcting the dysfunctions responsible for NTOS. According to Hooper et al, management of NTOS dysfunction is directed at “restoring normal arthrokinematics of surrounding joints, correcting related muscle weaknesses and imbalances, and improving nerve mobility in order to decrease tension or compression of the brachial plexus in the thoracic outlet container”.<sup>4</sup> Effective management strategies include: mobilization/manipulation of the 1<sup>st</sup> rib, manual therapy directed to the associated surrounding musculature, neural mobilization techniques, exercise programs, patient education, and body mechanics modification.<sup>4, 22, 23, 48-53</sup> It has been argued that TOS is a syndrome that develops secondary to multiple factors and aggravated by dysfunctions or traumas. Therefore, it is recommended to attempt to correct these factors and the overall goal of TOS treatments should be to alter factors that aggravate symptomatology.<sup>8, 47, 54</sup>

## Surgical Management

Although many cases of TOS will improve with conservative therapies, the presence of a cervical rib may require surgical intervention. Patients who show signs of neurological detriment, including muscle weakness, wasting of the intrinsic muscles of the hand, or a nerve conduction velocity less than 60 m/second, should be considered surgical candidates.<sup>4, 14, 55</sup> Additionally, patients who fail conservative therapies and experience ongoing symptomatology may be considered candidates for surgical intervention.<sup>56</sup> Surgical management in NTOS remains controversial, as there is no current consensus to the best surgical treatment.<sup>4, 23</sup> Surgical options may differ with each individual case based upon individual pathology and symptomatology. Surgical procedures that have been proposed include: scalenotomy, scalenectomy, first rib resection, pectoralis minor tenotomy, claviclectomy, or a combination of these procedures.<sup>23, 56</sup>

## Conclusion

Thoracic outlet syndrome continues to be a controversial condition that is often misdiagnosed and overlooked. TOS most commonly occurs in women between the ages of 20- 50 years and is frequently of neurogenic origin. A thorough clinical examination is critical in properly diagnosing and managing TOS. Conservative therapies are typically recommended and effective, with few patients requiring surgical intervention.

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