The False-positive Rate of Thoracic Outlet Syndrome Shoulder Maneuvers in Healthy Subjects

Michael C. Plewa, MD, Mark Delinger, MD

ABSTRACT

Objective: To estimate the incidence of false-positive findings of thoracic outlet syndrome (TOS) shoulder maneuvers, Adson’s test (AT), costoclavicular maneuver (CCM), elevated arm stress test (EAST), and supraclavicular pressure (SCP) in healthy subjects.

Methods: A cross-sectional, observational study was performed in a medical school and affiliated emergency medicine residency program setting. Participants included healthy adult volunteers without symptoms of TOS. The shoulder maneuvers AT, CCM, EAST, and SCP were performed in randomized order for 30 sec, 30 sec, 3 min, and 30 sec, respectively. Pulse quality and the presence and timing of pain or paresthesias were assessed.

Results: 53 subjects were enrolled, including 27 women, aged 29.7 ± 6.4 years (range 21–58 years). AT, CCM, EAST, and SCP resulted in an altered pulse in 11%, 11%, 62%, and 21%; pain in 0%, 0%, 21%, and 2%; and paresthesias in 11%, 15%, 36%, and 15% of cases, respectively. The following outcomes had reasonable false-positive rates (upper 95% confidence limit): pain with the AT (7%), CCM (7%), SCP (10%), or any 2 TOS shoulder maneuvers (10%); discontinuing the EAST because of symptoms (16%); or any symptom with 3 (13%) or 4 (7%) TOS shoulder maneuvers.

Conclusions: In a study of TOS shoulder maneuvers in healthy subjects, the outcomes of pulse alteration or paresthesias were unreliable in general. However, TOS shoulder maneuvers have reasonably low false-positive rates when a positive outcome is defined as pain after AT, CCM, or SCP; discontinuation of the EAST secondary to pain; pain in the same arm with ≥2 maneuvers; or any symptom in the same arm with ≥3 maneuvers.

Key words: physical examination; thoracic outlet syndrome; pain; paresthesia; perfusion; upper extremity.


Emergency physicians (EPs) should consider thoracic outlet syndrome (TOS) in the differential diagnosis during the evaluation of patients with upper-extremity symptoms of pain, weakness, numbness, or paresthesias. TOS can result from compression of the neurovascular bundle by the first rib, a cervical rib, congenital fibrous bands, or the anterior scalene muscle. There are several variants of TOS, depending on the site of compression, although all classically result in pain exacerbated with the arm in the elevated position. Vascular forms of TOS are rare, and can occur following venous compression in 4% of TOS cases, resulting in upper-extremity swelling, fatigue, venous distention, and cyanosis, or may be due to arterial compression in 1% of TOS cases, resulting in upper-extremity pallor, coolness, claudication, and eventually ulceration and gangrene. More than 95% of patients with TOS will have symptoms related to compression of the brachial plexus, including numbness, pain, or paresthesias, typically in the ulnar distribution but occasionally radiating to the chest and neck, and eventual weakness in the hand grip, triceps, and hand interosseous muscles.

The diagnostic evaluation of TOS should focus on excluding other disorders such as myocardial ischemia, arthritis, fibromyalgia, cervical disk disease, spinal stenosis, rotator cuff injury, reflex sympathetic dystrophy, multiple sclerosis, causalgia, carpal tunnel syndrome, Pancoast tumor, and arteritis. Although cervical spine and chest radiographs are recommended, evidence supporting their diagnostic utility is lacking. The rare case of complete vascular obstruction is confirmed by Doppler studies, venography, or arteriography. Patients with neurologic find-
ings such as weakness and muscle atrophy (especially in the intrinsic hand muscles) may also have electrophysiologic abnormalities on electromyographic, somatosensory evoked potential, or nerve conduction velocity (NCV) studies. NCV findings classically include low-amplitude median motor responses and ulnar sensory action potentials, and normal ulnar motor responses and median sensory responses and are also useful in excluding nerve entrapment disorders such as carpal tunnel and ulnar entrapment syndrome. The utility of MRI is accepted in excluding cervical disk disease and spinal stenosis, but is uncertain in the evaluation of neurovascular compression in the thoracic outlet.

The diagnostic standard for TOS is controversial. Many authors suggest the diagnosis of TOS can be made with the following criteria: 1) the presence of typical

![Figure 1](image)

**Figure 1.** Demonstration of the TOS shoulder maneuvers. A. Adson’s test (AT) involves full inspiration with the neck extended and turned to either side for 30 seconds. B. For the costoclavicular maneuver, both shoulders are pulled downward and backward, in an exaggerated military position, for 30 seconds. C. The elevated arm stress test (EAST) involves extension of both shoulders with opening and closing of both fists for 3 minutes. D. Supraclavicular pressure (SCP) is performed with both thumbs at the lowest portion of the anterior scalene muscle near the first rib for 30 seconds.
upper-extremity symptoms exacerbated by arm elevation, 2) positive findings on TOS shoulder maneuvers, and 3) the absence of other disorders. Others refute the existence of neurogenic TOS in the absence of objective physical (muscle wasting) or electrophysiologic findings, and have labeled this "disputed" neurogenic TOS.3,8

Regardless of the final diagnosis, it is important for EPs to be familiar with the various provocative TOS shoulder maneuvers necessary in the diagnostic evaluation of this syndrome. Schukla and Carlton2 have noted that 98% of TOS patients were missed during their initial ED evaluations, in the majority of these instances because TOS maneuvers were not performed. Several bedside physical maneuvers have been described to aid in the diagnosis of TOS, including Adson’s test (AT),9 the hyperabduction test,10 the elevated arm stress test (EAST),11 the costoclavicular maneuver (CCM),12 and supraclavicular pressure (SCP)11 (the Methods section and Figure 1 provide further descriptions regarding these techniques). These TOS shoulder maneuvers have been used with variable test performance parameters.12-16

Although several authors state that TOS shoulder maneuvers are unreliable and result in high percentages of false positives in normal subjects,17-20 these articles refer to the AT, hyperabduction test, and CCM, which were initially defined as positive if there was loss of the radial pulse. Most authors13,14,15,21 now suggest that positive TOS maneuvers, especially the EAST and SCP, should result in reproduction of the patient’s symptoms rather than pulse alteration. The false-positive rate of TOS maneuvers defined by pain and paresthesias, however, has been inadequately studied. Our objective was to estimate the incidence of false-positive findings of TOS shoulder maneuvers in healthy subjects.

I METHODS

Study Design: A cross-sectional, observational study was performed to estimate the incidence of abnormal TOS shoulder maneuvers in healthy volunteers. The study was approved by the Institutional Review Board of the St. Vincent Mercy Medical Center.

Setting and Population: The study was performed in a medical school and affiliated (EM) residency program setting during November and December 1996. Subjects included healthy adult volunteers who did not have a known history of previous clavicle, neck, or shoulder fracture, carpal tunnel syndrome, cervical disk disease, fibromyalgia, reflex sympathetic dystrophy, or symptoms (such as neck, shoulder or arm pain, or paresthesias) compatible with TOS.

Interventions and Measurements: The shoulder maneuvers AT, CCM, EAST, and SCP were performed on one arm at a time (except for the EAST, which was with both arms simultaneously) in each subject in a randomized order (according to a computer-generated random number list) for 30 sec, 30 sec, 3 min, and 30 sec, respectively, with an approximately 60-second rest period between maneuvers. See Figure 1 for details regarding these maneuvers. The hyperabduction test was not studied because this position is incorporated into the EAST.

Adson’s test (AT) involves sitting in the upright position with shoulders back and hands on the lap, taking a deep inspiration and extending the neck and the chin toward the affected side.9 This increases the tension of the anterior and middle scalene muscles, and decreases the interscalene space. This test has poor sensitivity, being positive in as few as 2% of patients with TOS.1

For the elevated arm stress test (EAST), both hands are opened and closed into fists for 3 minutes with both arms in the hyperabduction position, which closes the costoclavicular space and compresses the neurovascular bundle under the pectoralis minor muscle. A positive EAST, including reproduction of symptoms of pain and paresthesias in the arm, shoulder, chest, or neck and discontinuation with dropping of the arm for relief of pain, is considered the most reliable test with regard to sensitivity.11

The costoclavicular maneuver (CCM) involves pulling the shoulders downward and backwards in an exaggerated military position.13 This closes the space between the clavicle and the first rib.

For supraclavicular pressure (SCP), the observer’s thumb is pressed in the supraclavicular fossa over the medial scalene muscle for at least 30 seconds.11 This indirectly presses on the brachial plexus, and a positive test results in not only tenderness but reproduction of symptoms in the upper extremity.

The palpated radial pulse quality (present, absent, or diminished in comparison with previous pulse amplitude) and the presence, location, and time of onset of pain or paresthesias were recorded individually by an EM attending and a fourth-year medical student trained in these maneuvers. Measurements were neither repeated in the same subject (reproducibility) nor repeated with different observers (reliability). Pain was self-reported, but not quantified on a scale, and defined as any discomfort in the upper extremity, neck, or head on the involved side. Paresthesias were defined as any tingling, burning, "pins and needles," or otherwise "funny" sensation. The percentage of positive tests for each maneuver represents the number of positive tests present in either extremity over the total number of subjects.

Data Analysis: Data were described with 95% confidence intervals (CIs). A sample size of 50 subjects was chosen to obtain an estimated precision of ±10% if the percentage of subjects with a negative test is 85% or higher.
RESULTS

Fifty-three subjects were enrolled, including 27 women and 26 men, aged 29.7 ± 6.4 years (range 21–58 years). The incidence of abnormal TOS shoulder maneuvers is listed in Table 1. Pulse alterations were observed in some patients with all maneuvers, but were most common with the EAST in comparison with other maneuvers. Paresthesias were also more common with the EAST, were present only in the upper extremity, and did not radiate into the neck, head, or chest in any case. Pain was absent in cases with the AT and CCM maneuvers, and was present in 1 case with SCP. Although discomfort was more likely with the EAST, it resulted in discontinuation of the maneuver in only 3 (6%; 1–16%) subjects who dropped the arm at 100 ± 17 sec, 2 because of pain and 1 from fatigue. Pulse alteration, pain, and paresthesias with at least 1 maneuver were present in 74% (60–85%), 21% (11–34%) and 47% (33–61%) of subjects, respectively, although no subject had positive findings with all maneuvers. Table 2 lists the outcomes of altered pulse, pain, or paresthesias into the same extremity with >1 shoulder maneuver.

Pain occurred with the EAST in the shoulder in 1 case, the forearm and hand in 6, the hand in 3, and the thumb in 1. Pain occurred with SCP in the hand and arm in 1 case each. Pain did not follow the classic ulnar distribution in any case. Pain intensity was described as mild in all cases except for 1 subject, who described pain associated with EAST as severe. Although subjects were allowed to discontinue any TOS shoulder maneuver if necessary because of pain, only 2 individuals discontinued during the EAST because of pain.

Paresthesias occurred with the AT in the hand and small finger in 1 case each; with the CCM in the forearm in 2 cases and the hand in 6; with the EAST in the arm in 1 case, the forearm in 4, the forearm and hand in 4, the hand in 7, the small finger in 1, the thumb in 1, and all fingers in 1; with the SCP in the shoulder in 1 case, the arm in 2, the forearm in 4, and the hand in 1. Paresthesias were in the ulnar distribution in 5 cases, 3 in the forearm and 2 in the small finger. In all cases the paresthesias were mild and described as a tingling or "pins and needles" sensation rather than burning or pain.

DISCUSSION

There has been controversy regarding the accuracy of these shoulder maneuvers in the diagnosis of TOS because of varying definitions. When based on findings of a diminished radial pulse, these maneuvers are thought to be unreliable17–20 since pulse alterations may be found in a high percentage of asymptomatic individuals. Using photoplethysmographic recordings, Gergoudis and Barnes22 noted significant arterial obstruction (defined as ≥75% reduction in the digital pulse amplitude) in 51%, 14%, and 9% of cases using the Adson’s, costoclavicular, and hyperabduction maneuvers, respectively. Telford and Mottershead24 noted diminished radial pulses in approximately 50% of healthy medical students with the costoclavicular or hyperabduction maneuvers. Vin et al.14 described reasonable specificities for the maneuvers in 150 normal subjects, with pulse obliteration in no subjects with the Adson’s test, and in 1–17% with hyperabduction between 45° and 180°. Warrens and Heaton33 described false positives in 58% of cases with at least 1 maneuver, 27% with the costoclavicular test, 15% with Adson’s test, and 14% with the hyperabduction test. Wright noted hyperabduction of the arms obliterated the radial pulse in 83% of 150 young, healthy adult volunteers.17 Our results are consistent with these in that the majority of patients (74%) had alteration in pulse with at least 1 maneuver; however, we did find that diminished pulse was less common with AT and CCM than most previous reports. Whereas previous studies have not addressed pulse alterations with EAST and SCP, we found a diminished pulse in the majority of subjects following EAST (62%) and in a significant percentage of subjects following SCP (21%).

Positive findings on TOS shoulder maneuvers should include reproduction or exacerbation of the patient’s symptoms,5,11,21 although several authors criticizing the poor specificity of these maneuvers have not commented on production of pain or paresthesias with these tests.19,23,24 The few prior studies to prospectively evaluate the false-positive rate of TOS maneuvers in healthy subjects with regard to pain or paresthesias have addressed the hyperabduction maneuver17 and the EAST,23 and not the AT, CCM, or SCP. In the study described by Wright,17 only 2 of 150 normal volunteers noted neurologic symptoms of pain or paresthesias with shoulder hyperabduction. Novak et al.26 found 10 of 300 normal persons developed sensory symptoms within 2–4 minutes after arm elevation.

In the study by Costigan and Wilbourn,25 the EAST produced discomfort in 74% of control subjects, although none of these discontinued the maneuver secondary to pain. Similarly, we found that discontinuing the test because of pain, argued by Roos1 as being essential for a...
positive test, was quite uncommon (3%), and EAST elicited pain or paresthesias in 21% to 36% of subjects. Also, since many of our subjects did not develop symptoms until beyond 90 seconds, it is likely that the specificity of EAST might be improved by limiting the test to 90 seconds' duration.

Supraclavicular pressure, described by Roos as one of the most helpful tests in the diagnosis of TOS, has been the least studied of all the physical maneuvers. Costigan and Wilbourn noted supraclavicular tenderness in only 4% of controls and did not describe reproduction of symptoms in any of these healthy volunteers. We also found the SCP maneuver rarely caused pain, although paresthesias were present in 15%.

Our results suggest that resultant pain may be the most specific finding during TOS shoulder maneuvers, since pain was present in no subject during the AT or CCM tests, and in a single subject during SCP. In general, the incidence of false-positive findings of pain with the AT, CCM, and SCP were lower than with EAST and lower than findings of paresthesias with these maneuvers. Using the results of several shoulder maneuvers in combination may also improve the specificity for TOS, since paresthesias or pulse alterations in the same arm with ≥2 tests were uncommon (11%), and pain in the same arm with ≥2 tests was rare (2%).

Although some authors have discounted the TOS maneuvers as being nonspecific, they remain an integral component of the diagnosis of TOS. For example, Lindgren uses a "TOS index" defined as at least 3 of 4 criteria, including history of symptoms aggravated with arm elevation, paresthesias along the C8–T1 distribution, supraclavicular tenderness over the brachial plexus, and a positive EAST. Our results suggest that TOS shoulder maneuvers have reasonable specificity when they result in pain after AT, CCM, or SCP, discontinuation of the EAST secondary to pain, pain in the same arm with ≥2 maneuvers, or any symptom with ≥3 maneuvers.

Positive TOS maneuvers in the patient with arm pain, numbness, paresthesias, or weakness aggravated in the elevated position should suggest TOS as a possible diagnosis. Further workup should rule out other causes listed previously. Since the majority of patients with TOS can be managed with conservative measures such as simple analgesics, physical therapy, shoulder girdle and cervical spine mobility exercises, psychosocial intervention, and avoidance of precipitating factors, most patients can be managed by their primary care physician with possible referral to physical medicine and rehabilitation, neurology, rheumatology, and orthopedic or vascular surgery specialists, as necessary. Rarely, surgical transaxillary first rib resection will be indicated for cases with documented aneurysm, arterial or venous insufficiency, or true neurologic TOS with muscle weakness and atrophy, or cases refractory to conservative measures.

### Table 2

<table>
<thead>
<tr>
<th>Number of Maneuvers</th>
<th>Altered Pulse</th>
<th>Pain</th>
<th>Paresthesias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>6% (4–23%)</td>
<td>2% (9–10%)</td>
<td>21% (11–34%)</td>
</tr>
<tr>
<td>Three</td>
<td>4% (0–13%)</td>
<td>0% (0–7%)</td>
<td>4% (0–13%)</td>
</tr>
<tr>
<td>Four</td>
<td>0% (0–7%)</td>
<td>0% (0–7%)</td>
<td>0% (0–7%)</td>
</tr>
</tbody>
</table>

*95% CI in parentheses.

### Limitations and Future Questions

This study has several limitations that deserve discussion. Because of the small sample size, the confidence intervals around specificity estimates were wide. There were only 2 observers performing the TOS shoulder maneuvers, and observations were not repeated on the same subjects; therefore, the interrater variability could not be determined. The pressure was not measured during the CCM or SCP maneuvers, but was estimated to be approximately 10 pounds. In addition, we did not measure pain intensity, such as with a linear analog pain score, although many subjects described their discomfort as mild. It is possible that the pain intensities are quite different between subjects with and without TOS.

Since a complete radiographic and electrophysiologic evaluation of subjects was not performed, it is possible that positive shoulder maneuvers identified individuals with asymptomatic carpal tunnel syndrome or cervical disk disease, or predisposition to TOS in the future.

Several other tests were not evaluated, such as the hyperabduction test, the cervical rotation lateral flexion test, Tinel's sign (tenderness to percussion over the brachial plexus and supraclavicular fossa), and the scalene muscle block. It is possible that any of these could have better specificity than the 4 TOS shoulder maneuvers studied here.

The most serious study limitation was that our population of normal subjects does not reflect those patients presenting to the ED with symptoms suggestive of TOS. We did not address the false-positive rate of TOS shoulder maneuvers in patients with cervical disk disease, fibromyalgia, reflex sympathetic dystrophy, carpal tunnel syndrome, or other disorders mimicking TOS. In fact, Costigan and Wilbourn have found positive findings with the SCP and EAST in 23% and 92%, respectively, of patients with carpal tunnel syndrome. We also did not attempt to duplicate the typical 3:1 female-to-male ratio found in TOS cases. In addition, this study did not assess the sensitivities of these TOS shoulder maneuvers in symptomatic ED patients. In fact, prior studies have infrequently reported the sensitivity of these TOS shoulder maneuvers because they are usually included in the definition of TOS.

Future study should address the following issues: 1)
the optimal force required for the SCP and CCM maneuvers, 2) the interobserver variability of the various TOS maneuvers, 3) the utility of chest and cervical radiographic screening in patients with TOS symptoms, and 4) the optimal TOS shoulder maneuvers with regard to sensitivity and specificity in a prospective evaluation of patients presenting to the ED with symptoms suggestive of TOS.

**CONCLUSION**

In a study of TOS shoulder maneuvers in healthy subjects, which did not address sensitivity, we found outcomes of pulse alteration or paresthesias to be unreliable in general. However, TOS shoulder maneuvers have reasonably low false-positive rates when a positive outcome is defined as pain after AT, CCM, or SCP; discontinuation of the EAST secondary to pain; pain in the same arm with ≥2 maneuvers; or any symptom in the same arm with ≥3 maneuvers.

The authors thank Nancy Fenn Buderer, MS, for her statistical assistance and Brooke Thibert for manuscript preparation.

**REFERENCES**