Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome: Executive summary

Karl A. Illig, MD,[a] Dean Donahue, MD,[b] Audra Duncan, MD,[c] Julie Freischlag, MD,[d] Hugh Gelabert, MD,[e] Kaj Johansen, MD,[f] Sheldon Jordan, MD,[g] Richard Sanders, MD,[h] and **Robert Thompson, MD,[i]** *Tampa, Fla; Boston, Mass; London, Ontario, Canada; Sacramento and Los Angeles, Calif; Seattle, Wash; Aurora, Colo; and St. Louis, Mo*

Thoracic outlet syndrome (TOS) is a group of disorders all having in common compression at the thoracic outlet. Three structures are at risk: the brachial plexus, the subclavian vein, and the subclavian artery, producing neurogenic (NTOS), venous (VTOS), and arterial (ATOS) thoracic outlet syndromes, respectively. Each of these three are separate entities, though they can coexist and possibly overlap. The treatment of NTOS, in particular, has been hampered by lack of data, which in turn is the result of inconsistent definitions and diagnosis, uncertainty with regard to treatment options, and lack of consistent outcome measures. The Committee has defined NTOS as being present when three of the following four criteria are present: signs and symptoms of pathology occurring at the thoracic outlet (pain and/or tenderness), signs and symptoms of nerve compression (distal neurologic changes, often worse with arms overhead or dangling), absence of other pathology potentially explaining the symptoms, and a positive response to a properly performed scalene muscle test injection. Reporting standards for workup, treatment, and assessment of results are presented, as are reporting standards for all phases of VTOS and ATOS. The overall goal is to produce consistency in diagnosis, description of treatment, and assessment of results, in turn then allowing more valuable data to be presented. (J Vasc Surg 2016;64:797-802.)

BACKGROUND AND RATIONALE FOR THIS DOCUMENT

Thoracic outlet syndrome (TOS) is a group of potentially disabling conditions thought to be caused by compression of neurovascular structures serving the upper extremity.[1] There are three distinct types of TOS, depending on the principal anatomic structures involved and the clinical syndromes that result: neurogenic (NTOS), venous (VTOS), and arterial (ATOS). The goals of this document are twofold: first, to standardize terminology, nomenclature, and definitions and thus ensure that all are describing the same entities; and second, to establish consistent reporting standards regarding all three forms of TOS.

The following is an executive summary of the full document, which can be accessed online at www.jvascsurg.org. The full document contains recommended terminology and reporting items not covered in this abbreviated format, figures and full descriptions of the testing recommended here, and appendices supplying data sheets and outcome measure instruments.

CLASSIFICATION AND ANATOMY

TOS is commonly referred to as one clinical entity. However, there are three distinct types of TOS, depending on the principal anatomic structures involved and the clinical syndromes that result. Diagnosis, treatment, and outcomes vary, and these must be reported as separate entities.

Neurogenic symptoms are most common, caused by brachial plexus compression or irritation at the scalene triangle or pectoralis minor space. Venous symptoms are caused by subclavian vein compression at the costoclavicular junction or occasionally the pectoralis minor space and present as acute or chronic upper extremity deep venous

From the Division of Vascular Surgery, University of South Florida Morsani College of Medicine, Tampa[a]; the Division of Thoracic Surgery, Harvard Medical School, Boston, Mass[b]; the Division of Vascular Surgery, University of Western Ontario, London[c]; the Department of Surgery, University of California Davis, Sacramento[d]; the Division of Vascular Surgery, UCLA Geffen School of Medicine, Los Angeles[e]; the Division of Vascular Surgery, University of Washington School of Medicine, Swedish Medical Center, Seattle[f]; the Neurological Associates of West Los Angeles, Los Angeles[g]; the Division of Vascular Surgery, University of Colorado Health Science Center, Aurora, Colo[h]; and the Section of Vascular Surgery, Washington University, St. Louis.[i]

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Correspondence: Karl A. Illig, MD, USF Division of Vascular Surgery, 2 TGH Circle, STC 7016, Tampa, FL 33606 (e-mail: killig@health.usf.edu).

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thrombosis (Paget-Schroetter syndrome, effort thrombosis) or positional swelling (McCleery syndrome). Finally, ATOS occurs when the subclavian artery is compressed at the scalene triangle, often by an anomalous bone structure, and presents as either symptomatic ischemia with the arm elevated or fixed arterial damage (stenosis, occlusion, or aneurysmal degeneration resulting in upper extremity ischemia, commonly due to embolization). Because the brachial plexus and subclavian artery traverse the same spaces, arterial signs and symptoms can be present in patients with NTOS, although ATOS is not considered present unless proven symptomatic ischemia with compression or actual physical injury to the artery is present.

TERMINOLOGY

The following terms should be used in describing patients with TOS and the following definitions strictly adhered to (see pages xi-xix in reference 2 for a more detailed listing).

Neurogenic TOS (NTOS). Patients have symptoms caused by compression and irritation of the brachial plexus. Patients with neurogenic symptoms thought to be caused by compression at the pectoralis minor space are a subgroup of those with NTOS and should be referred to as having neurogenic pectoralis minor syndrome (NPMS). Those with NTOS whose pathophysiologic process is thought to be limited to the scalene triangle should be described as having **NTOS**; those at the retropectoral space, **NPMS**; and those at both, **NTOS/NPMS**.

Venous TOS (VTOS). Patients have signs and symptoms caused by intermittent compression or partial or complete thrombosis of the subclavian vein at the costoclavicular junction. Those with thrombotic occlusion can also be described by the eponym Paget-Schroetter syndrome or effort thrombosis, although VTOS includes those with intermittent positional obstruction in the absence of thrombosis (McCleery syndrome). Patients with VTOS whose pathophysiologic process is limited to the costoclavicular junction should be described as having **VTOS**; those at the pectoralis minor space, **VPMS**; and those at both, **VTOS/VPMS**.

Arterial TOS (ATOS). Patients have clinical symptoms due to documented symptomatic ischemia or objective subclavian artery damage caused by compression at the level of the first rib or other related anomalous bone structures. Note that to diagnose ATOS, the limb must be objectively ischemic with stress maneuvers; pulse obliteration and asymptomatic hemodynamic or anatomic changes with provocative maneuvers in the absence of such changes do *not* meet the definition of ATOS.[3]

NEUROGENIC TOS

Definition. NTOS should be defined by the presence of *three or more of the following four criteria*.

1. LOCAL FINDINGS
   a. History: Symptoms consistent with irritation or inflammation at the site of compression—scalene triangle in the case of NTOS and pectoralis insertion site in the case of NPMS—along with symptoms due to referred pain in the areas near the thoracic outlet. Patients may complain of pain in the chest wall, axilla, upper back, shoulder, trapezius region, neck, or head (including headache).
   b. Examination: Pain on palpation of the affected area as above
2. PERIPHERAL FINDINGS
   a. History: Arm or hand symptoms consistent with central nerve compression. Such symptoms can include numbness, pain, paresthesias, vasomotor changes, and weakness (with muscle wasting in extreme cases).
      i. These peripheral symptoms are often exacerbated by maneuvers that either narrow the thoracic outlet (lifting the arms overhead) or stretch the brachial plexus (dangling; often driving or walking/running).
   b. Examination: Palpation of the affected area (scalene triangle or pectoralis minor insertion site) often reproduces the peripheral symptoms.
      i. Peripheral symptoms are often produced or worsened by provocative maneuvers that are believed to narrow the scalene triangle (EAST) or to stretch the brachial plexus (ULTT).
3. ABSENCE of other reasonably likely diagnoses (cervical disk disease, shoulder disease, carpal tunnel syndrome, chronic regional pain syndrome, brachial neuritis) that might explain the majority of symptoms
4. In those who undergo it, the response to a properly performed TEST INJECTION is positive.[4]

Reporting standards: Workup. As many as possible of the following factors should be reported, if performed for evaluation of NTOS.

1. History
   a. Symptoms: Pain, numbness, tingling, and weakness
      i. Type of symptoms and distribution
      ii. What causes the symptoms and what makes them worse?
         1. Specifically arms overhead, driving, exercising, and activities of daily living
   b. Prior treatment and results (if surgery, residual vs recurrent symptoms)
   c. History of trauma, with single episode vs repetitive motion injury clearly described and differentiated
   d. Occupation, with specific description of any potential relevant factors (prolonged keyboarding, arms overhead)
   e. Relevant avocations, sports activities
   f. Arm dominance
2. Physical examination
   a. Posture and any abnormal movement
   b. Spontaneous use of affected arm

   c. Presence or absence of visible hand (thenar, hypothenar, or interosseous) muscle atrophy compared with contralateral side
   d. Neurovascular examination at rest
   e. Point tenderness at scalene triangle (NTOS) or pectoralis minor insertion site (NPMS)
   f. Reproduction of arm or hand symptoms on palpation over supraclavicular scalene triangle (NTOS) or subcoracoid pectoralis minor muscle insertion site (NPMS)
   g. Any other maneuvers performed to exclude other diagnoses
   h. Provocative testing
      i. Response to elevated arm stress test (EAST)
      ii. Response to upper limb tension test (ULTT)
3. Presence or absence of other diagnoses
   a. Results of any other workup indicated
   b. Opioid dependence or psychological/psychiatric diagnoses
   c. Whether patient is disabled and a party to litigation or workers' compensation claim
4. Response to scalene or pectoralis minor test injection with local anesthetic, if performed
5. A chest radiograph or cervical spine series should be performed in all patients and the presence or absence of a cervical rib or elongated C7 transverse process reported
6. If available, objective grip strength (kg)
7. Results of commonly used scoring assessment instruments should be recorded
   a. Shortened Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire
   b. Cervical Brachial Symptom Questionnaire (CBSQ)
   c. TOS disability scale (included on all data sheets). The patient should be asked to rate disability (0 being none, 10 being complete), not just pain, related to thoracic outlet symptoms on the affected side.

Diagnosis and assessment of severity. At this point, a judgment should be made on two axes: the degree of suspicion that NTOS exists, ranked as low, medium, or high; and the degree of severity, as mild, moderate, or severe. The degree of suspicion is largely based on the provider's judgment, whereas the degree of severity is derived from the patient's perspective of how severely the symptoms affect his or her life. Each should be reported.

Reporting standards: Treatment. As many as possible of the treatment options and details for NTOS should be reported.

- Ergonomic modifications at work and home or workplace
- Physical therapy
- Any other therapies attempted (massage, chiropractic) and results thereof
- Medications
- Therapeutic muscular, perineural, epidural, or other injections (steroids, botulinum toxin)
- Operative decompression of the thoracic outlet, potentially including brachial plexus neurolysis
  - Surgical approach and structures removed or altered, with precise attention paid to terminology as described earlier (including extent of rib resection, anomalous anatomy observed, pectoralis minor tenotomy, neurolysis, and any wrapping or other treatment of the nerves)
  - Pleural entry, use of chest drainage
  - Intraoperative complications
  - Postoperative pain control methods used
  - Length of hospital stay
  - All postoperative complications or readmissions within 30 days

Reporting standards: Results. At all visits for NTOS, as many as possible of the following should be reported.

- Description and severity of interval symptoms, including impact on work, school, recreation, and daily activities
- Extent of interval involvement in physical therapy and progress achieved
- Adjunctive procedures or interventions performed
- Current medications, including opioid narcotics
- Physical examination
- Scoring instruments
  - QuickDASH score
  - CBSQ score
  - TOS disability scale

Results should be specifically reported at 3, 6, 12, and 24 months after the initiation of any therapy or surgery. Reporting by means of life-table curves[5] using these scores is strongly recommended for the duration of follow-up.

VENOUS TOS

Definitions and diagnostic criteria. VTOS is defined as an abnormality of the subclavian vein caused by extrinsic compression at the costoclavicular junction (VTOS) or, rarely, the pectoralis minor space (VPMS).[6] In general, all three of the following criteria must be present in patients with this diagnosis, but even if the patient is asymptomatic, ultrasonic or venographic documentation of axillosubclavian thrombus in the absence of other factors is enough for the diagnosis to be made.

1. HISTORY
   a. Arm swelling, usually with discoloration and heaviness
      i. This can occur with the arms overhead only, suggesting nonthrombotic VTOS, or present as a fixed symptom, suggesting subclavian vein thrombosis.

   b. Absence of inciting cause (indwelling catheter, malignant neoplasm)
2. EXAMINATION
   a. Visible arm swelling at rest, although if the arm swelling is reported only with exertion or arms overhead, the arm may be normal at rest.
   b. Arm discoloration
   c. Shoulder, upper arm, or chest wall venous collaterals
3. IMAGING
   a. Documentation of venous compression at the costoclavicular junction by ultrasound, venography, or cross-sectional imaging
      i. If the vein is occluded from mid upper arm to the innominate in the setting of appropriate symptoms (and no secondary cause is present), VTOS may be assumed to be present.
      ii. If the vein is patent but abnormal, the location of the abnormality (costoclavicular junction or pectoralis minor space) should be documented.
      iii. If the vein appears normal at rest, results of ultrasound or venography with the arm abducted >90 degrees should be reported.

Reporting standards: Workup. As many as possible of the following items should be specifically documented in patients with VTOS.

1. History
   a. Symptoms: Swelling, discoloration, heaviness, pain
      i. Present all the time or just with activity?
      ii. If the latter, what causes the symptoms and what makes them worse?
         1. Specifically arms overhead, driving, and exercising
      iii. Any recent unusual or strenuous activity or exertion?
   b. Prior trauma to chest, clavicle, shoulder, ribs
   c. Personal history of clotting disorders, deep venous thrombosis/pulmonary embolism, central venous or peripheral access
   d. Family history of clotting disorders
   e. Contralateral symptoms, prior ipsilateral symptoms?
   f. Occupation, with specific description of any potential relevant factors (prolonged keyboarding, arms overhead)
   g. Relevant avocations, sports activities
2. Examination
   a. Appearance of arm
      i. At rest and with arms elevated overhead
      ii. Swelling, discoloration
   b. Shape of clavicles, any abnormality or trauma
   c. Chest wall or shoulder venous collateralization
   d. Spontaneous use of affected arm
   e. Neurovascular examination at rest, including assessment for signs of NTOS
   f. Status of contralateral arm
3. Imaging
   a. Results of venous imaging should be reported in all cases.
4. TOS disability scale, as described before

Diagnosis and description of the problem. At this point, a diagnosis should be recorded, depending on the presence or absence of thrombosis and whether the underlying subclavian (or axillary) vein is normal, injured, or occluded. The clinical duration of symptoms should be recorded and the following categories used for classification:

- Acute: 0 to 14 days
- Subacute: 14 days to 3 months
- Chronic: 3 months or more

Reporting standards: Treatment. As many as possible treatment options and details should be documented in patients with VTOS.

- Axillosubclavian venous thrombolysis
  - Duration of symptoms in days and classification as before
  - Successful or unsuccessful wire passage
  - Technique: conventional (infusion during 6 to 48 hours) or pharmacomechanical (immediate mechanically aided clot removal)
  - Any adjunctive measures used (eg, balloon venoplasty—note that stenting is contraindicated in this situation)
  - Results of thrombolysis
  - Any complications
- Operative thoracic outlet decompression or venous intervention
  - Whether the patient has received thrombolysis before surgery, and results thereof
    - If so, interval in days between the cessation of thrombolysis and surgery
  - Status of the subclavian vein at the time of operation, as defined before
  - Surgical approach and structures removed, as described and defined before
  - Presence or absence of occult anterior first rib fracture or osteophytic degeneration
  - Use of external axillary-subclavian venolysis and status of vein thereafter
  - Whether any adjunctive procedures were performed
  - Pleural entry, use of chest drainage
  - Intraoperative complications
  - Postoperative pain control methods used
  - Length of hospital stay
  - All postoperative complications or readmissions within 30 days
  - Postoperative anticoagulation or antiplatelet therapy, with duration

Reporting standards: Results. At all visits for VTOS, as many as possible of the following should be reported.

- Overall subjective status: symptoms at rest and with activity, any extent of limitations on activity
- Medications including anticoagulation
- Return and performance to work, school, and sport
- Objective examination—status of affected arm (swelling, discoloration, collateralization) at rest and elevation
- Rationale and results of any imaging studies (duplex ultrasound, venography, computed tomography [CT], or magnetic resonance imaging [MRI]) performed since previous follow-up visit
- Rationale and results of any venous interventions performed since previous follow-up visit
- TOS disability scale

Results, especially objectively determined venous patency (duplex ultrasound, MRI, CT, or venography) should be specifically reported at 3, 6, 12, and 24 months after surgical or interventional treatment. Reporting by means of life-table curves using patency and the TOS disability score is strongly recommended for the duration of follow-up.

ARTERIAL TOS

Definitions and diagnostic criteria. ATOS is defined as an objective abnormality of the subclavian artery caused by extrinsic compression and subsequent damage at the scalene triangle. Such an abnormality can be symptomatic (ischemia or embolization) or asymptomatic (aneurysm, occlusion, or silent embolization).[3] Loss of pulses or discoloration with provocative maneuvers in patients with NTOS does *not* mean that ATOS is present; documented injury to the subclavian artery or symptomatic arm ischemia with arms elevated must be present for this diagnosis to be made. In the authors' opinions, most symptoms in patients with TOS and positional arterial compression are due to neurogenic factors, but if true symptomatic ischemia is thought to be present, this should be defended.

Reporting standards: Workup. As many as possible of the following items should be documented during evaluation for ATOS.

1. History
   a. Classic symptoms and signs of chronic or acute ischemia
      i. Rest pain in the arm, hand, or fingers
      ii. Paresthesias (numbness or tingling or falling asleep) in the arm and hand
      iii. Ischemia of the arm and hand with extreme exertion or arms overhead
      iv. Loss of dexterity in the hand, clumsiness of the arm
      v. Coldness color changes, temperature sensitivity in the arm and hand, or other symptoms suggestive of Raynaud syndrome
   b. Isolated finger pain or ulceration (suggestive of embolization)
   c. A history of
      i. Potential prior embolic events or arterial thrombosis
      ii. Trauma to the shoulder and upper extremity
      iii. Fractures of clavicle or first rib
   d. Any known anatomic or genetic abnormalities (eg, a cervical rib)
2. Examination
   a. Status of pulses in the arm (brachial, radial, ulnar) at rest
   b. Pulse examination, symptoms, and ideally objective hemodynamic data with arms positioned to reproduce potentially ischemic symptoms
   c. Presence of hand or digit lesions consistent with arterial thrombosis or embolization
   d. Neurologic examination
   e. Presence of arm or hand weakness, atrophy, or paralysis
   f. Presence of ulceration, gangrene, or tissue loss
   g. Presence of vasospastic changes
   h. Presence of discoloration
   i. Presence of pulsatile mass at supraclavicular or infraclavicular fossa
   j. Presence of bruit at supraclavicular or infraclavicular fossa
3. Results of imaging
   a. Duplex ultrasound, including direct imaging of the subclavian and axillary arteries and outflow arteries of the arm
   b. Hemodynamic testing including finger plethysmography (at rest, with provocative maneuvers, or after exercise if normal at rest and suspicion is high)
   c. Arteriography, including digital subtraction imaging to the tips of the fingers
   d. CT angiography or MR angiography
4. Imaging to evaluate the bony thoracic outlet (CT, MRI, chest radiography, or cervical spine films). The presence or absence of a cervical rib, elongated C7 transverse process, or anomalous first rib should be reported.
5. TOS disability scale

Diagnosis and description. At this point, a diagnosis should be recorded according to the disease present locally and peripherally, its potential cause, symptom status, and degree of limb threat. The duration of symptoms should be recorded as well.

- Local disease: symptomatic positional compression, intimal injury, thrombosis, stenosis, aneurysm
- Cause: normal anatomy, cervical rib/band, other
- Distal disease: none, macroembolization (eg, brachial artery), microembolization (fingers)
- Symptom status: asymptomatic, exertional muscular pain, rest pain, ulceration/gangrene

- Limb threat: none, unlikely, minor amputation needed, major amputation needed

Reporting standards: Treatment. Description of treatment should be categorized into the three goals of treatment for patients with ATOS:

1. repair/replacement of the damaged subclavian artery (local disease);
2. correction of the original inciting cause at the thoracic outlet (cause); and
3. correction of any distal embolic or other problems (distal disease).

As many as possible treatment options and details should be documented for patients with ATOS.

- Catheter-directed thrombolysis
- Operative management
  - Whether the patient has received thrombolysis before surgery
    - If so, interval in days between the cessation of thrombolysis and surgery
  - Status of the artery at the time of operation, as before (at scalene triangle and in arm)
  - Surgical approach and structures removed, as described before
  - Whether any adjunctive procedures were performed
  - Completion arteriography or duplex ultrasound
  - Neurologic status *before* and *after* operation
  - Pleural entry, use of chest drainage
  - Intraoperative complications
  - Postoperative pain control methods used
  - Length of hospital stay
  - All postoperative complications or readmissions within 30 days

Reporting standards: Results. At all visits for ATOS, as many as possible of the following should be reported.

- Overall subjective status: symptoms at rest and with activity, any extent of limitations on activity
- Medications including anticoagulation
- Return and performance to work, school, and sport
- Objective examination—status of affected arm at rest and elevation
- Results of any imaging studies (duplex ultrasound, venography, CT, or MRI) performed since previous follow-up visit
- Rationale for and results of any interventions performed since previous follow-up visit
- TOS disability scale

Results, especially objectively determined arterial patency (duplex ultrasound, MRI, CT, or arteriography), should be specifically reported at 3, 6, 12, and 24 months after surgical or interventional treatment. Reporting by means of life-table curves using patency and the TOS disability score is strongly recommended for the duration of follow-up.

SUMMARY

TOS is inconsistently diagnosed and described. If unified terminology, diagnostic workup, and consistent reporting standards can be agreed on, accurate, consistent data can be collected, consolidated, and compared to gather enough evidence to better define treatment options. A practice guideline is not possible at this point because of the level of evidence, but if all who have an interest in this diagnosis agree to participate in unified data collection as described before, this paper can eventually be followed by a true practice standards guidelines document and thus allow treatment to be guided by empirical, reproducible data.

AUTHOR CONTRIBUTIONS

Conception and design: KI, DD, AD, JF, HG, KJ, SJ, RS, RT
Analysis and interpretation: KI, DD, AD, JF, HG, KJ, SJ, RS, RT
Data collection: KI, DD, AD, JF, HG, KJ, SJ, RS, RT
Writing the article: KI, DD, AD, JF, HG, KJ, SJ, RS, RT
Critical revision of the article: KI, DD, AD, JF, HG, KJ, SJ, RS, RT
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