Development of Consensus-Based Diagnostic Criteria for NTOS

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Abstract

The diagnosis of neurogenic thoracic outlet syndrome (NTOS) depends upon clinical suspicion, pattern-recognition, and exclusion of more common conditions that have overlapping features. In most patients a diagnosis of NTOS can be made or excluded on the basis of the clinical history, description of symptoms, and physical examination, with the provisional diagnosis being supplemented by a limited number of diagnostic studies. In this chapter we describe ongoing efforts by the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS) to develop and validate diagnostic criteria for NTOS, based on an expert group consensus approach using Delphi methodology, and present a preliminary set of diagnostic criteria. Careful follow-up studies using standardized assessment instruments, particularly through consortium efforts to involve larger number of patients than available at any single center, will provide further insight into the most accurate diagnostic and prognostic criteria for NTOS.

Introduction

Thoracic outlet syndromes are rare conditions caused by compression of neurovascular structures within the anatomic space posterior to the clavicle, above the first rib, and extending to the subcoracoid space. Neurogenic thoracic outlet syndrome (NTOS) is the most frequent of these conditions, representing 85–95 % of all patients. NTOS is due to brachial plexus nerve compression caused by a combination of (1) congenital variations in anatomy, such as a cervical rib, anomalous scalene musculature, and/or aberrant fibrofascial bands, coupled with (2) a history of neck or upper extremity injury or repetitive trauma that has resulted in spasm, fibrosis and other pathological changes in the scalene and/or pectoralis minor muscles [1–5]. Acquired changes in posture, abnormalities in neck and shoulder muscle mechanics, and excessive perineural fibrosis also contribute to brachial plexus nerve compression

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Table 21.1 Differential diagnosis of NTOS

Carpal tunnel syndrome	Cubital canal syndrome	Rotator cuff tendinitis
Cervical spine strain	Cervical disc disease	Cervical arthritis
Fibromyositis	Brachial plexus injury	Acromioclavicular joint
Fibromyalgia	Vasculitis	Atheroembolism
Raynaud's syndrome	Scleroderma	CRPS/RSD
Cervical dystonia	Lymphedema	Psychogenic syndrome
Parsonage-turner syndrome	Nerve sheath neoplasm	Pancoast tumor
Catheter-induced thrombosis	Primary thrombosis	Arterial embolism

[6–9]. In some cases NTOS may be combined with cervical spine radiculopathy or additional peripheral nerve compression disorders (e.g., carpal tunnel, cubital canal, and/or radial canal syndromes), to produce what has been termed the "double-crush" phenomenon [10–13]. NTOS may also be part of a regional pain syndrome with multiple simultaneous sources of pain generation (e.g., shoulder dysfunction, fibromyalgia), or it may co-exist with complex regional pain syndrome (CRPS), with or without a sympathetic-mediated component [14–17].

In the presence of a congenital cervical rib, some patients with NTOS present with weakness, overt electrophysiological abnormalities and thenar or hypothenar muscle atrophy ("Gilliatt-Sumner hand") [18, 19]. Although this clinical presentation has been termed "true" NTOS, these findings may simply represent an advanced form of NTOS with longstanding and possibly irretrievable nerve injury. In contrast, most patients with NTOS exhibit varying degrees of sensory symptoms with no hand muscle weakness or atrophy, and normal or non-specific findings on conventional electrophysiological testing and/or imaging studies. These individuals are identified primarily through comprehensive clinical diagnosis and the exclusion of other conditions. Because there remain no validated objective tests by which to definitively establish the diagnosis of brachial plexus compression in such patients, these individuals are often considered to have "non-specific" or "disputed" NTOS. Such modifying terms for NTOS have not been found to be particularly helpful, either in understanding the condition or in clinical evaluation and management, and have been largely discarded by most investigators.

NTOS is clinically important because when unrecognized and/or inadequately treated, it can cause chronic pain syndromes and/or long-term restrictions in use of the upper extremities, and because it produces substantial disability in relatively young, active, and otherwise healthy individuals in the prime of working life. Accurate diagnosis of NTOS remains a significant challenge in clinical practice, yet properly identified patients can respond quite well to treatment. The various methods used in the diagnosis and treatment of NTOS are more specifically discussed in Chap. 7, "Clinical Presentation of Patients with NTOS."

Differential Diagnosis

Because the symptoms, diagnosis and management of NTOS often overlap with other upper extremity neurological and musculoskeletal disorders, this condition is associated with a particularly broad differential diagnosis (Table 21.1). Indeed, many unresolved issues surrounding NTOS revolve around defining the most accurate clinical criteria to differentiate this condition from other cervical-brachial syndromes and the optimal means to select patients for different forms of treatment. The diagnosis of NTOS depends upon clinical suspicion and pattern-recognition based on the history, description of symptoms, and targeted physical examination, along with the exclusion of more common conditions that have overlapping features. In most patients a provisional diagnosis of NTOS can be made or excluded on this basis. There has been a longstanding effort to establish testing procedures that can improve diagnostic accuracy and/or better predict outcomes of treatment, including

various forms of soft tissue imaging [20–25], advances in electrophysiologic testing [26–29], the application of selective scalene and pectoralis muscle blocks, and ongoing refinement of clinical criteria [30, 31]. Although such tests and studies may be of value, both in excluding other conditions and in supporting the suspected diagnosis, with the exception of scalene/pectoralis muscle blocks, no single test is entirely specific for NTOS.

Initial Development of Consensus-Based Diagnostic Criteria

Comparisons of outcome for the treatment of NTOS are limited by the diverse diagnostic criteria used in various publications and a corresponding lack of uniformity in the patient populations represented. To help address this issue, the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS) was formed several years ago as a multidisciplinary effort to facilitate comparative-effectiveness research. One of the first tasks undertaken by the CORE-TOS group was to begin establishing a consensus-driven set of defined diagnostic criteria for NTOS. This was addressed utilizing a Delphi process approach, a group-consensus strategy that has been widely utilized in other specialties of medicine [32–35].

The Delphi method refers to a step-wise process by which an expert group reaches consensus on a given set of criteria for predicting a particular outcome. The main characteristics of the process are as follows: (1) A panel or group of experts is selected for their experience or opinions regarding the topic under study; (2) A facilitator is selected that facilitates, and receives the results of each survey in the initial and all subsequent steps, and processes the information received in each iteration and filters out irrelevant content; (3) An initial step intended to identify a set of features to be considered as potentially relevant to the topic under study; (4) A second step in which each member rates each of the selected features with regard to its frequency in individuals with the condition under study (diagnostic sensitivity) and its frequency in individuals without the condition under study (reverse diagnostic specificity), with the ratings of each member of the group submitted to the facilitator along with any appropriate comments and criticisms explaining the rating, then having these ratings and comments collated by the facilitator in an anonymous manner and redistributed to members for further consideration; (5) A third step in which each member is asked to re-evaluate their previous ratings for each feature in light of the results submitted by other group members and the group as a whole, as well as the anonymous comments submitted by other group members, with each member encouraged to make modifications in their ratings, which are then resubmitted to the facilitator and collated in an anonymous manner and common and conflicting viewpoints continue to be elucidated; and (6) Repeat of steps 4 and 5 at least once more and perhaps more often, as needed, in order to reach a consensus where possible and to identify features for which clear consensus cannot be reached. The step-wise process inherent in the Delphi approach allows each group member to modify their responses based on the additional information received during each iteration of rating and commentary by the group. Maintaining the anonymity of ratings and responses helps to limit potential domination of the process by a few individuals, allows each group member equal opportunity to articulate opinion, promotes free expression of opinion and open critique, and encourages members to identify errors and correct their earlier judgments. These are some of the ways that the Delphi method helps overcome common problems in group dynamics and consensus building, separating it from other methodologies.

A panel of 12 experienced clinicians with expertise in the care of patients with NTOS participated in the survey process, initially developing a broad list of 223 clinical features considered to be potentially important in establishing a diagnosis of NTOS. This included features principally related to (a) clinical history, (b) description of symptoms, (c) physical examination findings, and (d) tests and studies. The data elements also included clinical features associated with poor

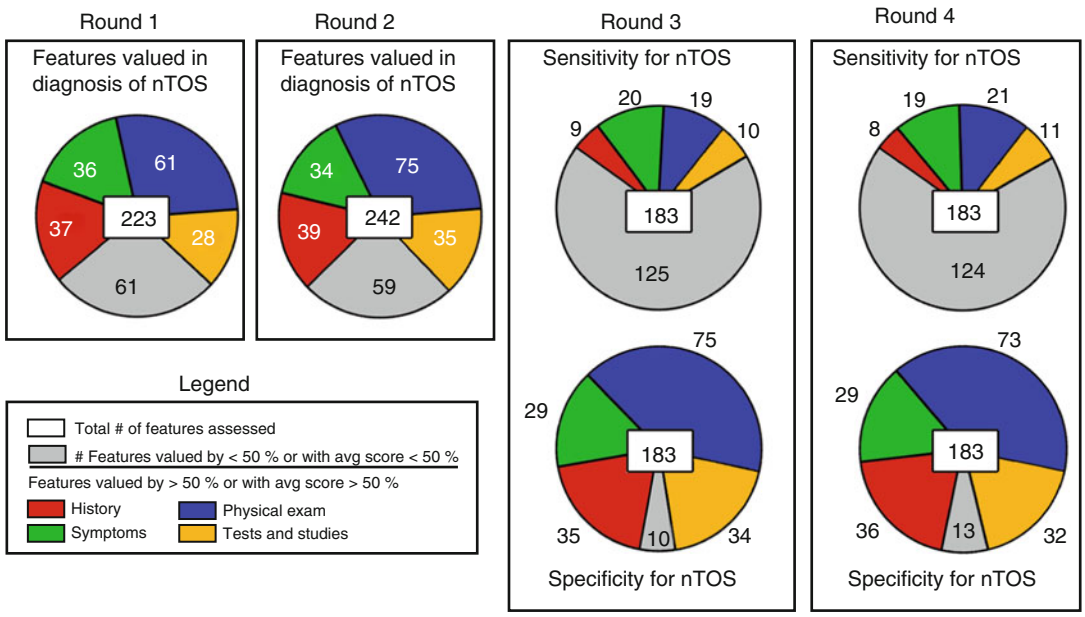

Fig. 21.1 Delphi process for diagnostic criteria of NTOS. The results of the first four rounds of the Delphi process are shown. Rounds 1 and 2 were qualitative surveys to identify features considered of value in diagnosis; rounds 3 and 4 were quantitative surveys to estimate sensitivity and specificity of features in diagnosis

clinical outcomes of treatment in patients with NTOS in previous studies, particularly signs and symptoms of depression, fibromyalgia, complex regional pain syndrome, peripheral nerve compression syndromes, and coexisting musculoskeletal disorders [30, 31].

In the first round of the Delphi survey, 162 of the initial 223 features were considered to be of potential diagnostic value by >50 % of the evaluators (Fig. 21.1). These features were then modified and/or consolidated during the feedback/discussion phase and additional features were added for more specificity. In a second round of survey evaluation the consensus panel evaluated 242 features, of which 183 were considered to be of potential value by >50 % of evaluators. In a third survey round, panel members were asked to score each of the identified features with respect to: (1) the "proportion of patients with a cervical-brachial syndrome attributed to NTOS that would be expected to exhibit that feature" (diagnostic sensitivity), and (2) the "proportion of patients with a cervical-brachial syndrome not attributed to NTOS that would be expected to exhibit that feature" (reverse diagnostic specificity). Following analysis of the results and an additional feedback/discussion phase, the list of diagnostic features was consolidated to 62 that appeared to exhibit the greatest estimated diagnostic sensitivity, specificity, and accuracy (Table 21.2) [36].

Second-Stage Consensus-Based Diagnostic Criteria

While the initial consolidated list of diagnostic features provided some insight into the items upon which the expert panel reached greatest consensus, the main limitation of this stage was the absence of information about the relative "weights" that would be placed on different items in arriving at a clinical diagnosis. To define more valid consensus-based diagnostic criteria for NTOS, the expert panel next re-evaluated the series of items derived from the previous work with respect to the relative importance of each item in making a clinical diagnosis of NTOS, seeking to assess which items carried the greatest analytical strength as consensus-derived criteria. This approach was modeled after the survey

Table 21.2 Initial consensus-based diagnostic criteria for NTOS

Type and description of feature	+NTOS %	–NTOS %
Clinical history		
Symptoms not explained by other condition	100	1
Symptoms worsened by work	90	60
History of neck/arm injury (all types)	80	50
Repetitive strain injury	78	25
Age 15–35 years	70	60
Symptoms worse/minimally improved with conservative Rx	58	37
Substantial improvement with conservative Rx for TOS	15	5
History of cervical rib	10	1
Performance music or sports, arm overhead/weights	10	5
History of peripheral nerve surgery (median, ulnar)	8	6
History of previous treatment or surgery for TOS	5	3
History of clavicle or first rib fracture	4	2
Symptoms		
Paresthesias in digits 4 and 5	90	12
Complaint of hand/digit numbness	90	25
Symptom exacerbation with daily activities or work	90	60
Symptom exacerbation with arm use especially overhead	88	35
Pain interferes with sleep	85	37
Paresthesias radiate in ulnar distribution	83	20
Pain in neck, upper back, shoulder, and/or arm	83	70
Complaint of weakness in arm or hand	72	25
Paresthesias radiate from supraclavicular space	70	5
Headache occipital	60	20
Pain in hand/digits especially with arm use	50	23
Complaint of hand/digit swelling or coldness	50	22
Paresthesias in hand and/or all digits	43	15
Complaint of neck swelling	20	10
Physical examination		
Tenderness/pain on palpation scalene triangle	95	5
Upper limb tension test reproduces symptoms	95	20
Tenderness/pain on palpation >1 areas	90	30
Hand/digit paresthesias on passive arm elevation	90	10
Head tilt/neck rotation reproduces symptoms contra only	83	22
Palpable muscle spasm scalene triangle	80	5
Hand/digit paresthesias on palpation scalene triangle	80	5
Tinel's supraclavicular	80	15
Head tilt/neck rotation reproduces Sx ipsilateral only	80	30
Postural abnormalities (e.g., slumped head-forward)	68	20
Tenderness/pain on palpation pectoralis minor	60	10
3-Min EAST unable to complete or moderate symptoms	60	17
1-Min EAST unable to complete	55	5
Radial pulse ablated or diminished on arm elevation	55	17
Palpable muscle spasm pectoralis and/or trapezius	50	20
Pale hand upon arm elevation	50	10
Diminished sensation in hand/digits esp. digits 4/5	49	12
Hand/digit paresthesias on palpation pec minor	45	7

(continued)

Table 21.2 (continued)

Type and description of feature	+NTOS %	–NTOS %
Weakness of handgrip, intrinsic muscles or digit 5	44	18
Pain-limited ROM neck, shoulder, or arm	33	33
Tenderness/pain SCM, ant chest, rhomboid, or trap	29	21
Visible arm swelling, cyanosis, distended subcut veins	9	4
Hyperalgesia/allodynia neck	8	5
Palpable supraclavicular mass	5	2
Digital ischemia, ulceration, emboli, or Raynaud's	4	2
Thenar or hypothenar atrophy	4	5
Radial, brachial, or axillary pulse not *palpable* at rest	2	1
Indwelling subclavian vein access, past or present	1	3
Tests and studies		
Cervical imaging: Normal C-spine	80	50
Scalene muscle block moderate or dramatic improvement	79	3
Vascular lab: Diminished arterial pressures arm elevation	72	21
Venogram: Subclavian vein stenosis and/or thrombosis	34	15
Cervical imaging: Cervical rib or wide C7 affected side	13	1
Abnormal EMG/NC studies: Brachial plexus	8	5
Arteriogram: Subclavian artery aneurysm and/or stenosis	5	1
Vascular lab: Axillary-subclavian vein thrombosis	5	0

Using a Delphi process, each of 118 potential diagnostic features of NTOS were rated by an expert panel with regard to diagnostic sensitivity (+NTOS, the estimated percent of patients with NTOS that would exhibit the feature listed) and specificity (–NTOS, the estimated percent of patients without NTOS that would exhibit the feature listed). Data shown indicate the mean ratings for the entire 12-member panel of evaluators, for the 62 features exhibiting the highest rankings. Unpublished data from the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS)

construction and statistical analysis of Delphi-based survey results that has been used by Graham and Wright, in developing criteria for the diagnosis of carpal tunnel syndrome [32, 37, 38].

Survey Construction

For this purposes of this last survey, the diagnosis of neurogenic TOS was considered to represent symptoms caused by brachial plexus compression at the level of the scalene triangle and/or the subcoracoid (pectoralis minor) space. The diagnosis was also considered to represent a clinically significant condition that would warrant treatment, but without specifying the treatment that might be recommended. In addition, efforts were made to focus primarily on those items most important in establishing the diagnosis, rather than items that might be used principally in evaluating the severity of symptoms, degree of disability, prognosis, type of treatment to be recommended, or the likelihood of response to treatment. Finally, the items considered were primarily those that would be potentially important (or not important) in reaching a diagnosis based on clinical features (patient characteristics, history, previous treatment, symptoms and physical examination), rather than the results of any specific tests or studies, but did include items referring to previous or current diagnoses, treatments, and test results. Additional items were included to indicate potential tests and studies to be performed beyond the clinical evaluation, in order to identify those considered important (or not important) in reaching a more definitive diagnosis of neurogenic TOS.

The survey instrument consisted of 194 items, with 118 related to clinical diagnosis (23 history, 40 symptoms, 55 examination), 60 related to previous tests, diagnoses, and treatments (30, 12, and 18, respectively), and 16 describing potential tests/studies to be performed. Panel members were asked to rate the importance of each item

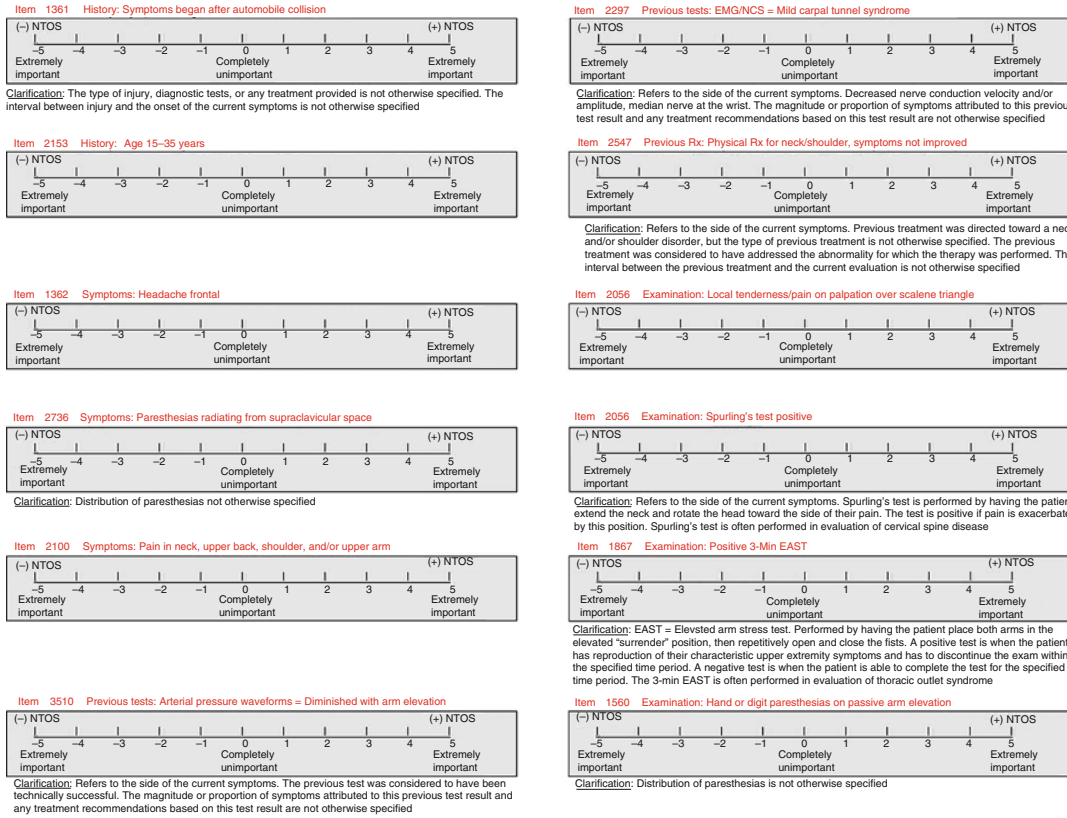

Fig. 21.2 Consensus survey of diagnostic criteria for NTOS. After identification of 178 features considered of potential value in the diagnosis of NTOS, a survey questionnaire was submitted to a 12-member expert consensus panel. Each panel member scored the diagnostic importance of each feature using an 11-point visual analog scale, ranging from −5 to +5. Several examples of the questions used in the survey instrument are shown (there were 23 items related to clinical history, 40 items related to symptoms, 12 items related to previous diagnoses, 18 items related to previous treatments, 30 items related to previous tests, and 55 items related to physical examination)

in reaching (positive) or excluding (negative) a clinical diagnosis of NTOS, using an 11-point horizontal visual analog scale (VAS), which ranged from a negative "extremely important" (−5.0), to neutral "completely unimportant" (0.0), to a positive "extremely important" (+5.0). The instructions reiterated that panel members should imagine how important a given item might be in helping reach a diagnosis of NTOS during a typical clinical evaluation in the office. It was indicated that items rated as extremely important should be those that one would require to be present in order to exclude or make a diagnosis of NTOS, whereas items rated as completely unimportant should be those that make no difference in one's assessment of a patient for this diagnosis. Items that might help support or exclude a diagnosis of NTOS, but not considered essential, were expected to be rated at some relative level of intermediate importance. It was emphasized that although a given item might be frequently observed in patients with NTOS, that item may or may not be important in actually making a diagnosis. Similarly, a given item may indicate a certain magnitude of symptoms, extent of disability, or likelihood of responsiveness to treatment, but may or may not be important in reaching a clinical diagnosis. Several examples of the survey questions are illustrated in Fig. 21.2.

Table 21.3 Diagnostic criteria for NTOS, items of greatest diagnostic importance, subcategories related to clinical diagnosis

Rank	Item description	Mean ± SD	Variance
1	Local tenderness/pain on palpation scalene triangle	4.5 ± 0.7	0.47
2	Hand/digit paresthesias on palpation scalene triangle	4.2 ± 0.8	0.72
3	Known presence of a cervical rib	4.1 ± 1.0	1.04
4	Symptom exacerbation with overhead arm use	4.1 ± 0.8	0.59
5	Thenar or hypothenar atrophy	4.0 ± 1.5	2.15
6	Positive Tinel's supraclavicular	4.0 ± 1.0	1.01
7	Weakness of handgrip, intrinsic muscles or digit 5	3.8 ± 1.3	1.60
8	Diminished sensation in digits 4 and 5	3.8 ± 1.3	1.63
9	Paresthesias in digits 4 and 5	3.8 ± 1.0	0.99
10	Repetitive strain activities	3.7 ± 0.8	0.70
11	Paresthesias radiating from supraclavicular space	3.6 ± 1.6	2.46
12	Positive 1-min EAST	3.6 ± 1.6	2.60
13	Paresthesias radiating in ulnar distribution	3.5 ± 1.3	1.74
14	Symptoms exacerbated by driving	3.5 ± 0.9	0.74
15	Paresthesias radiating through arm to hand	3.4 ± 1.1	1.15
16	Hand and/or digit paresthesias on palpation pec minor	3.4 ± 1.6	2.53
17	Hand or digit paresthesias on passive arm elevation	3.4 ± 1.7	3.00
18	Complaint of weakness in hand, clumsiness	3.3 ± 1.2	1.52
19	Palpable muscle spasm scalene triangle	3.3 ± 1.4	1.84
20	Previous ipsilateral clavicle or first rib fracture	3.3 ± 1.4	1.98
21	Complaint of weakness in arm or hand	3.2 ± 1.1	1.28
22	Symptoms began after injury at work/change in activity	3.2 ± 1.1	1.28
23	Positive upper limb tension test	3.2 ± 1.6	2.68
24	Symptoms are exacerbated by work-related activities	3.2 ± 1.2	1.42
25	Occupation or recreation, overhead sports	3.1 ± 1.3	1.78
26	Complaint of hand and/or digit numbness	3.1 ± 2.2	4.69
27	Local tenderness/pain on palpation pectoralis minor	3.0 ± 1.4	1.87
118	Negative 3-min EAST	−3.2 ± 2.0	3.81

The importance of each feature related to Clinical Diagnosis of NTOS (n = 118) was scored using an 11-point visual analog scale (VAS), ranging from −5 to +5. Items were ranked by the mean score for the entire 12-member expert panel, with the data shown including the standard deviation and variance. There was a high degree of consistency in scoring by the overall panel (Cronbach's alpha = 0.901), indicating a high degree of consensus. Unpublished data from the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS)

Results and Analysis

There was excellent overall group consensus for the 118 items related to "Clinical Diagnosis", with an overall value for Cronbach's alpha, a measure of internal test consistency, of 0.901. There were 27 items (23 %) considered of great diagnostic importance (mean score > +3.00 or < −3.00), 32 items (27 %) considered of intermediate importance, and 57 items (48 %) considered unlikely to be important (mean score between −2.00 and +2.00). There were 71 items (60 %) with a group variance greater than 2.0, and the correlations for individual panelists and the group ranged from 0.553 to 0.886. The items considered of greatest diagnostic importance are summarized in Table 21.3 and those considered of no diagnostic importance are listed in Table 21.4.

For the 60 items related to "Previous Tests, Diagnoses, and Treatments", there was relatively low overall group consensus with a Cronbach's alpha of only 0.629. There were 13 items (22 %) considered of great diagnostic importance, 9 items (15 %) considered of intermediate importance,

Table 21.4 Diagnostic criteria for NTOS, items of no diagnostic importance, subcategories related to clinical diagnosis

Rank	Item description	Mean ± SD	Variance
76	2-point fingertip discrimination diminished (>5 mm)	0.9 ± 1.6	2.53
77	Symptoms began after chiropractic manipulation, neck	0.9 ± 2.1	4.22
78	Hyperalgesia/allodynia anterolateral neck	0.8 ± 1.8	3.21
79	Radial, brachial, or axillary pulses not palpable at rest	0.8 ± 2.7	7.54
80	Palpable muscle spasm pectoralis major and/or trapezius	0.6 ± 2.7	7.05
81	Phalen's sign negative	0.6 ± 1.6	2.45
82	Axial compression/traction test negative	0.6 ± 2.0	3.96
83	Digital ischemia, ulceration, or emboli	0.5 ± 3.9	15.10
84	Arm swelling, cyanosis, or distended subcutaneous veins	0.5 ± 3.1	9.34
85	Pain in upper back or neck, midline	0.3 ± 2.0	4.07
86	Normal hand color upon arm elevation	0.3 ± 1.0	1.01
87	Upper extremity deep tendon reflexes normal	0.3 ± 0.6	0.37
88	Local tenderness/pain on palpation over rhomboid muscles	0.2 ± 1.9	3.72
89	Obesity	0.2 ± 0.4	0.17
90	Hyperalgesia/allodynia entire upper extremity	0.0 ± 2.5	6.24
91	2-point fingertip discrimination normal	0.0 ± 0.3	0.12
92	Radiating pain in extensor forearm, not proximal to elbow	−0.3 ± 2.4	5.73
93	Diminished sensation in digits 1, 2 and 3	−0.3 ± 2.9	8.19
94	Symptoms present for < 6 weeks	−0.3 ± 1.7	2.87
95	Positive Tinel's test ulnar nerve at elbow	−0.4 ± 2.1	4.28
96	Headache frontal	−0.5 ± 1.6	2.57
97	Indwelling subclavian vein access, past or present	−0.5 ± 2.0	3.98
98	Relief of symptoms by shaking hand	−0.6 ± 1.9	3.69
99	Normal ROM neck, shoulder, and arm	−0.7 ± 1.8	3.34
100	Head tilt/neck rotation reproduces ipsilateral symptoms	−0.7 ± 2.4	5.54
101	Normal arterial pulses in all arm positions	−0.8 ± 1.0	0.96
102	Paresthesias radiating proximally from hand	−0.8 ± 2.5	6.38
103	Age > 50 years	−0.9 ± 1.1	1.20
104	Upper extremity deep tendon reflexes abnormal	−0.9 ± 1.9	3.74
105	Positive Tinel's test median nerve at wrist	−0.9 ± 2.2	4.73

The importance of each feature related to Clinical Diagnosis of NTOS (n = 118) was scored using an 11-point visual analog scale (VAS), ranging from −5 to +5. Items were ranked by the mean score for the entire 12-member expert panel, with the data shown including the standard deviation and variance. There was a high degree of consistency in scoring by the overall panel (Cronbach's alpha = 0.901), indicating a high degree of consensus. Unpublished data from the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS)

and 38 items (63 %) considered unlikely to be important. There were 41 items (68 %) with a group variance greater than 2.0, and the correlations for individual panelists and the group ranged from 0.412 to 0.888. The items considered of greatest diagnostic importance are summarized in Table 21.5.

For 16 items related to "Tests to be Performed", there were four items (25 %) considered of great diagnostic importance: "Anterior Scalene/Pectoralis Minor Anesthetic Muscle Block" (mean score +3.34), "Assess Response to Physical Therapy for NTOS" (mean score +3.28), "Cervical Spine Radiographs" (mean score +3.24), and "Chest X-Ray" (mean score +3.03). All 12 other items, including "Upper Extremity Arterial Doppler Studies" (mean score +1.70), were considered unlikely to be important. In this subset of items there were 15 (94 %) with a group variance greater than 2.0, indicating a wide spectrum of opinion.

Table 21.5 Diagnostic criteria for NTOS, items of greatest diagnostic importance, subcategories related to previous tests, diagnoses, and treatments

Rank	Item description	Mean ± SD	Variance
1	Anterior scalene muscle block = significant improvement	4.2 ± 1.5	2.12
2	Cervical radiographs = cervical rib or wide C7 process	4.1 ± 1.2	1.36
3	Combined ASM/PM muscle block = significant improvement	4.0 ± 1.5	2.24
4	Pectoralis minor muscle block = significant improvement	3.9 ± 1.6	2.39
5	Contralateral surgery for NTOS, symptoms improved	3.7 ± 1.5	2.12
6	Physical Rx for NTOS, symptoms improved	3.6 ± 1.4	2.02
7	EMG/NCS including MAC = abnormal MAC	3.4 ± 1.8	3.11
8	Ipsilateral surgery for NTOS, symptoms improved	3.4 ± 1.9	3.49
9	EMG/NCS: Abnormal for brachial plexus	3.3 ± 1.6	2.73
10	Ipsilateral pectoralis minor tenotomy, symptoms improved	3.2 ± 1.5	2.25
11	Upper extremity arteriogram = subclavian artery aneurysm	3.0 ± 3.2	10.12
59	Ipsilateral surgery for NTOS, symptoms not improved	−3.1 ± 1.3	1.75
60	Combined ASM/PM muscle block = no improvement	−3.2 ± 1.5	2.37

The importance of each feature related to Previous Tests, Diagnoses, and Treatments with regard to the diagnosis of NTOS (n = 60) was scored using an 11-point visual analog scale (VAS), ranging from −5 to +5. Items were ranked by the mean score for the entire 12-member expert panel, with the data shown including the standard deviation and variance. There was a relatively low degree of consistency in scoring by the overall panel (Cronbach's alpha = 0.629), indicating a lack of consensus. Unpublished data from the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS)

From the results of this last survey, the 28 items related to "Clinical Diagnosis" that were rated of greatest diagnostic importance were examined to identify potential quantitative and qualitative similarities. These items were then grouped and consolidated to establish terms that would reflect overlapping information from the similarly grouped items. These consolidated items indicated a series of 18 new items that, taken together, would be expected to capture the most important features needed to establish a clinical diagnosis of NTOS. These items are summarized as "provisional CORE-TOS criteria for the diagnosis of NTOS" in Table 21.6.

Future Directions

Given the provisional set of diagnostic criteria for NTOS developed through the Delphi process, the next steps in this effort are focused on re-testing these criteria in a different form of the survey process that employs a series of case scenarios. These case scenarios are developed in a manner that varies the presence or absence of each of the individual criteria, with expert evaluators providing numerical scores for the likelihood of the diagnosis of NTOS on a VAS for each case scenario. Statistical analysis of the results from this survey will be used to establish a logistic regression model for predicting the clinical diagnosis of NTOS. This statistical model will then be validated and tested further in case scenarios and in real patient populations. This effort will be supplemented by use of additional instruments used to evaluate the extent of symptoms and disability from NTOS, such as the DASH (Disabilities of the Arm, Shoulder, or Hand) [39–41], CBSQ (Cervical-Brachial Symptom Questionnaire) [30], BPI (Brief Pain Inventory) [42–44], and SF-12 (Medical Outcomes Study Short Form-12) [45], as well as other outcomes assessed following treatment, including return-to-work [46].

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Table 21.6 Provisional CORE-TOS criteria for the clinical diagnosis of NTOS

Unilateral or bilateral upper extremity symptoms that:
(1) Extend beyond the distribution of a single cervical nerve root or peripheral nerve
(2) Have been present for at least 12 weeks
(3) Have not been satisfactorily explained by another condition, and
(4) Meet at least one criteria in at least four of the following five categories:
Principal symptoms
1A Pain in the neck, upper back, shoulder, arm and/or hand
1B Numbness, paresthesias, and/or weakness in the arm, hand, or digits
Symptom characteristics
2A Pain/paresthesias/weakness exacerbated with elevated arm positions
2B Pain/paresthesias/weakness exacerbated with prolonged or repetitive arm/hand use, or by prolonged work on a keyboard or other repetitive strain
2C Pain/paresthesias radiate down the arm from the supraclavicular or infraclavicular space
Clinical history
3A symptoms began after occupational, recreational, or accidental injury of the head, neck or upper extremity, including repetitive upper extremity strain or overuse activity
3B Previous clavicle or first rib fracture, or known cervical rib(s)
3C Previous cervical spine or peripheral nerve surgery without sustained improvement
3D Previous conservative or surgical treatment for TOS
Physical examination
4A Local tenderness on palpation over scalene triangle or subcoracoid space
4B Arm/hand/digit paresthesias on palpation over scalene triangle or subcoracoid space
4C Weak handgrip, intrinsic muscles or digit 5, or thenar/hypothenar atrophy
Provocative maneuvers
5A Positive upper limb tension test (ULTT)
5B Positive 1- or 3-min elevated arm stress test (EAST)

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