Controversies in NTOS: Is Laboratory Testing Necessary in Patients with NTOS?

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Abstract

The diagnosis of neurogenic thoracic outlet syndrome (NTOS) is made on clinical grounds and affirmed by a positive response to a properly performed scalene muscle block. Numerous laboratory evaluations – including electrodiagnostic, non-invasive vascular, and cross sectional imaging studies – have been used in the assessment of patients potentially harboring neurogenic TOS. However, none has a sensitivity and specificity to a degree that is dependable in making the diagnosis of the condition. Instead, such laboratory tests are useful in ruling out the alternative conditions with which neurogenic TOS may initially be confused.

Introduction

All involved in the management of patients potentially harboring neurogenic thoracic outlet syndrome (NTOS) agree that this condition is diagnosed predominantly on clinical grounds, i.e. on the basis of the patient's injury history, symptomatology, physical examination – including various provocative maneuvers – and clinical course over time, including the patient's response to various conservative measures such as rest or physical therapy. The role of various scalene (or other) skeletal muscle denervation tests, considered by many to be crucial confirmatory evaluations for the diagnosis of NTOS, is discussed in Chap. 20. Is there a role for additional testing in confirming, refining or ruling out the diagnosis of NTOS?

Three broad categories of laboratory examinations – imaging studies, noninvasive vascular laboratory assessment, and electrodiagnostic modalities – have been utilized in patients thought possibly to harbor NTOS. The accuracy and relevance of such studies continues to be debated, to a substantial degree because of an ongoing lack of complete certainty about the underlying pathophysiology of NTOS.

Medical Imaging Studies

Numerous different types of medical imaging studies can provide excellent definition of the anatomy of the thoracic outlet, both in normal subjects as well as in patients who may harbor NTOS [1]. Some may also have a role to play in

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demonstrating (or at least suggesting) pathophysiologic changes characteristic of NTOS in the brachial plexus or the structures which surround it, although correlation between imaging and outcomes have not been thoroughly studied (see Chap. 18).

Plain radiography can upon occasion provide useful insights in patients whose clinical picture suggests the presence of NTOS. An obvious example is the demonstration, on a cervical spine or apical lordotic chest x-ray, of the presence of a cervical rib, a displaced or ectopic first thoracic rib, or a past or current clavicular fracture. Bony erosion in this region may indicate the presence of an apical pulmonary (Pancoast) or other malignancy, invasion of which into the brachial plexus results in the patient's NTOS symptoms.

Standard gray-scale ultrasonography has been utilized for assessment of the anatomy of the thoracic outlet [2]. Such studies can demonstrate scalene muscle hypertrophy, a constant finding in patients with NTOS.

Computerized tomographic (CT) scanning has less commonly been utilized for anatomic assessment of the structures of the thoracic outlet. Particularly when contrast-enhanced, CT scanning provides excellent detail of various anatomic relationships, both normal and abnormal, at this level [3], but data are sparse in this regard.

Magnetic resonance (MR) imaging has been extensively utilized in the evaluation of the anatomic relationships within and around the thoracic outlet. Because of this modality's capability to characterize normal and abnormal tissue densities representative of various forms of pathophysiology in the region, MR has provided real insights into this condition. For example, abnormal scalene muscle structure (edema, hypertrophy, scarring, inflammation) can be demonstrated with exquisite detail on MR imaging of the thoracic outlet and its structures [4]. However, whether MR (or other) imaging studies can provide diagnostic results which are of a high enough sensitivity and specificity to be utilized as a "gold standard" for the diagnosis of NTOS remains elusive.

Noninvasive Vascular Laboratory Evaluation

Various vascular ultrasonographic modalities have been utilized in the assessment of patients thought possibly to be harboring NTOS. Most commonly, vascular laboratory studies, both direct (by focused duplex scanning [5]) and indirect (by digital plethysmography [6]), have been utilized to attempt to demonstrate extrinsic compression of the subclavian artery (or vein) within or near the thoracic outlet. Because the subclavian artery travels through the thoracic outlet in close proximity to the brachial plexus, it is felt by some that the same extrinsic compression which results in the symptoms of NTOS should also impinge upon the subclavian artery at this site. Indeed, presuming that such extrinsic compression is part of the actual pathophysiology of NTOS, the negative predictive value of a normal subclavian artery duplex scan (i.e. unchanged with the arm in provocative postures) is likely high. However, because at least 30 % of the normal asymptomatic population demonstrate extrinsic compression of the subclavian artery with the arm in the same provocative postures [7], the positive predictive value of an abnormal subclavian duplex scan in a patient thought to be harboring NTOS is so low as to make such a finding nondiagnostic.

Electrodiagnostic Studies

It would seem logical that a condition such as NTOS caused by neural compression at the level of the thoracic outlet would be characterized by consistent electrodiagnostic abnormalities. While this is indeed the case in the event of cases resulting from direct blunt or penetrating brachial plexus trauma [8], the vast majority of patients with nonspecific NTOS have normal (or at least inconclusive) results of standard electrodiagnostic studies [9, 10]. Indeed, when such patients' studies show an abnormal result, the abnormality is almost uniformly indicative of nerve impingement either centrally at the cervical spine or at

more peripheral sites such as the carpal or cubital tunnels (see Chap. 19).

In NTOS patients, routine electrodiagnostic testing demonstrates neither nerve conduction abnormalities at the site of brachial plexus compression nor neuromuscular disturbances more peripherally, probably for three separate reasons. First, the site of nerve compression – at the level of the scalene triangle – is too medial for placement of a "control" electrode for measurement of nerve conduction abnormalities across the site of nerve impingement [11]. Second, standard electrodiagnostic studies are too insensitive, i.e. do not have adequate resolution, to detect the nerve or muscle membrane changes relevant to the brachial plexus compression that occurs in the usual form of NTOS. Finally, NTOS is a dynamic condition in which pathophysiologic compression of the brachial plexus usually occurs only with the arm in provocative postures: Extrinsic impingement on the brachial plexus is not constantly present.

Pilot studies of newer and more sensitive electrodiagnostic techniques – for example, that of the median antebrachial sensory nerve conduction velocity [12, 13] – have been introduced but have yet to be validated. Further, such studies appear to have substantial variability based upon operator skill and persistence.

Other Laboratory Studies

Histopathologic evaluation of scalene muscle removed at the time of thoracic outlet decompression surgery has demonstrated a predictable alteration of such muscle, including a markedly increased collagen deposition and a wholesale change in skeletal muscle fiber type [14]. Such findings are currently *ex post facto* only – they simply help confirm that the condition being treated was indeed NTOS – but their consistency suggests the possibility that some as-yet undetermined new imaging or electrophysiologic study might be demonstrated to be adequately sensitive and specific for use in diagnosing NTOS during a preoperative evaluation.

Discussion

As noted above, the diagnosis of NTOS depends to a significant degree upon the patient's clinical presentation and course. A critical aspect of making the diagnosis of NTOS, however, is the satisfactory *exclusion* of alternative diagnoses which might share a similar clinical presentation to that of NTOS, such as abnormalities of the cervical spine or nerve roots, shoulder pathology, myofascial or rheumatologic conditions such as fibromyalgia or polymyalgia rheumatic, or a peripheral nerve compression syndrome. Many of these conditions can be ruled in or out, thereby narrowing the differential diagnosis, by means of the various laboratory or imaging studies discussed above. MR or CT scanning of the shoulder joint can accurately demonstrate the presence or absence of a rotator cuff tear; electrodiagnostic or medical imaging studies can demonstrate the presence of cervical spine or neural foraminal abnormalities; and EMG and/or NCV studies are highly sensitive and specific in finding the presence of carpal or cubital tunnel syndrome.

Accordingly, perhaps the greatest role to be played by the performance of various laboratory studies in assessing patients thought potentially to be harboring NTOS is to rule out alternative competing conditions. If cervical spine, nerve root, shoulder and peripheral nerve compression problems have been satisfactorily excluded, the likelihood that NTOS is the actual diagnosis rises markedly. The profusion of diagnostic tests promoted to evaluate patients who might be harboring NTOS is proof positive of the unhappy truth that none is adequately sensitive or specific to confirm or eliminate that diagnosis, but such evaluations remain valuable for excluding other potential diagnoses.

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