Neurogenic Thoracic Outlet Syndrome

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Disclosures

- Consultant/Advisory Board: GlaxoSmithKline Consumer Healthcare, Eli Lilly
- Media Work: Algiatry, LLC
- This presentation may contain references to off-label or investigational use of drugs or products

Learning Objectives

- Identify the three forms of thoracic outlet syndrome and which one is the most common?
- Recognize the histologic findings that demonstrate the anterior or middle scalene muscles may be a causative factor for NTOS
- Describe the value of chemodenervation of the anterior scalene muscle with botulinum toxin

Epidemic

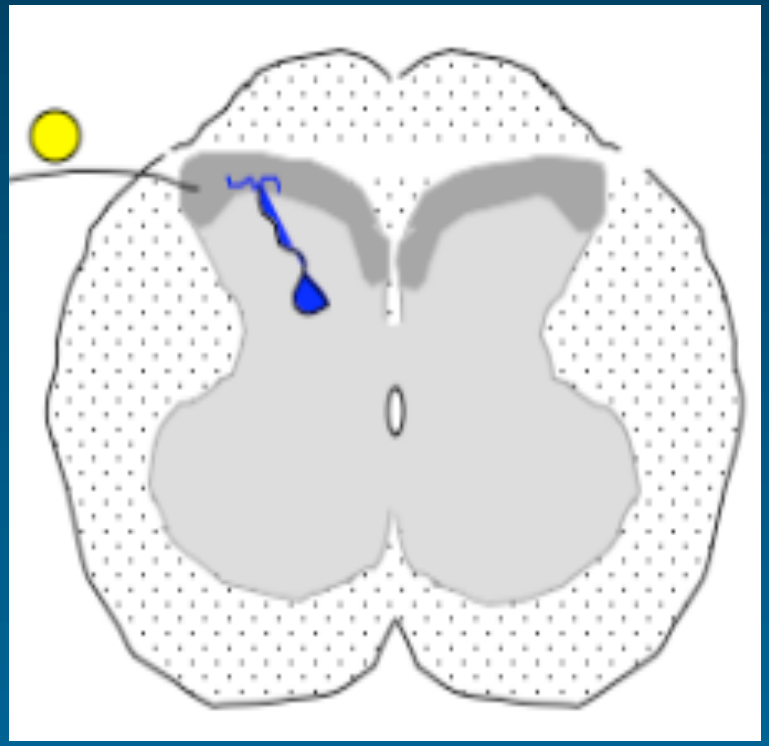
- Undiagnosed, untreated, undertreated pain significant public health problem
- Diminishes quality of life, financial well-being
- Increases disability, functional limitations, depression & anxiety
- Approximately *116 million* living with chronic pain
- Economic costs between *$560-625 billion annually*
- *Pain as a disease*

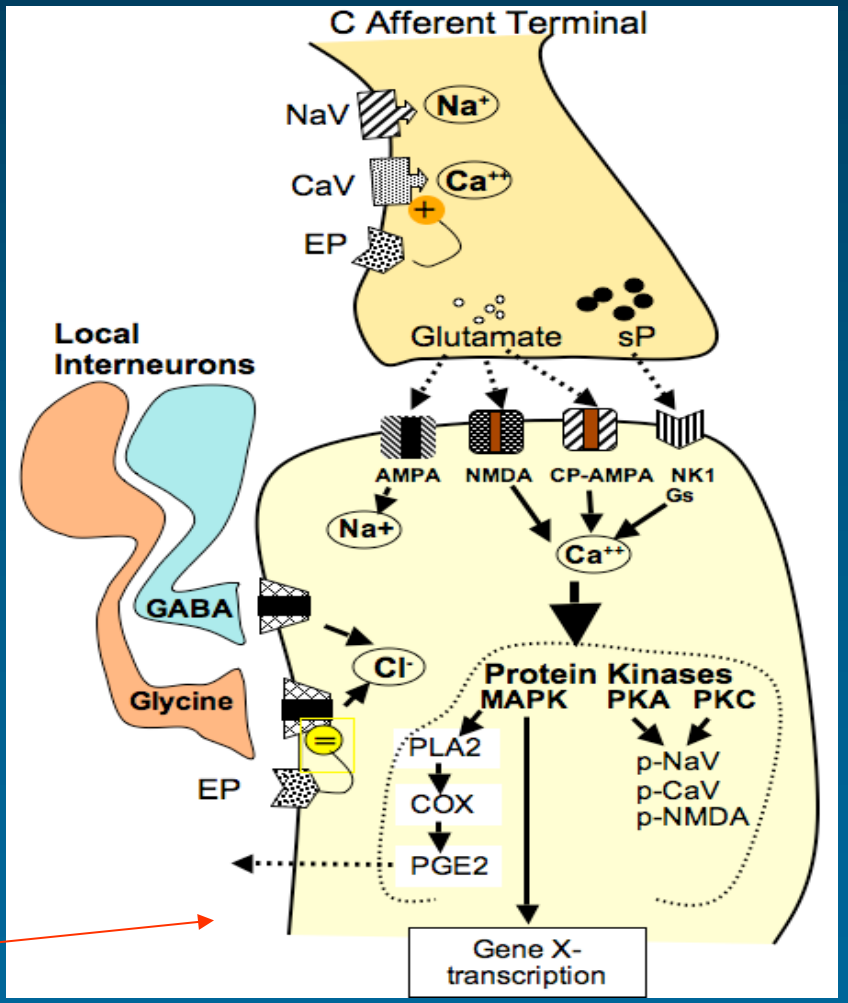
Green CR. Journal of Pain (2008); 9 (12): 1071-1073; Stewart WF, Ricci JA, et al. JAMA (2003);290:2443-2454; Farrell MJ. Am Pain Soc Bull (2000);10:8-12

Helme R, Gibson S: In Crombie IK (ed): Epidemiology of Pain (1999), 103-112

Institute of Medicine of The National Academies: Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education and Research to Congress (June 2011)

Central Sensitization





Dorsal horn of spinal cord:

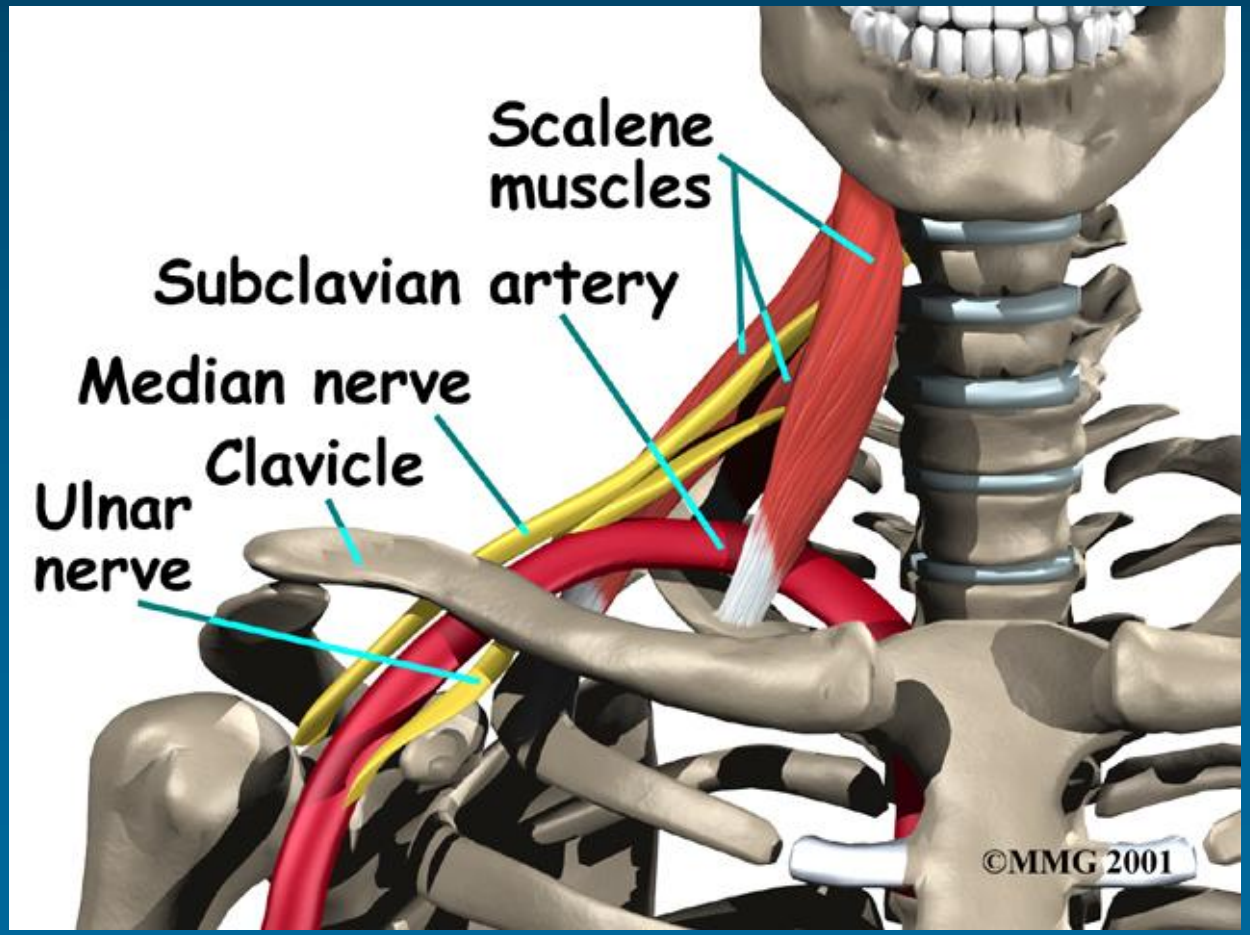
Dorsal horn of spinal cord: Neural injury leads to glutamate release from primary afferent fibers and this triggers intracellular events that lead to activation of gene transcription

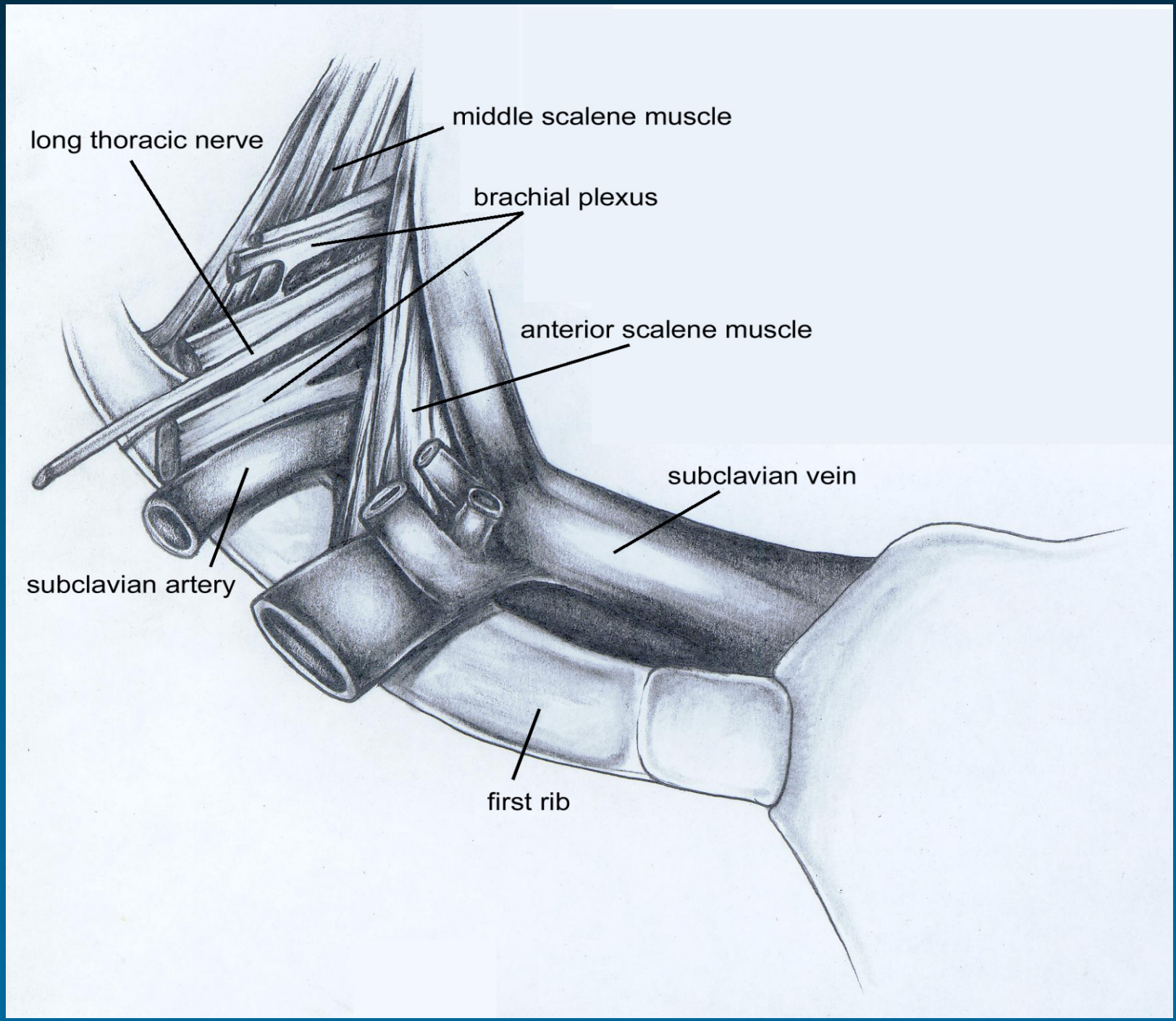
(Yaksh, TL)

True Neurogenic Thoracic Outlet Syndrome

Figure. Atrophy of left thenar and hypothenar muscles.

Thoracic Outlet Syndrome



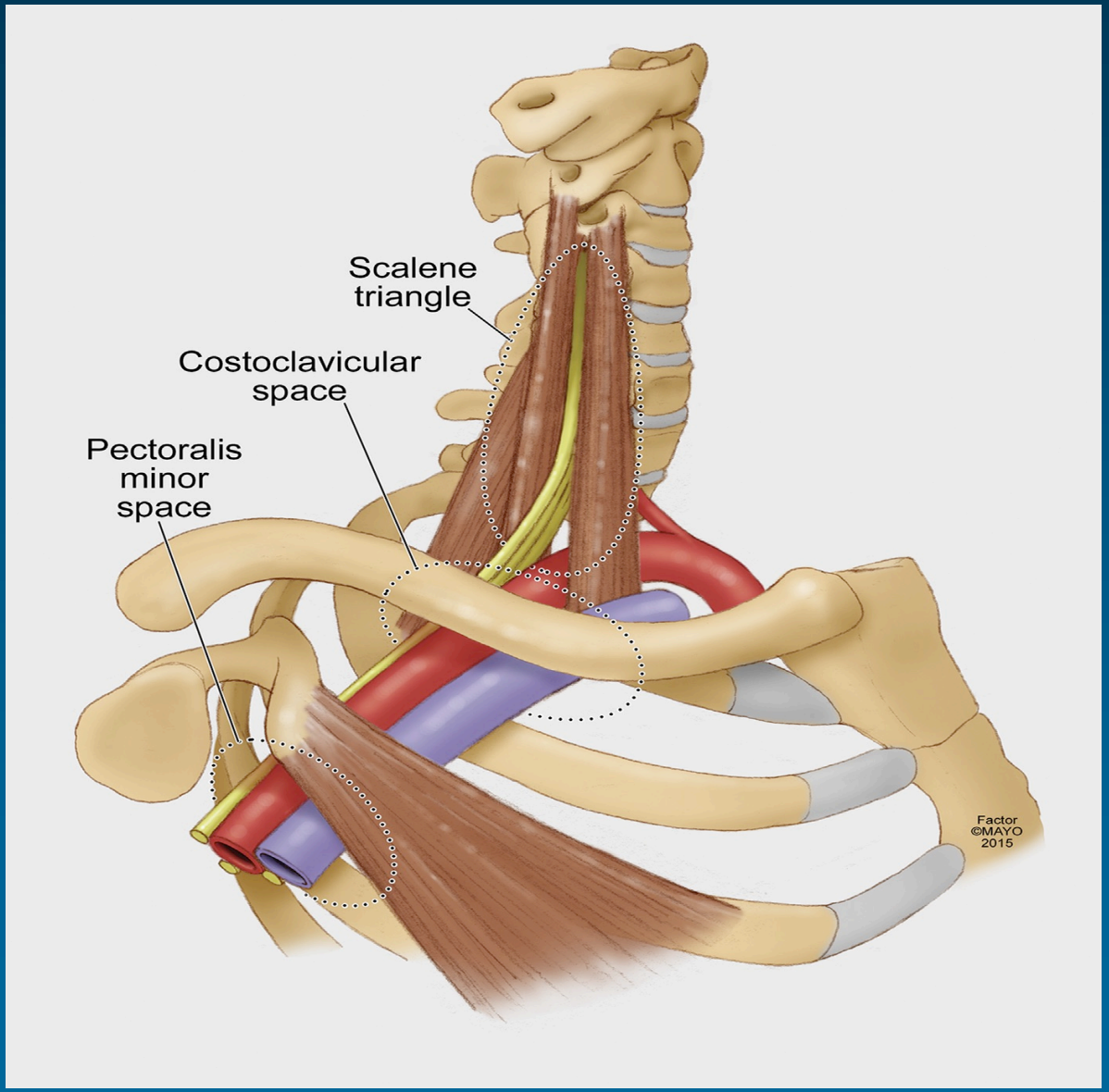

long thoracic nerve
middle scalene muscle
brachial plexus
anterior scalene muscle
subclavian vein
subclavian artery
first rib

Thoracic Outlet Syndrome
Overview

- Compression of the brachial plexus or blood vessels (subclavian artery or vein)
  - 95-98% *neurogenic* source
- Inadequate passageway between base of the neck and the armpit (scalene hypertrophy, fibrosis, cervical rib)
  - Repetitive activities - assembly line, keyboard typing
  - Neck injuries from MVA - whiplash
  - Sports – swimmers, volleyball, baseball pitchers, weightlifters
  - String instruments – violin, viola
- Numbness, tingling in fingers, pain in neck, shoulder or arm, muscle spasms around scapula, headaches, upper extremity weakness

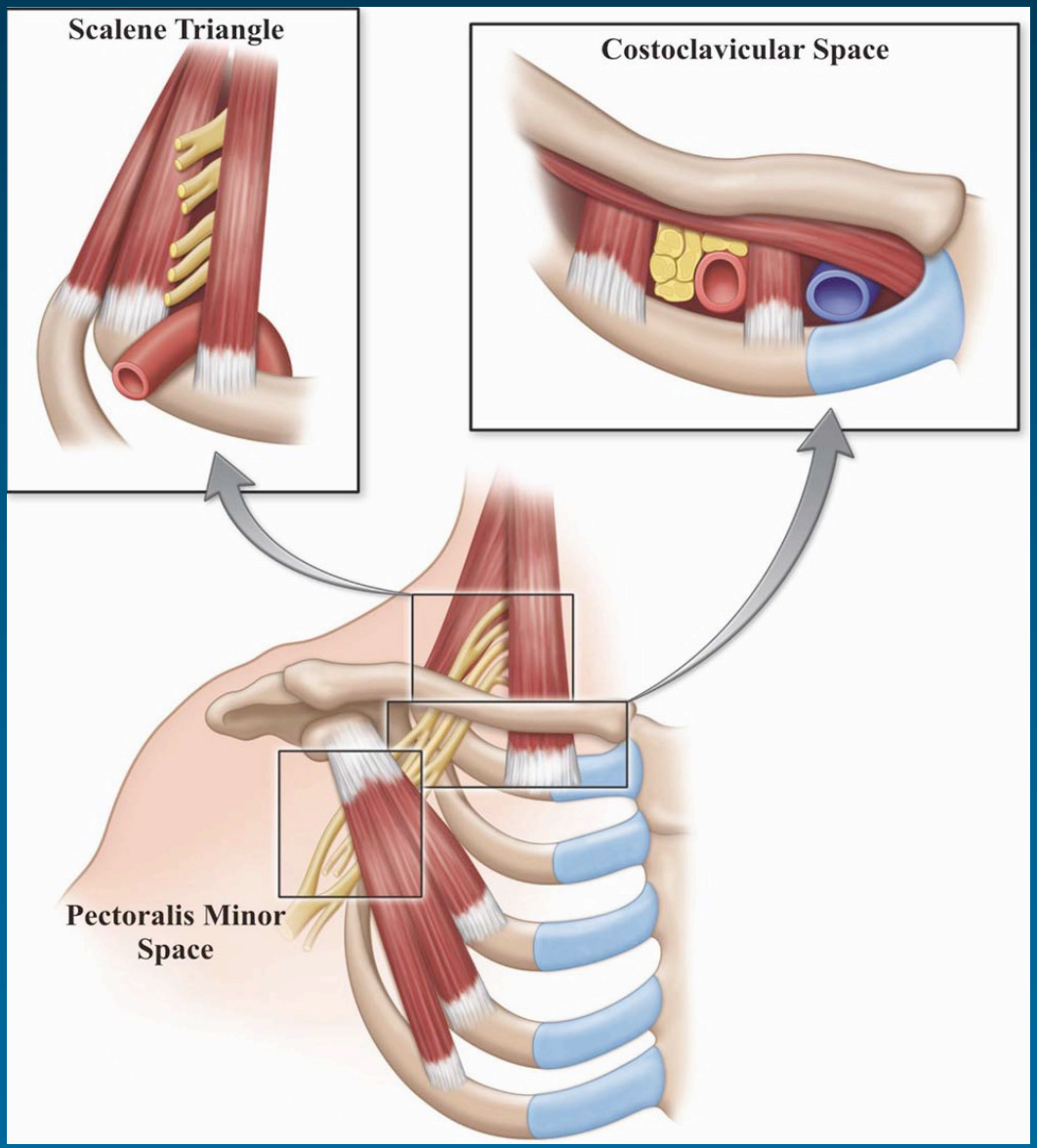
Christo PJ, McGreevy K: Updated Perspectives on Neurogenic Thoracic Outlet Syndrome. Anesthetic Techniques in Pain Management. In: Silberstein SD (ed): *Current Pain and Headache Reports,* Philadelphia, PA., 15 (1): 14-21; DOI 10.1007/s11916-010-0163-1 (2011).

Potential Compression Sites



Illig et al. Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome. Journal of Vascular Surgery. 2016;64:e23-35

Potential Compression Sites



Klaassen et al. Thoracic outlet syndrome: A neurological and vascular disorder. Clinical Anatomy 27:724-732 (2014)

Neurogenic Thoracic Outlet Syndrome
Overview

- Congenital predisposition and injury compromises outlet
- Narrowed space affects scalene muscles, brachial plexus, long thoracic and suprascapular nerves, and stellate ganglion
- Complex spectrum disorder provokes controversy
  - One of the most controversial diagnoses in medicine
- If untreated, QOL as impaired as those with chronic heart failure

Chang, DC, Rotellina-Coltvet LA, et al. Surgical intervention for thoracic outlet syndrome improves patient's quality of life. J Vasc Surg, 2009 49(3), 630-5

Neurogenic Thoracic Outlet Syndrome
Classification

- Three forms exist
  - Neurogenic/Disputed (presumed brachial plexus compression)
  - Arterial (subclavian artery compression)
  - Venous (subclavian vein compression)

- True NTOS
  - Subclassification with objective findings; 1% of cases

- Common/Disputed NTOS; 99% of neurogenic cases
  - Symptoms suggestive of brachial plexus compromise, but not many objective findings

Atasoy, E. Thoracic outlet compression syndrome. Orthop Clin North Am. 1996 27 (2) 265-303.
Brantigan, CO, Roos DB. Etiology of neurogenic thoracic outlet syndrome. Hand Clin. 2004 20(1) 17-22.

Neurogenic Thoracic Outlet Syndrome
Etiology

- A Space Problem
  - Congenital anomalies with superimposed traumatic injury, muscle spasm, fibrosis
  - Congenital – cervical rib and fibrous bands narrow space through which nerve roots of brachial plexus pass. Induce symptoms
- Hyperextension-Flexion Injuries, Whiplash, Repetitive Stress Injury
- Histologic studies show either ASM or middle scalene muscle injury likely causative factor
  - Muscle fibrosis prime finding upon exam of excised scalene muscles
  - Scar tissue 3 X greater than controls

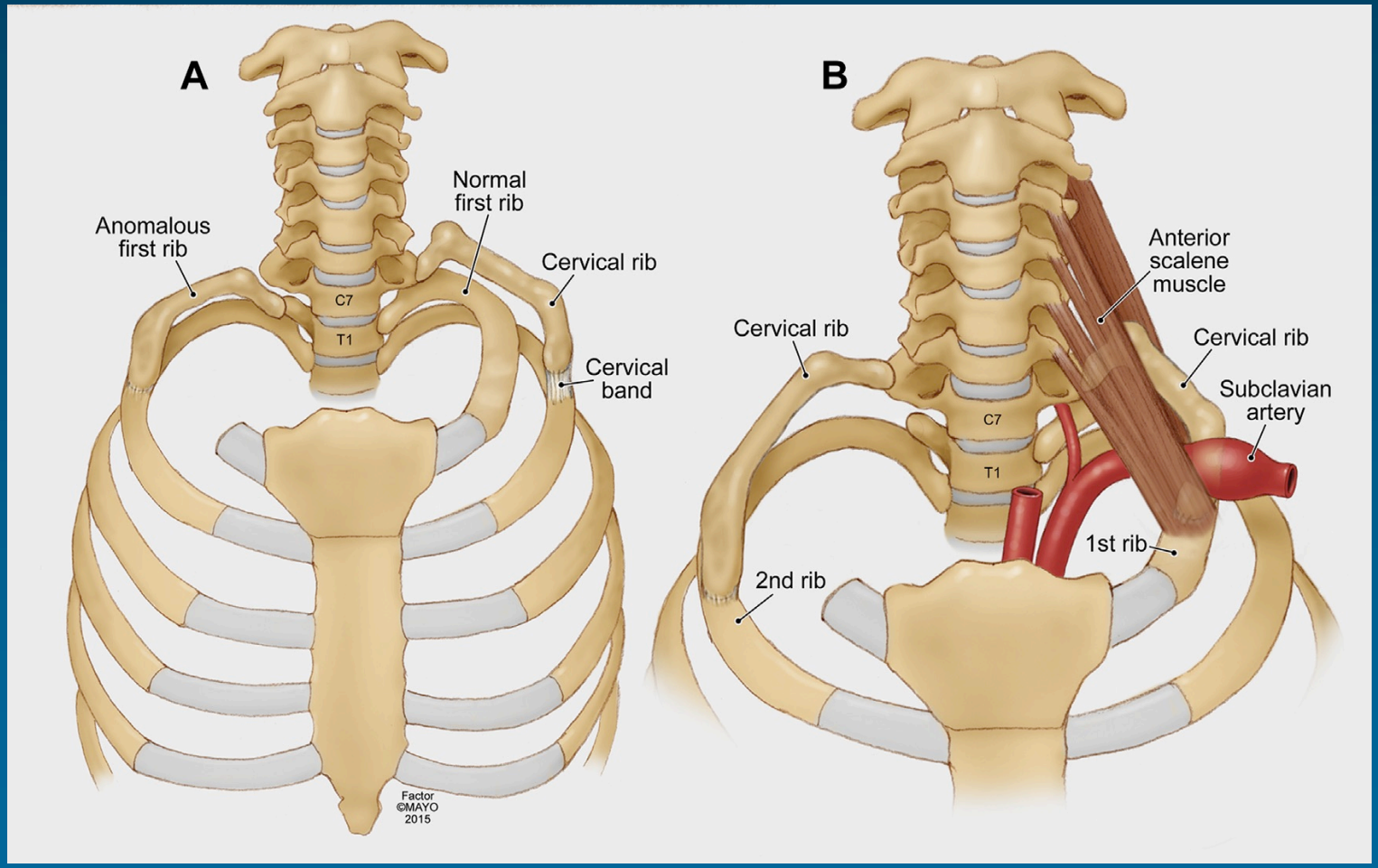
Brantigan, CO, Roos DB. Etiology of neurogenic thoracic outlet syndrome. Hand Clin. 2004 20(1) 17-22.

Sanders RJ, Hammond SL, et al. Thoracic Outlet Syndrome. A Review. The Neurologist 2008. 14 (6) 365-373.

Machleder HI, Moll F, et al. The anterior scalene muscle in thoracic outlet compression syndrome. Histochemical and morphometric studies. Arch Surg 1986;121(2):405-9

Aranyi Z, Csillik A, Bohm J, et al. Ultrasonographic identification of fibromuscular bands associated with neurogenic thoracic outlet syndrome: the wedge-sickle sign. Ultrasound Med Biol 2016;42:2357-66

Anomalous Ribs



Illig et al. Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome. Journal of Vascular Surgery. 2016;64:e23-35

Neurogenic Thoracic Outlet Syndrome
Etiology – Anterior Scalene Muscle

- ASM derives from transverse processes of C3-C6 vertebrae
  - Attaches to first rib
  - Accessory muscle of respiration
  - Bends and rotates neck slightly
- Spasm puts traction on brachial plexus and causes muscle edema, neural edema and limits outlet
- Scar development and fibrosis worsen neural compromise and perpetuate pain
- Target ASM to relieve tension, spasm and interrupt events leading to NTOS

Brantigan, CO, Roos DB. Etiology of neurogenic thoracic outlet syndrome. Hand Clin. 2004 20(1) 17-22.
Atasoy E. Thoracic outlet syndrome: anatomy. Hand Clin 2004. 20(1); 7-14

Neurogenic Thoracic Outlet Syndrome
Clinical Presentation

- 3-4 Xs more frequent in women than men
- Incidence – 3 to 80 cases per 1,000 people
- Violinists, data entry personnel, assembly line workers especially vulnerable
- Athletes with repetitive overhead arm motion (volleyball, swimming, baseball pitchers, weightlifters)
- History of neck trauma, or to shoulder girdle and arm reported in 70-80% of patients

Sanders RJ, Hammond SL, et al. Thoracic Outlet Syndrome. A Review. The Neurologist 2008. 14 (6) 365-373.
Doneddu PE, Coraci D, et al. Thoracic outlet syndrome: wide literature for few cases. Status of the art. Neurol Sci (2017) 38:383-388

Neurogenic Thoracic Outlet Syndrome
Clinical Presentation

- Classic: Pain from shoulder and radiates down inner aspect of arm (lower plexus compression traditionally)
- Often: neck, trapezius, mastoid, anterior chest wall pain, or HAs from upper plexus compression (C5-C7)
- Can see neurogenic and vascular symptoms from SNS activation (C8-T1 fibers)
- Exam shows:
  - Tender scalene muscles, trapezius, chest wall
  - Positive Tinel sign over brachial plexus in neck
  - Reduced sensation to light touch in fingers
  - Positive provocative maneuvers

Sanders RJ, Hammond SL, et al. Thoracic Outlet Syndrome. A Review. The Neurologist 2008. 14 (6) 365-373.
Doneddu PE, Coraci D, et al. Thoracic outlet syndrome: wide literature for few cases. Status of the art. Neurol Sci (2017) 38:383-388

Neurogenic Thoracic Outlet Syndrome
Differential Diagnosis

- Entire arm often involved without dermatomal preference
- Often nonspecific clinical presentation
- Confounds accurate diagnosis
- Distinguish between:
  - Cervical radiculopathy from disc herniation or stenosis
  - Carpal tunnel syndrome, Cubital tunnel

Laulan J, Fouquet B, et al. Thoracic outlet syndrome: definition, aetiological factors, diagnosis, management and occupational impact. J Occup Rehabil (2011) 21 (3):366-373

Neurogenic Thoracic Outlet Syndrome
Diagnosis

- Thorough history and physical exam - key
- Ancillary testing lacks sensitivity and specificity
- Provocative testing (Adson maneuver, Roos, Wright) unknown reliability and low specificity
- Provocative Maneuvers
  - Nerve Tension Tests
    - Thumb pressure over brachial plexus
    - EAST (Elevated Arm Stress Test) – maybe most reliable
  - Vascular Tests
    - Adson Test – many false positives
  - Other Tests
    - Spurling test – identify cervical disc disease

Roos, DB. New concepts of TOS that explain etiology, symptoms, diagnosis and treatment. Vasc Surg 1979; 13: 313-21
Brantigan, CO, Roos DB. Diagnosing thoracic outlet syndrome. Hand Clin 2004; 20(1) 27-36
Rayan GM, Jensen C. Thoracic outlet syndrome: provocative examination maneuvers in a typical population. J Shoulder Elbow Surg. 1995 4(2) 113-117
Doneddu PE, Coraci D, et al. Thoracic outlet syndrome: wide literature for few cases. Status of the art. Neurol Sci (2017) 38:383-388

Neurogenic Thoracic Outlet Syndrome

Diagnostic Testing

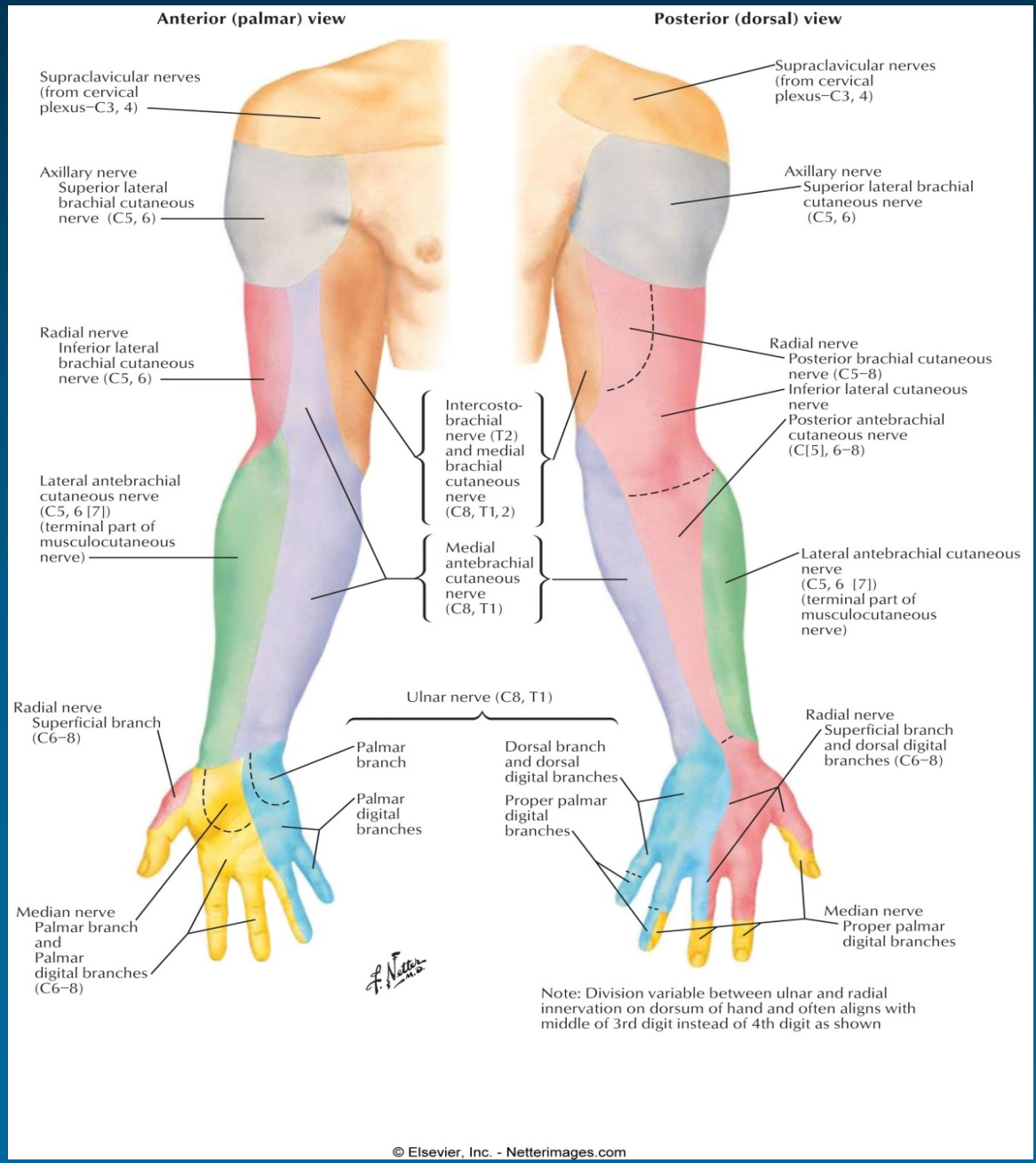
- EMG/NCT
  - Often normal
  - Can exclude radiculopathy, carpal tunnel syndrome, cubital tunnel syndrome, polyneuropathy
- Chest X ray
  - Identify cervical rib
- MRI/CT
  - Rule out conditions that can mimic NTOS
- 3T-MR Brachial Plexus Neurography
  - 7/30 patients identified with morphological correlates (fibrous bands of the brachial plexus) of TOS which were confirmed by surgical exploration
- Medial Antebrachial Cutaneous Nerve Conduction Study (MAC)
  - Can detect milder cases of NTOS
  - Measures sensory function of lower trunk of brachial plexus
  - Can be abnormal in pts with normal EMG/NCT
  - Need more validation studies

Foley JM, Finlayson H, et al. A review of thoracic outlet syndrome and the possible role of botulinum toxin in the treatment of this syndrome. Toxins (Basel). 2012;4:1223-1235

Sanders RJ, Hammond SL, et al. Thoracic Outlet Syndrome. A Review. The Neurologist 2008. 14 (6) 365-373.

Baumer P, Kele H, et al. Thoracic outlet syndrome in 3T MR neurography-fbrous bands causing discernible lesions of the lower brachial plexus. Eur Radiol (2014) 24(3):756-761

Cutaneous Innervation of the Upper Extremity



Netter, F. Atlas of Human Anatomy. Plate 464.permission granted

Neurogenic Thoracic Outlet Syndrome
Anterior Scalene Block

- Intramuscular Supportive Test
- Paralyzes the muscle in spasm, allows first rib to descend (ASM attaches to the first rib), and decompresses thoracic outlet
- First described in 1939
- Positive response correlates well with good surgical outcomes
  - Temporary muscle relaxation helps predict benefit from decompression
  - 94% of patients with positive block had good outcomes following decompressive surgery V 50% having surgery with a negative block who underwent surgery.
- Anatomic Landmarks, EMG, Ultrasound, CT Guidance
- CT minimizes Horner's sign, dysphonia, brachial plexus block, dysphagia

Fugate MW, Rotellini-Coltvert L, et al. Current management of thoracic outlet syndrome. Curr Treat Options Cardiovasc Med 2009, 11 (2); 176-83.

Jordan SE, Machleder HI. Diagnosis of thoracic outlet syndrome using electrophysiologically guided anterior scalene blocks. Ann Vasc Surg 1998 12: 260-4

Mashayekh A, Christo PJ, et al. CT guided injection of the anterior and middle scalene muscles: Techniques and complications. American Journal of Neuroradiology 2011; 32: 495-500

CT Guided Scalene Injections

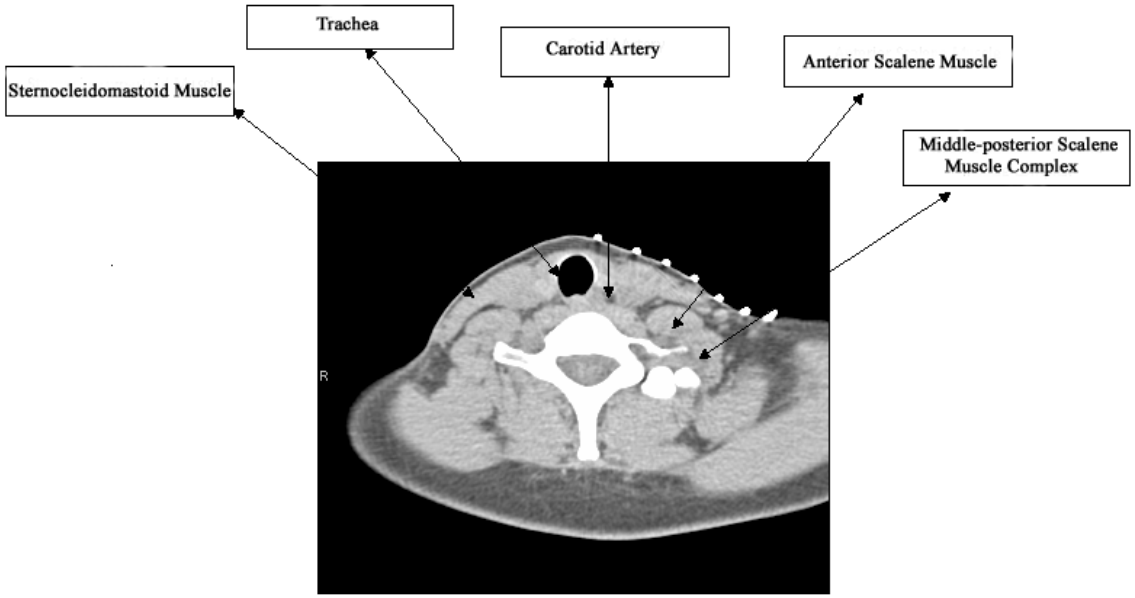


Figure 1: Axial non-contrast CT scan image at the level prior to injection demonstrates the anterior scalene muscle, the middle –posterior scalene muscle complex, the trachea, the sternocleidomastoid muscle and the carotid artery. Note on subsequent images, needle insertion into the anterior scalene muscle followed by contrast accumulation, and then spread of contrast after injection of botulinum toxin.

Christo PJ, Christo DK, Carinci AJ, Freischlag JA: Single CT-Guided Chemodenervation of the Anterior Scalene Muscle with Botulinum Toxin for Neurogenic Thoracic Outlet Syndrome. *Pain Medicine* 2010;11:504-511.

CT Guided Scalene Injections

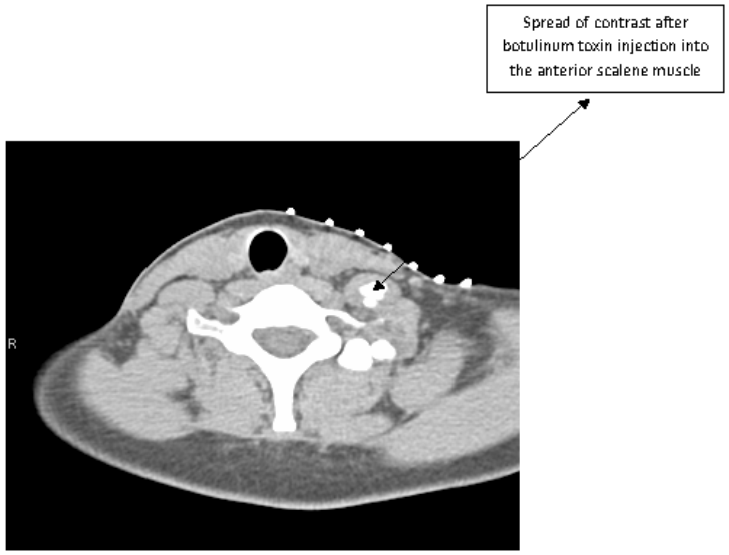


Figure 4

Christo PJ, Christo DK, Carinci AJ, Freischlag JA: Single CT-Guided Chemodenervation of the Anterior Scalene Muscle with Botulinum Toxin for Neurogenic Thoracic Outlet Syndrome. *Pain Medicine* 2010;11:504-511.

Neurogenic Thoracic Outlet Syndrome

Conservative Treatments

- Conservative
  - Ergonomic Correction
  - Posture Correction
  - Nerve Glides
  - Stretching exercises
  - Biofeedback
- These focus on decompressing the brachial plexus, restoring muscle balance in the neck, providing neural mobility
- Cognitive Behavioral Therapy
  - Modify pain perception: reframe experience in positive terms
  - Modify self talk
  - Minimize catastrophizing

Crosby CA, Wehbe MA. Conservative treatment of thoracic outlet syndrome. Hand Clin 2004; 20: 43+49.

Novak CB, Collins ED, et al. Outcome following conservative management of thoracic outlet syndrome. J Hand Surg Am 1995; 20A: 542-548

Neurogenic Thoracic Outlet Syndrome
Physical Therapy

- Some data support the use of heat packs, exercise program, cervical traction.
- Inpatient rehab followed by home exercise program high % satisfaction rate
- Sig pain decrease and treatment satisfaction with postural correction and shoulder girdle strengthening exercises over 14 months
- 60-70% may be successfully managed non-operatively when PT performed consistently for at least 8 weeks
- In general, some improve but others worsen without other interventions

Doneddu PE, Coraci D, et al. Thoracic outlet syndrome: wide literature for few cases. Status of the art. Neurol Sci (2017) 38:383-388

Taskaynatan MA, Balaban B, et al. Cerivcal traction in conservative management of thoracic outlet syndrome. Journal of Muscular Pain 2004 15 (1): 89-94

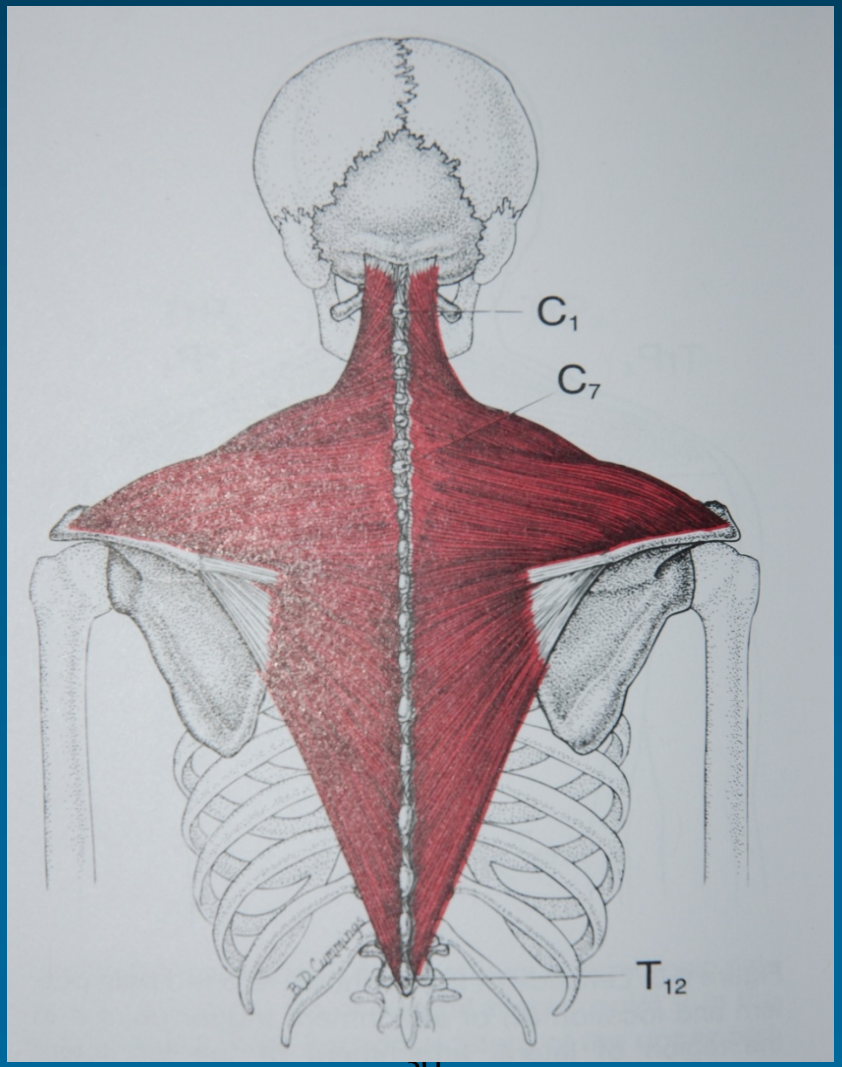
Gulbahar S, Akalin E, et al. Regular exercise improves outcome in droopy shoulder syndrome: a subgroup of thoracic outlet syndrome. Journal of Muscle Pain 2005; 13(4): 21-6

Neurogenic Thoracic Outlet Syndrome
Medications

- Muscle Relaxants
  - Tizanidine (Alpha 2 agonist)
- NSAIDS
  - Ibuprofen
- Trigger Point Injections (with local anesthetic)
- Tricyclic Antidepressants (nortriptyline)
- Serotonin-norepinephrine reuptake inhibitors (duloxetine)
- Membrane Stabilizers (gabapentin)
- If quality of life deteriorates and trials of other therapies fail, consider opioids

Sanders RJ, Hammond SL, et al. Thoracic Outlet Syndrome. A Review. The Neurologist 2008. 14 (6) 365-373.

Trapezius Muscle



Simons, D. et al .figure 6.5. permission granted.

Neurogenic Thoracic Outlet Syndrome
Minimally Invasive Approach – Botulinum Toxin

- CT imaging to place needle for diagnostic blocks/anterior scalene muscle alone
- Single, low dose injection into anterior scalene muscle with CT
- Botulinum Toxin (onabotulinumtoxinA) reduces muscle overactivity and may decrease pain and inflammation
- Approved use for hemifacial spasm, blepharospasm, strabismus, chronic migraine, et al.
- Safety and clinical benefit has expanded off-label use for lumbosacral myofascial pain, piriformis syndrome, lateral epicondylitis

Christo PJ, Christo DK, et al. Single, CT guided chemodenervation of the anterior scalene muscle with botulinum toxin for neurogenic thoracic outlet syndrome. Pain Med, 2010; 11(4): 504-11

Gracies JM. Pathophysiology of spastic paresis. II: Emergence of muscle overactivity. Muscle Nerve 2005; 31(5): 552-71

Aoki K. Review of proposed mechanism for the antinociceptive action of botulinum toxin type A. Neurotoxicology 2005; 26:785-793

Neurogenic Thoracic Outlet Syndrome
Botulinum Toxin

- Therapeutic effects
  - Reduces muscle overactivity
    - Blocks the release of acetylcholine & weakens the muscle for periods up to 3-4 months
  - May decrease pain and inflammation
    - Inhibit release of neuropeptides (substance P, glutamate) involved with nociceptive transmission and central sensitization
  - May improve wound healing in injured muscles & reduce scarring
  - Benefits in muscles affected by radiation fibrosis syndrome
  - 1969 evidence suggests that onabotulinumtoxinA effectively reduces painful muscular contractions from piriformis syndrome, cervical dystonia, foot dystonia, myofascial pain, and facial dystonia

Sheeran G. Botulinum toxin for the treatment of musculoskeletal pain and spasm. Curr Pain Headache Rep 2002; (6): 460-469

Christo PJ, McGreevy K: Updated Perspectives on Neurogenic Thoracic Outlet Syndrome. Anesthetic Techniques in Pain Management. In: Silberstein SD (ed): *Current Pain and Headache Reports,* Philadelphia, PA., 15 (1): 14-21; DOI 10.1007/s11916-010-0163-1 (2011).

Neurogenic Thoracic Outlet Syndrome
Chemodenervation Anterior Scalene Muscle

- Single, low dose injection (20 units onabotulinumtoxinA) into anterior scalene muscle with CT
- Prospective, longitudinal study
- 27 pts underwent 29 procedures under CT-guidance
- SF-MPQ prior to and at 1, 2, 3 months post onabotulinumtoxin A injection
- Substantial relief at months 1 and 2
- Significant relief at 3 months in sensory and VAS scores
  - 29% decrease in sensory and 15% decrease in VAS
  - Pain scores did not return to pre- intervention levels at 3 months

Christo PJ, Christo DK, Carinci AJ, Freischlag JA: Single CT-Guided Chemodenervation of the Anterior Scalene Muscle with Botulinum Toxin for Neurogenic Thoracic Outlet Syndrome. *Pain Medicine* 2010;11:504-511

Neurogenic Thoracic Outlet Syndrome

CT Imaging

- Benefits
  - Visualize nearby structures
  - Fast, accurate, reliable, safe
  - CT fluoroscopy permits real time imaging
  - Image not obscured by obesity and adjacent osseous structures
    - Can occur with ultrasound
  - Higher percentage of anesthetic injections result in positive blocks
    - 82% under CT versus Ultrasound (38%), EMG + fluoroscopy (18%), EMG alone (72%)
    - Verified by high rate of improvement after surgery (70%) which helps confirm true cases of NTOS using CT blocks
  - CT exposure time rarely exceeds 60 seconds

Christo PJ, Christo DK, Carinci AJ, Freischlag JA: Single CT-Guided Chemodenervation of the Anterior Scalene Muscle with Botulinum Toxin for Neurogenic Thoracic Outlet Syndrome. *Pain Medicine* 2010;11:504-511

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Mashayekh A, Christo PJ, et al. CT guided injection of the anterior and middle scalene muscles: Techniques and complications. American Journal of Neuroradiology 2011; 32: 495-500

Neurogenic Thoracic Outlet Syndrome Chemodenervation and *Other Imaging Studies*

- Fluoroscopic and EMG guidance (Jordan and Machleder 1998)
  - 64% of pts experienced more than 50% relief at 1 month
    - ASM, MSM, Trapezius
  - Mean duration of relief – 3 months
- Ultrasound + EMG (Jordan , Ahn, et al 2007)
  - 91% good outcome
- Fluoroscopy + EMG (Jordan , Ahn, et al 2007)
  - 81% good outcome
- Ultrasound (Torriani, Gupta et al 2009)
  - 69% pain relief after injection into ASM and pectoralis
  - Mean duration of relief 31 days

Neurogenic Thoracic Outlet Syndrome Chemodenervation and *Other Imaging Studies*

- EMG guidance (Finlayson et al, 2011)
  - No significant pain improvement in 20 patients receiving onabotulinumtoxinA
  - 18 patients received placebo (saline)
  - ASM and Middle Scalene Muscle targeted
  - 6 month follow up
  - Dbl blind, RCT
  - Several Limitations
    - Mean pain duration of 6 years
      - ? Development of chronic pain and central sensitization
    - Some had low levels of baseline pain
    - Suboptimal blinding methods leading to unblinding or allocation bias

Overview of Neurogenic Thoracic Outlet Syndrome

Christo PJ, McGreevy K. Updated Perspectives on Neurogenic Thoracic Outlet Syndrome. *Current Pain and Headache Reports* 2010

Etiology	Cervical trauma (hyperextension/whiplash injury, exercise-induced scalene muscle hypertrophy, sagging shoulders), cervical rib, hypertrophied anterior scalene muscle, repetitive work-related injury, anomalous first ribs, congenitally narrowed interscalene triangle, fibrous bands
Clinical presentation	**Upper plexus** (C5—C7) symptoms: ipsilateral neck or ear pain; pain in face, temple, mandible, and/or occipital areas with headaches; clavicular and pectoral pain that moves to trapezius and deltoid down lateral arm
	Lower plexus (C8–T1) symptoms: anterior and posterior shoulder pain that radiates down medial arm forearm to hand and fourth and fifth fingers. Pain may occur in ipsilateral neck, mastoid, or occiput, causing headaches.
	General: aching, radiating down arm. Arm elevation (eg, brushing hair, working overhead, painting, housework) or carrying heavy objects exacerbates pain. Numbness, paresthesias, progressive weakness, fatigue, hand dysfunction. Symptoms may be worse at end of day; sleep disruption and cold weather worsen symptoms. Sympathetic disturbance rare: bluish-red discoloration of arm, blanching of hand.
Diagnostic measures	No definitive test. Careful history and physical examinations are critical (pressure over anterior scalene muscle and supraclavicular fossa may reproduce symptoms). EAST is most reliable provocative maneuver. Electrodiagnostics, radiographs, ad MRI useful for excluding other causes (carpal or cubital tunnel syndrome, cervical disc disease, cervical ribs, shoulder problems). Anterior scalene block may be an effective confirmatory test by relaxing muscle, letting first rib to descend, and decompressing brachial plexus. Useful for predicting successful surgical outcome. • MR Neurography
Minimally invasive therapies	Physical Modalities: physiotherapy, ergonomic correction, work limitations, postural correction; Medications: muscle relaxants, NSAIDS, TCAs, SNRIs, membrane stabilizers, opioids; Intramuscular cervicothoracic botulinum toxin injections: Guided by CT, ultrasound, fluoroscopy, and/or EMG. Targeting various muscles: anterior scalene, middle scalene, trapezius, pectoralis minor, spenius cervicis, supraspinatus, rhomboid major, subclavius.
Surgical Interventions	Procedure and approach: first rib resection, scalenectomy, or first rib resection and scalenectomy either by supraclavicular and/or transaxillary techniques

Neurogenic Thoracic Outlet Syndrome

- Minimally Invasive Therapy with onabotulinumtoxinA
  - Pain reduction for 3 months
  - Avoids surgery, surgical complications, time off work
    - PT starts 2 wks after surgery for 8 weeks; 2-3 months off work; no lifting 10 lbs for 6 months
  - Value – non surgical candidates, bridge to surgery, trial before surgery

Christo PJ, McGreevy K: Updated Perspectives on Neurogenic Thoracic Outlet Syndrome. Anesthetic Techniques in Pain Management. In: Silberstein SD (ed): *Current Pain and Headache Reports,* Philadelphia, PA., 15 (1): 14-21; DOI 10.1007/s11916-010-0163-1 (2011).


4/29/2002

NeurogenicThoracic Outlet Syndrome
Surgical Approach

- Different Approaches
- Comparative efficacy data lacking on approaches
  - Low quality evidence that transaxillary first rib resection reduces pain more than supraclavicular scalenectomy
    - No randomized evidence that either is better than no treatment
- Reports of high success and low complication rates
  - 90% success rate
- Longitudinal Studies
  - 60% recurrence within first year after surgery, and 80% within 2nd year
- Persistent disability in 60% of pts 1 year after surgery
  - Complication rate higher than 30%
- Endoscopic transaxillary first rib resection or robotic first rib resection

Franklin GM, Fulton-Kehoe D, et al. Outcome of surgery for thoracic outlet syndrome in Washington state worker's compensation. Neurology 2000;54:1252-7
Chang DC, Lidor AO, et al. Reported in hospital complications following rib resections for neurogenic thoracic outlet syndrome. Ann Vasc Surg 2007;21 (5): 564-70
Atasoy E. A hand surgeon's further experience with thoracic outlet compression syndrome. J Hand Surg Am 2010; 35(9):1528-38
Povlsen B, Hansson T, et al. Treatment for thoracic outlet syndrome. Cochrane Database of Systematic Reviews 2014, Issue 11

Neurogenic Thoracic Outlet Syndrome
Conclusion

- Most common type of TOS
- Often overlooked and misdiagnosed → Objective findings scarce
- Persistent pain, impaired function, emotional distress
- If untreated, QOL as impaired as those with chronic heart failure
- Emerging evidence supports minimally invasive chemodenervation of cervicothoracic musculature with botulinum toxin
  - Before or in lieu of surgical decompression

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