Neurogenic Thoracic Outlet Syndrome

Robert D McBane II MD

Gonda Vascular Center

Disclosures

- No relevant disclosures related to this talk

Neurogenic Thoracic Outlet Syndrome: Learning Objectives

- To review the pertinent anatomy of the thoracic outlet
- To appreciate the different clinical presentations of thoracic outlet syndrome
- To understand the results of recent randomized clinical trials for thoracic outlet syndrome treatment
- To digest a proposed randomized clinical trial design from Gonda 4 Vascular Center

Resource

Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome

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:e23-e35.)

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.[1-3] 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). Moreover, neurovascular compression can potentially occur at three different anatomic levels: the interscalene triangle, the costoclavicular space, or the pectoralis minor space. NTOS especially is often difficult to manage, in part because of nonspecific symptoms, poorly understood pathophysiologic mechanisms, limited applicability of "objective" testing procedures, and potential overlap with other clinical disorders as well as an absence of well-defined, generally accepted, or consistently applied criteria for diagnosis and treatment. Summarizing these points, the diagnosis of TOS (particularly neurogenic) is subjective, controversial, and highly variable. As a result, research in this area is challenging to plan and perform, and published literature is frequently difficult to interpret and compare. This leads to highly variable care.

The importance of addressing this situation was highlighted in a recent Cochrane Collaboration review of treatment for TOS, which concluded that there is no randomized evidence to support the most commonly used treatments and that there is a need for agreed definitions, consistent outcome measures, and high-quality clinical trials that compare the outcome of interventions with no treatment and with each other.[2] The goals of this document are therefore twofold:

1. *To standardize terminology, nomenclature, and definitions* and thus ensure that all are describing the same entities. There needs to be consensus on the diagnosis itself, degrees of severity, and methods of measuring outcomes. Only by ensuring that all are speaking the same language can results be compared in a meaningful way.
2. To establish consistent *reporting standards* regarding all three forms of TOS. Such standards should lead to description of each situation with a high degree of reliability and consistency over time and among practitioners, guide accurate assessment of outcomes, and ensure consistent reporting when formal descriptions of results are made so that experiences can be more accurately compared with each other.

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]

Author conflict of interest: none.

Independent peer review and oversight has been provided by members of the SVS Document Oversight Committee: Peter Gloviczki, MD (Chair), Ruth Bush, MD, Michael Conte, MD, Hans Henning Eckstein, MD, Mark Eskandari, MD, Thomas Forbes, MD, Glenn LaMuraglia, MD, Michel Makaroun, MD, Gregory Moneta, MD, Amy Reed, MD, Russell Samson, MD, Piergiorgio Settembrini, MD.

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

0741-5214

http://dx.doi.org/10.1016/j.jvs.2016.04.039

J Vasc Surg 2016;64:e23-e35

37 year-old right-handed female

- 1998 Right clavicular fracture
- 2011 Self employed “sewing factory”
- 2015 Self employed “painter”
- 2018 Began to note “shooting pain” right shoulder to finger-tips.
  Ortho: “Radial tunnel syndrome”, ***try physical therapy***
- 2019 Vascular Surgery: “neurogentic TOS”, ***try physical therapy***
- 2020 Ortho: Scalene block with complete symptom relief
  Surgery offered but deferred
- 2021 Thoracic surgery: Repeat scalene block successful
  Botox offered but deferred

37 year-old right-handed female

- 2021 Gonda Vascular Center Referral TOS Clinic

  "Daily Stabbing pain begins in shoulder radiating to fingers.

  <u>Aggravating</u>: unloading dishwasher, painting, any overhead activity."

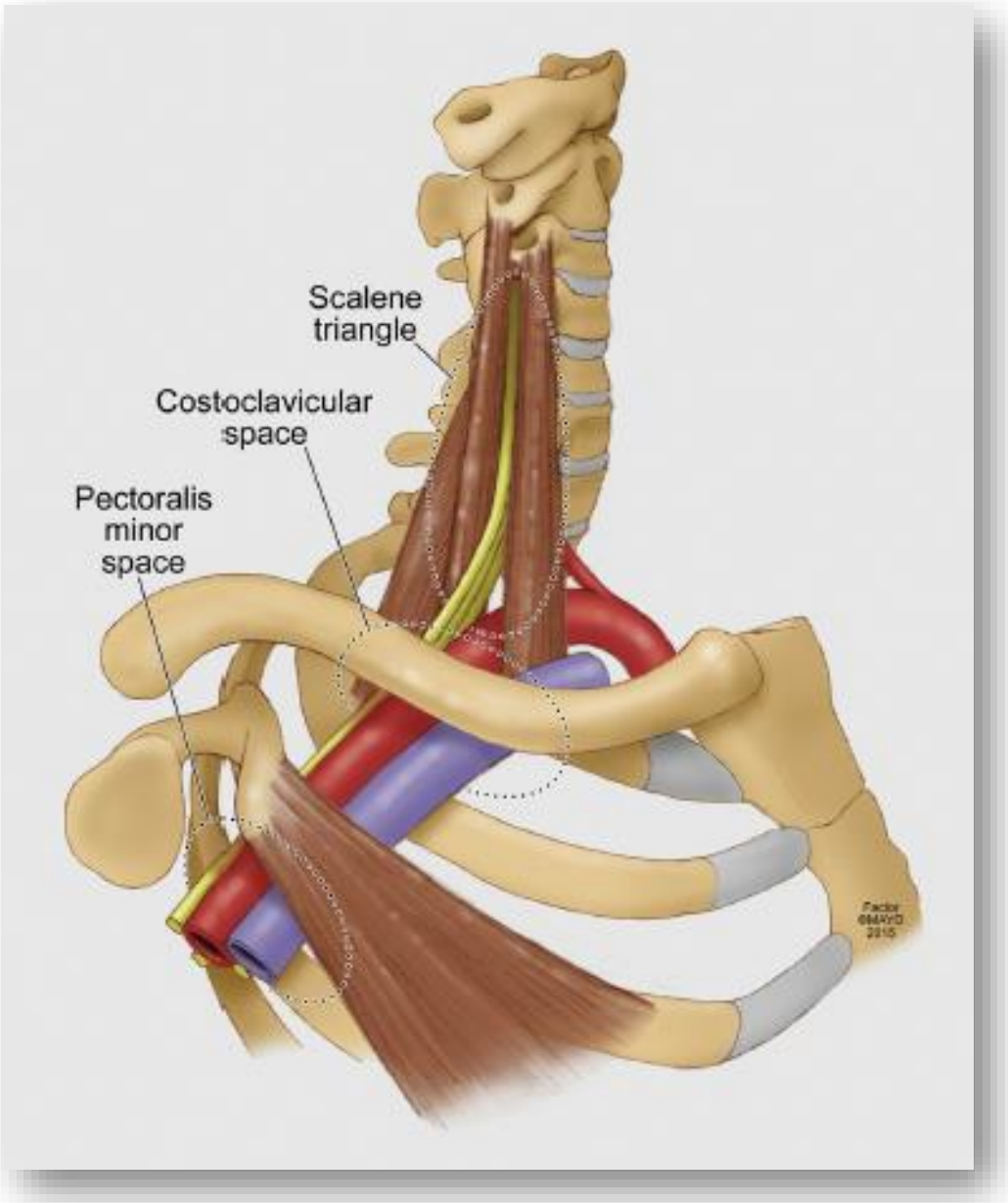
  "Fatigue with intermittent numbness"

  Pain severely impacting her life. No longer paints.

Thoracic Outlet Syndrome

What is the ***Thoracic Outlet***?
What are the disease ***categories***?
Where does ***“pinching”*** occur?

Right Thoracic Outlet



Scalene Triangle (N, A)
Costoclavicular Space (V)
Pectoralis Minor Space (N)

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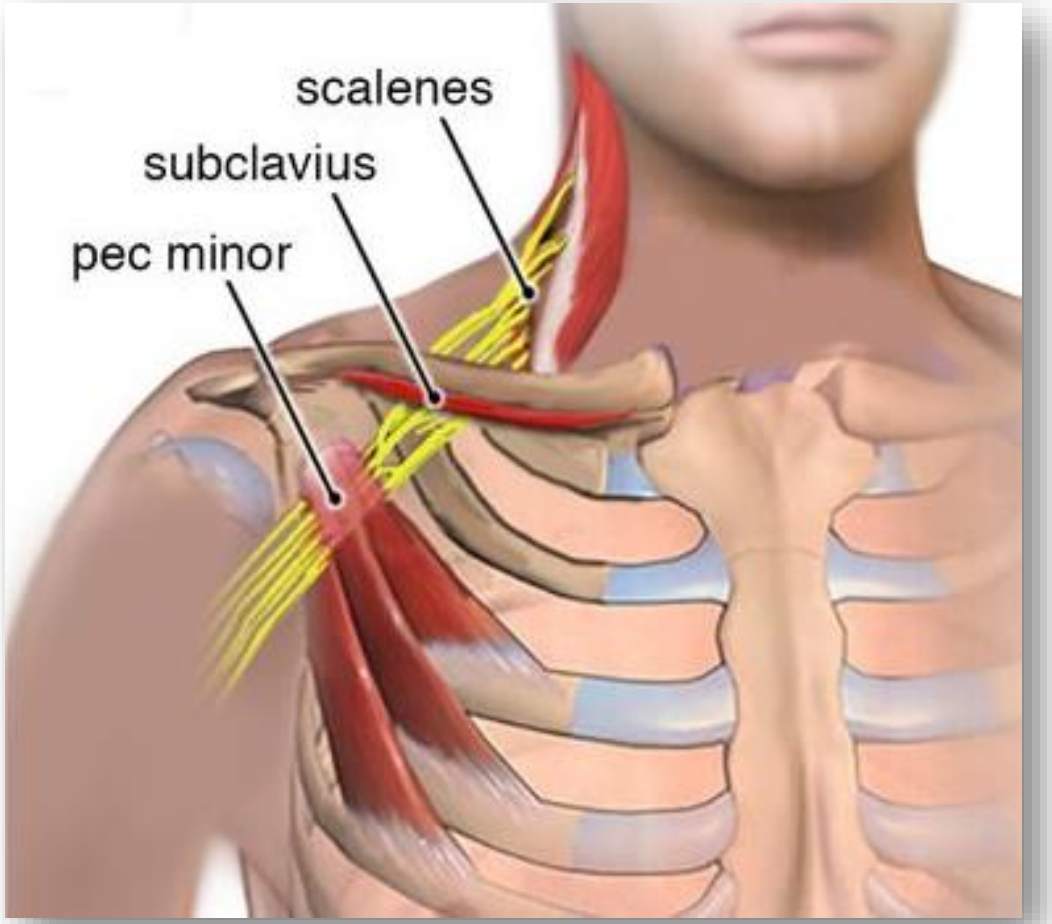
Thoracic Outlet Syndrome Categories

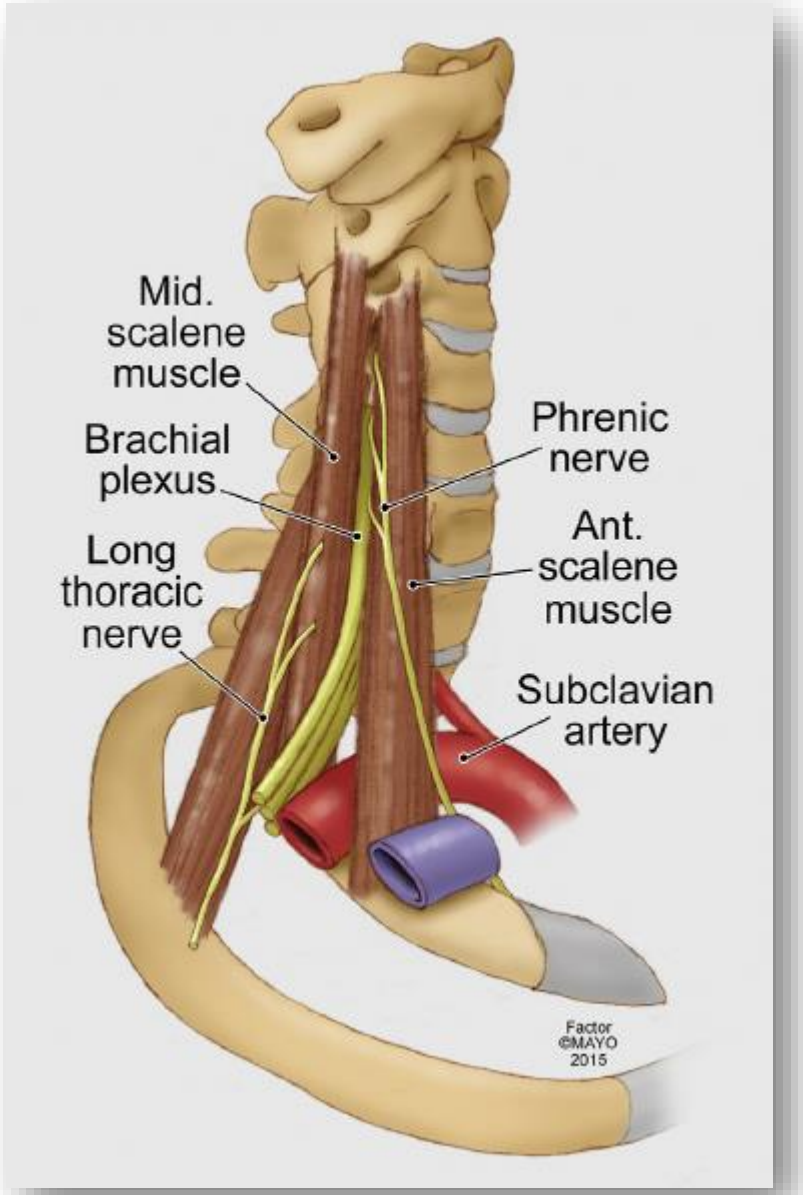
- Neurogenic (90%)
- Venous (8%)
- Arterial (2%)

Neurogenic TOS



- Most common (90%)
- Brachial plexus compressive/irritation at scalene triangle or pec minor space
- **Symptoms**
  - Arm pain, paresthesias, weakness
  - Neck and shoulder pain/tenderness
  - Other: headache, chest wall, upper back, trapezius pain
  - Exacerbated with ***overhead activities***
- Palpable tenderness ***scalene triangle*** or ***pectoralis minor space***
- History of ***trauma*** is common

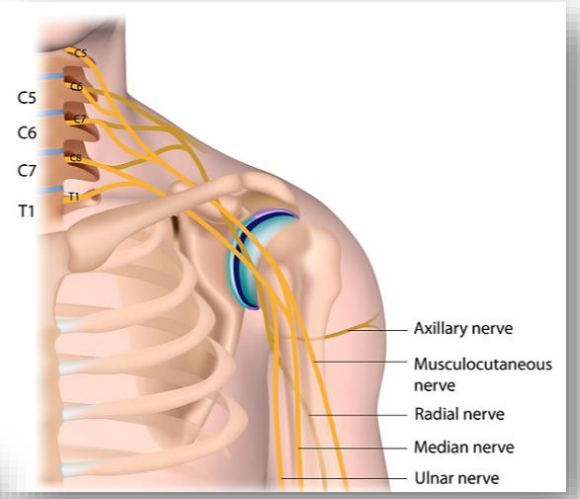
Nerves of Thoracic Outlet



Brachial Plexus

(C5-T1) Shoulder girdle and arm

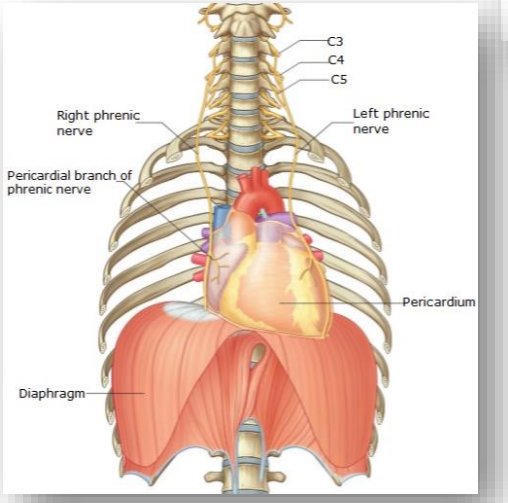
Everything motor/sensory arm



Phrenic N

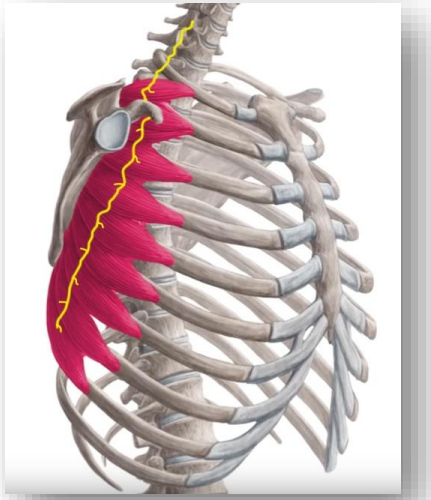
Diaphragm

Breathing!!

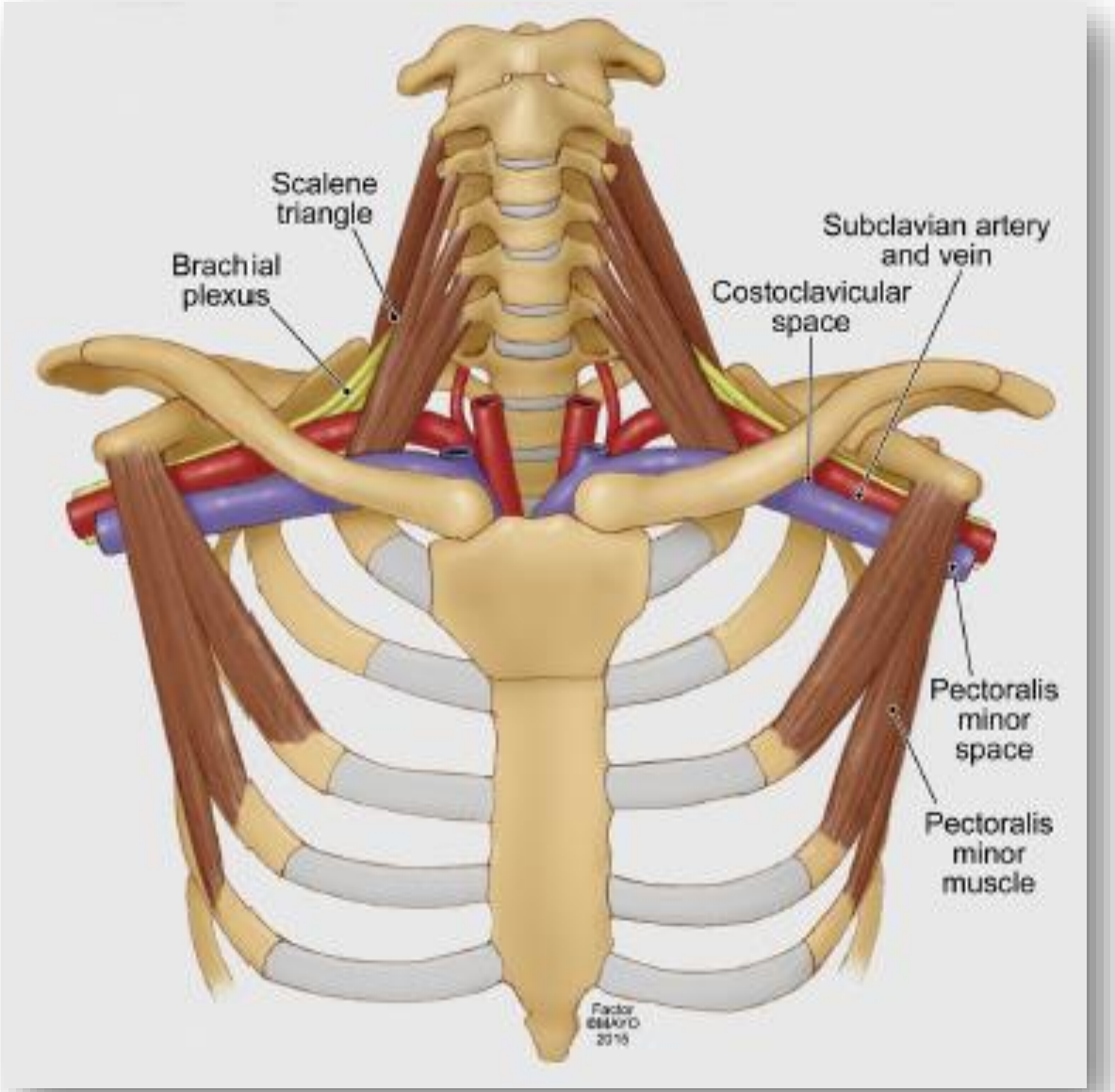


Long Thoracic N

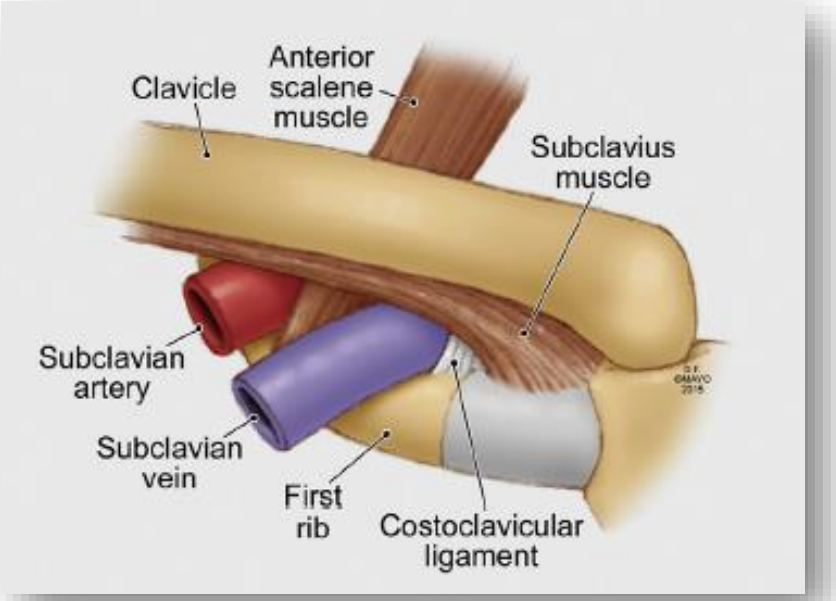
Serratus Anterior m: Upward scapula rotation (overhead lifting, throwing a punch).



Venous TOS

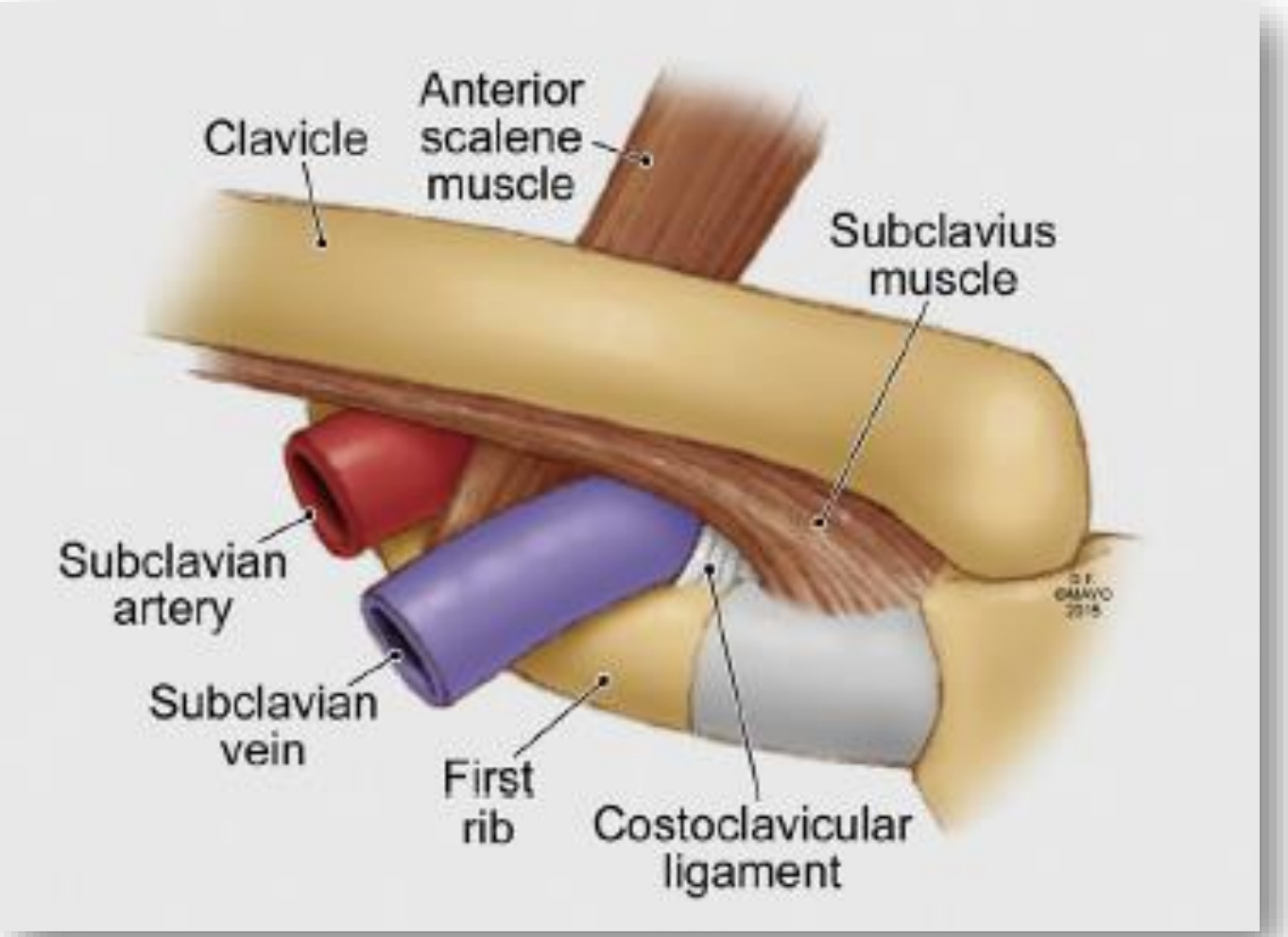


Subclavian vein passes ***anterior*** to the anterior scalene muscle



J Vasc Surg 2016;64:e23-e35

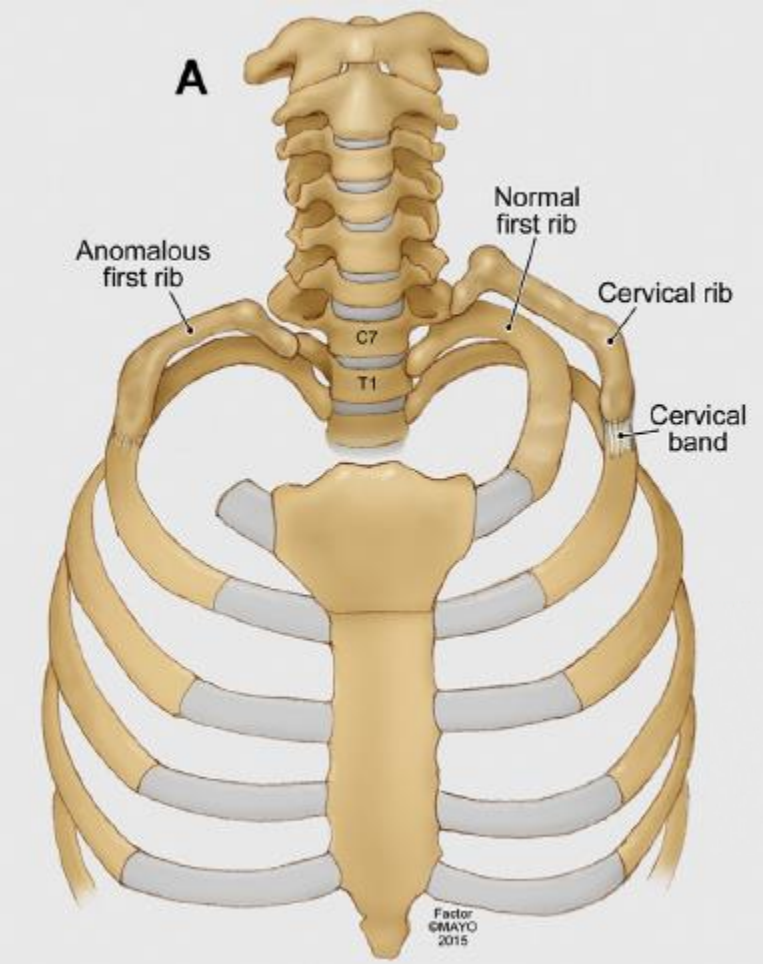
Venous TOS

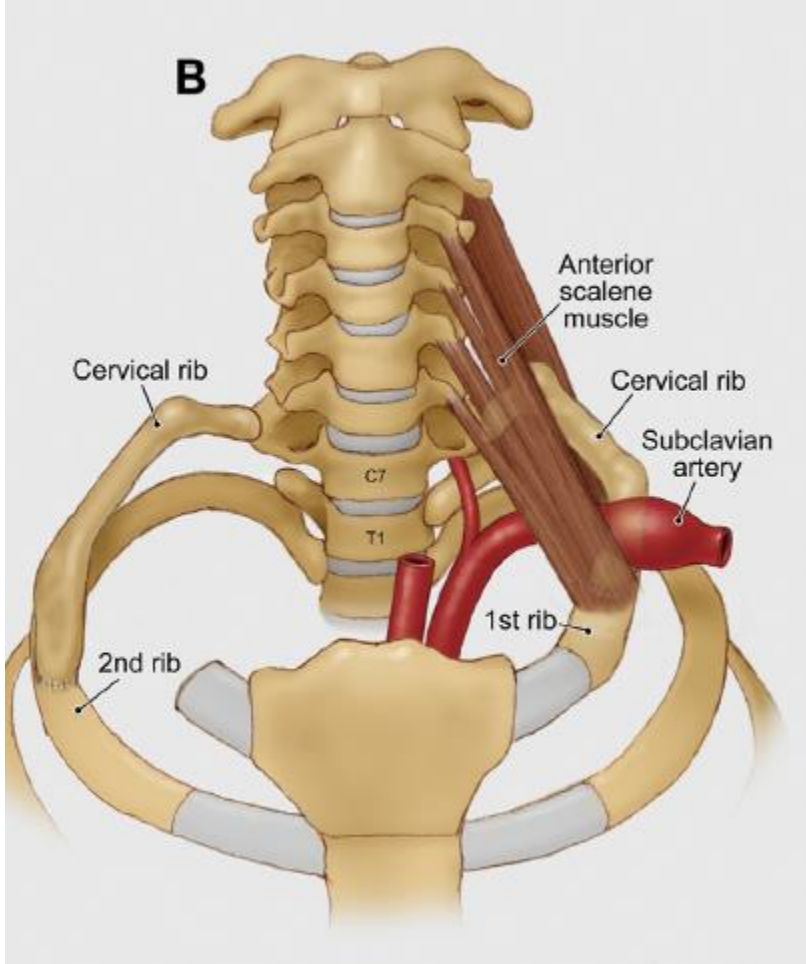


- **5 – 8% of TOS**
- **Venous injury between 1st rib and clavicle**
- **Acute or chronic thrombosis of Subclavian vein**
  "Paget Schroetter or Effort thrombosis"
- **Positional arm swelling**
  "McCleery Syndrome"

J Vasc Surg 2016;64:e23-e35

Arterial TOS





- 1 - 2% of TOS
- Aneurysm, thrombosis and embolization
- Hand ischemia
- Ischemia is central to documentation

Bony abnormality
Cervical rib

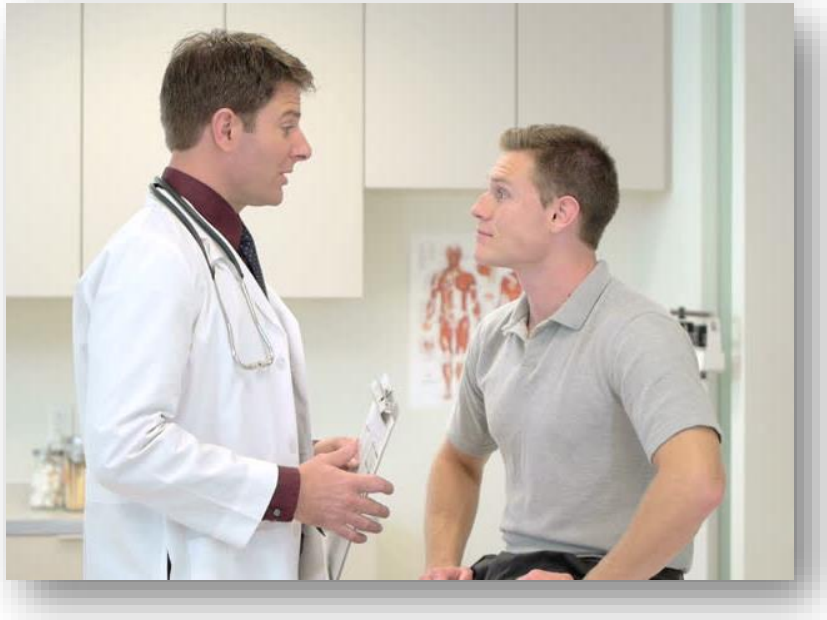
Repetitive injury
Aneurysm formation

J Vasc Surg 2016;64:e23-e35

Neurogenic TOS

What is the ***evaluation***?

nTOS Evaluation

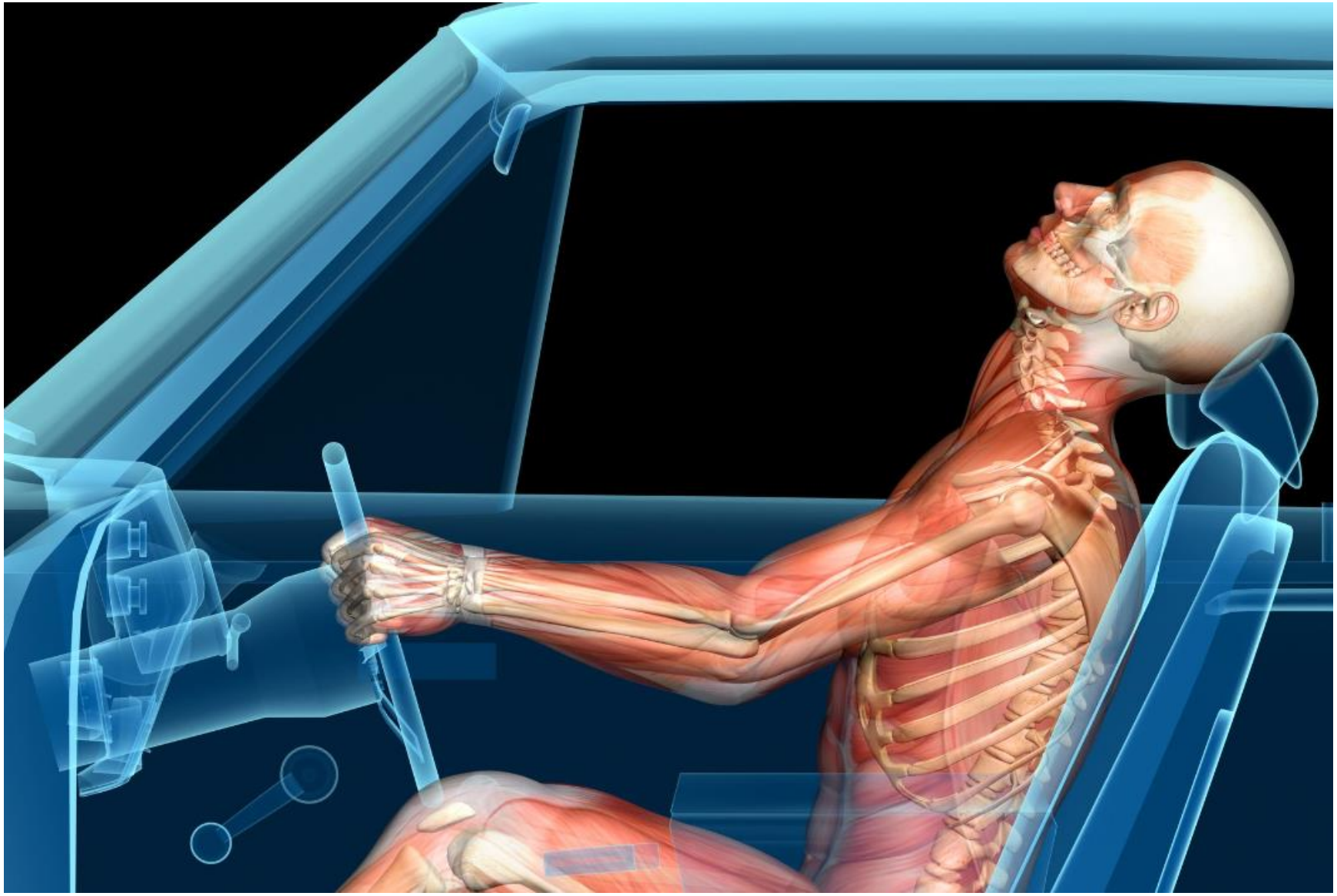


Detailed History

- Symptoms/distribution
- Aggravation/Relief
- Trauma (single/repetitive)
- Occupation/hobbies
- Prior treatment

- Differential diagnosis
  - Cervical disk disease, brachial plexopathy, peripheral neuropathy, chronic regional pain syndrome, shoulder pathology, carpal tunnel, cubital tunnel…….

Extension – Flexion Injury

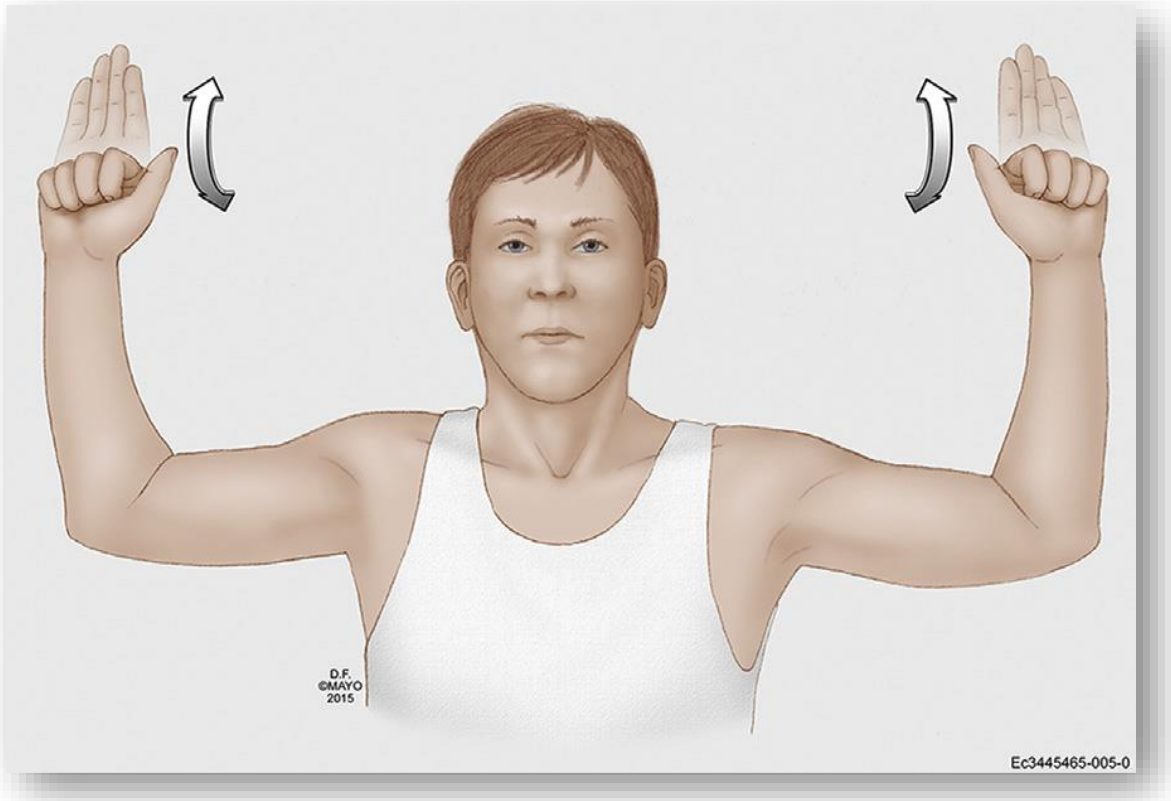


Occupation Injury: Repetitive Motion

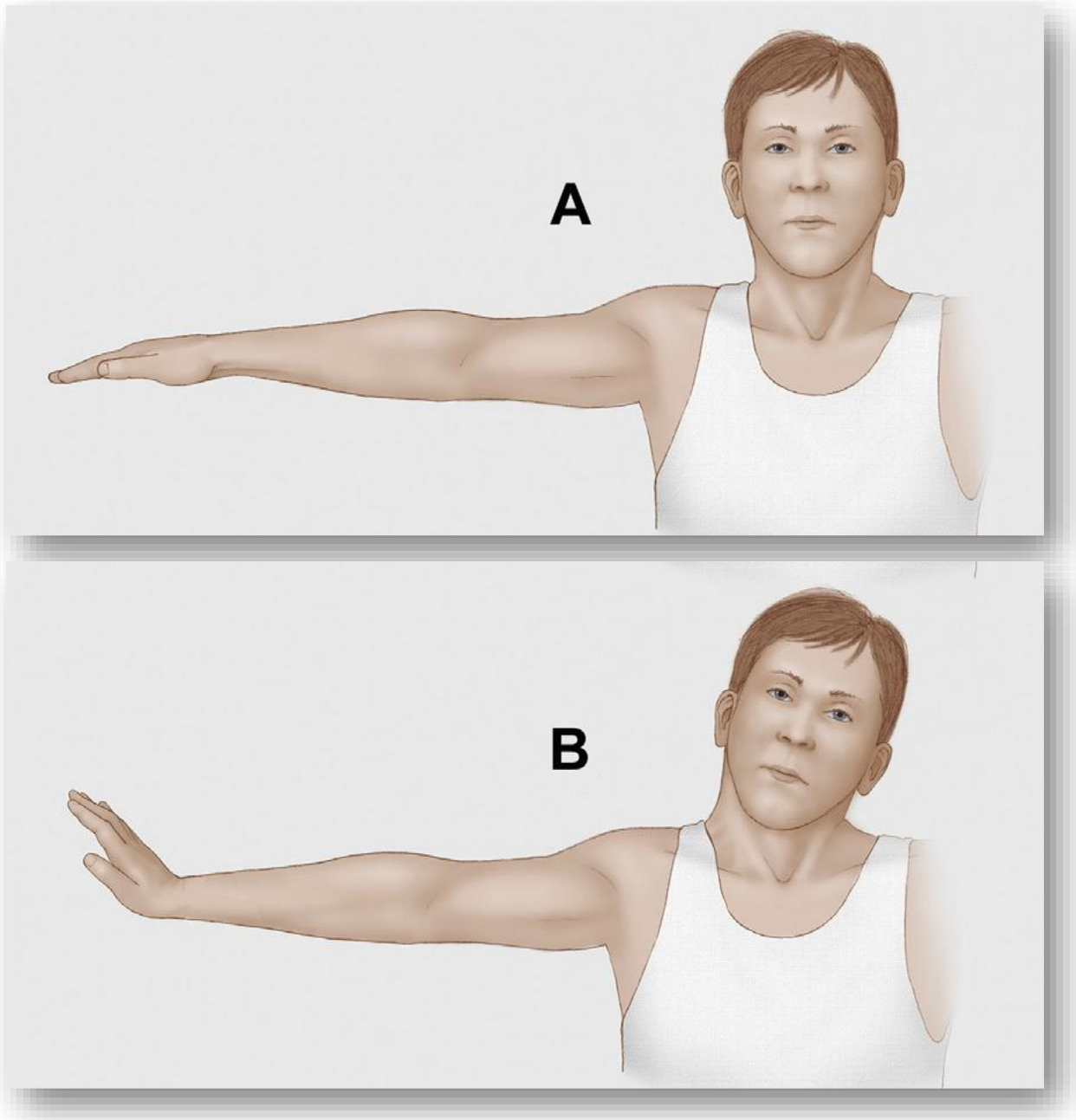
nTOS Evaluation

Physical Examination

- Neurovascular
- TOS maneuvers
- Careful palpation for point tenderness & symptom reproduction



Elevated Arm Stress Test (EAST)



Upper limb tension test

- Stretch of the brachial plexus
- Reproduce symptoms

37 year-old right-handed female

- 2021 Gonda Vascular Center Referral TOS Clinic

Monday	Tuesday	Wednesday	Thursday	Friday
Vasc Med Eval				
Vasc US				
Vasc Lab				
Shoulder Xray				
C-spine Xray				

Vascular Lab

Doppler Signal

	Right Waveform	Left Waveform
Subclavian	Triphasic	Triphasic
Axillary	Triphasic	Triphasic
Brachial	Triphasic	Triphasic
Radial	Triphasic	Triphasic
Ulnar	Triphasic	Triphasic
Palmar Arch	Triphasic	Triphasic

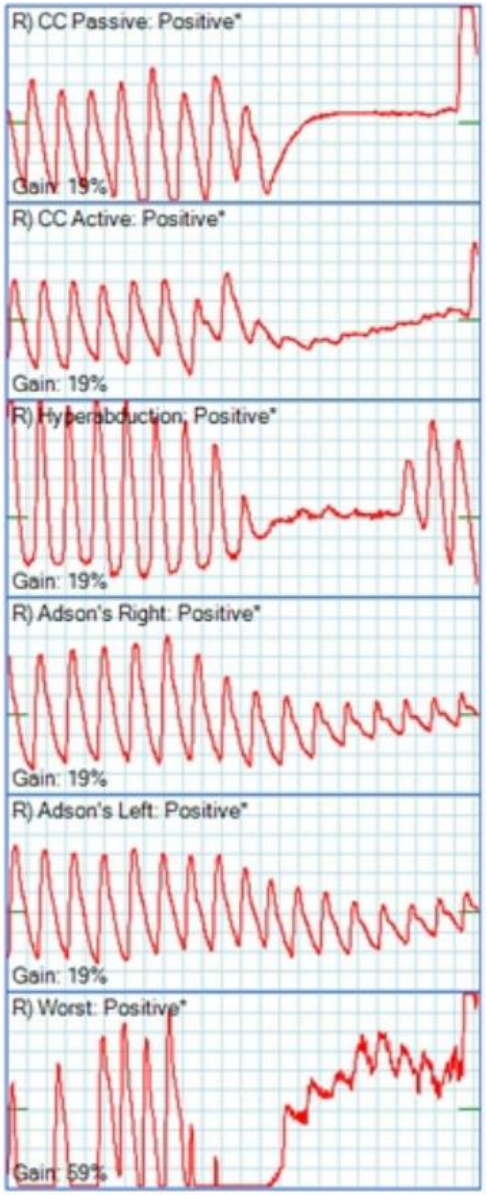
Systolic Pressures

	Right		Left	
	Systolic	Index	Systolic	Index
Arm: brachial	114		106	
Forearm: radial	125	1.10	113	0.99
Forearm: ulnar	132	1.16	113	0.99

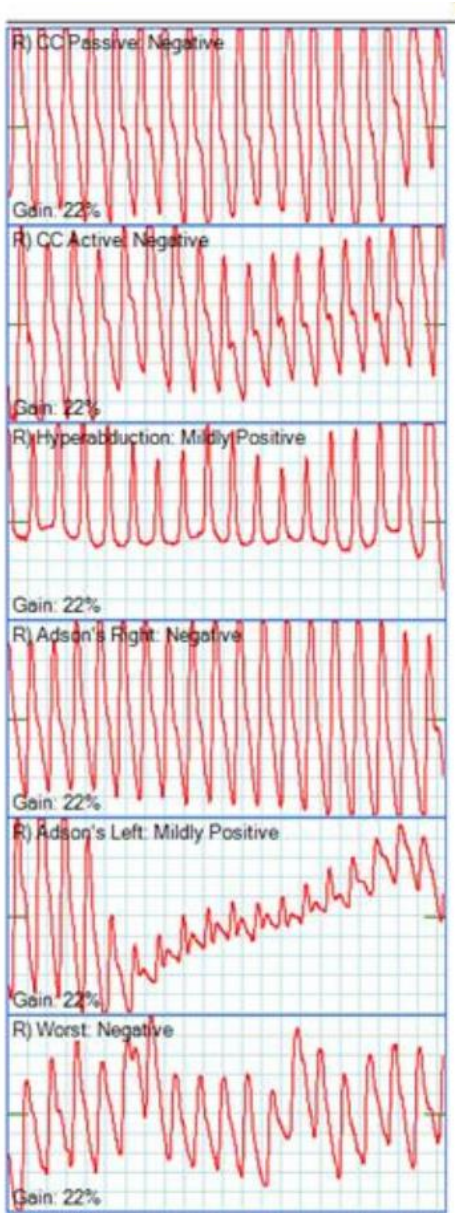
Allen's

	Right		Left	
	Source Artery		Source Artery	
	Radial	Ulnar	Radial	Ulnar
Arch:	Complete		Complete	

Vascular Lab

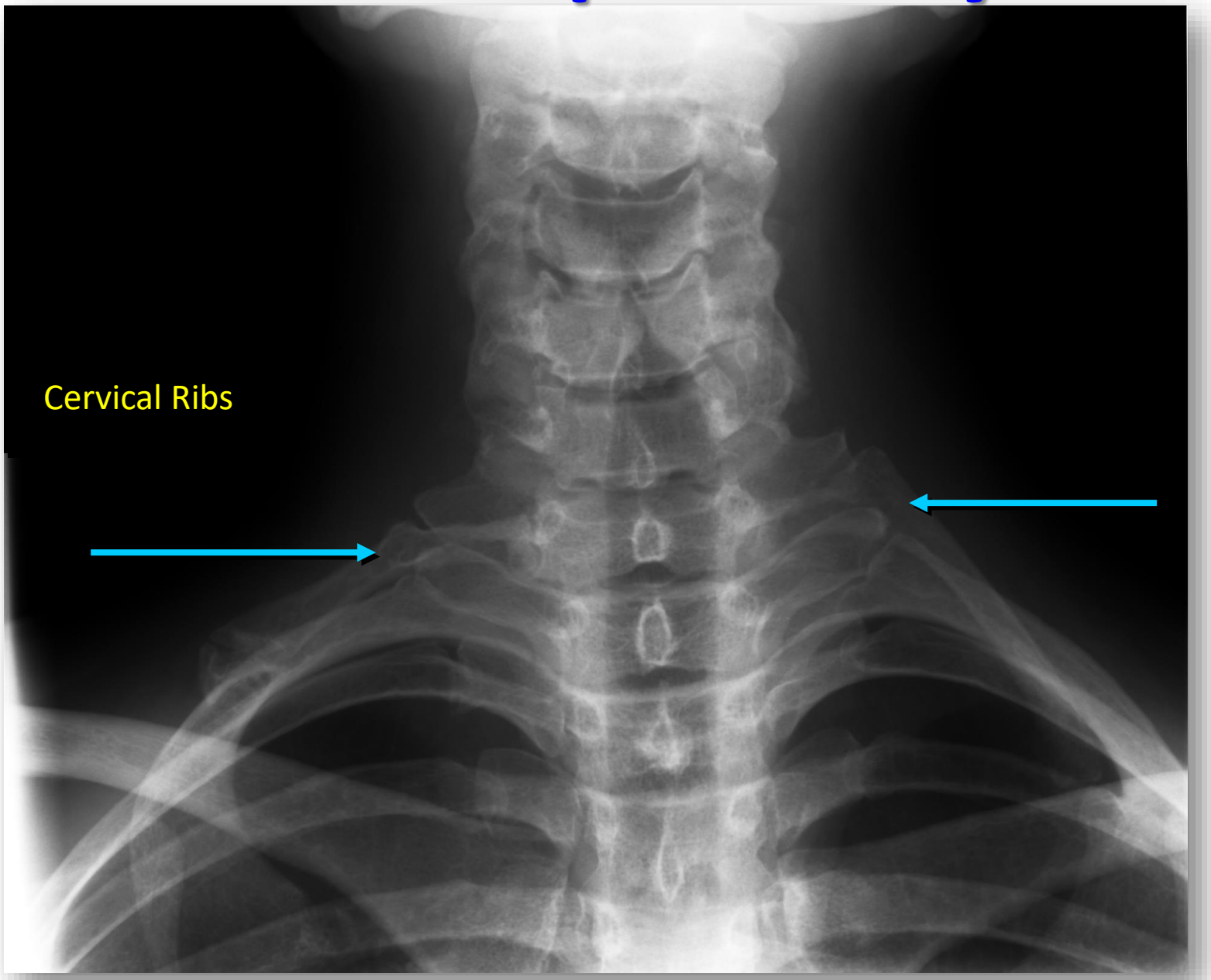


Our patient

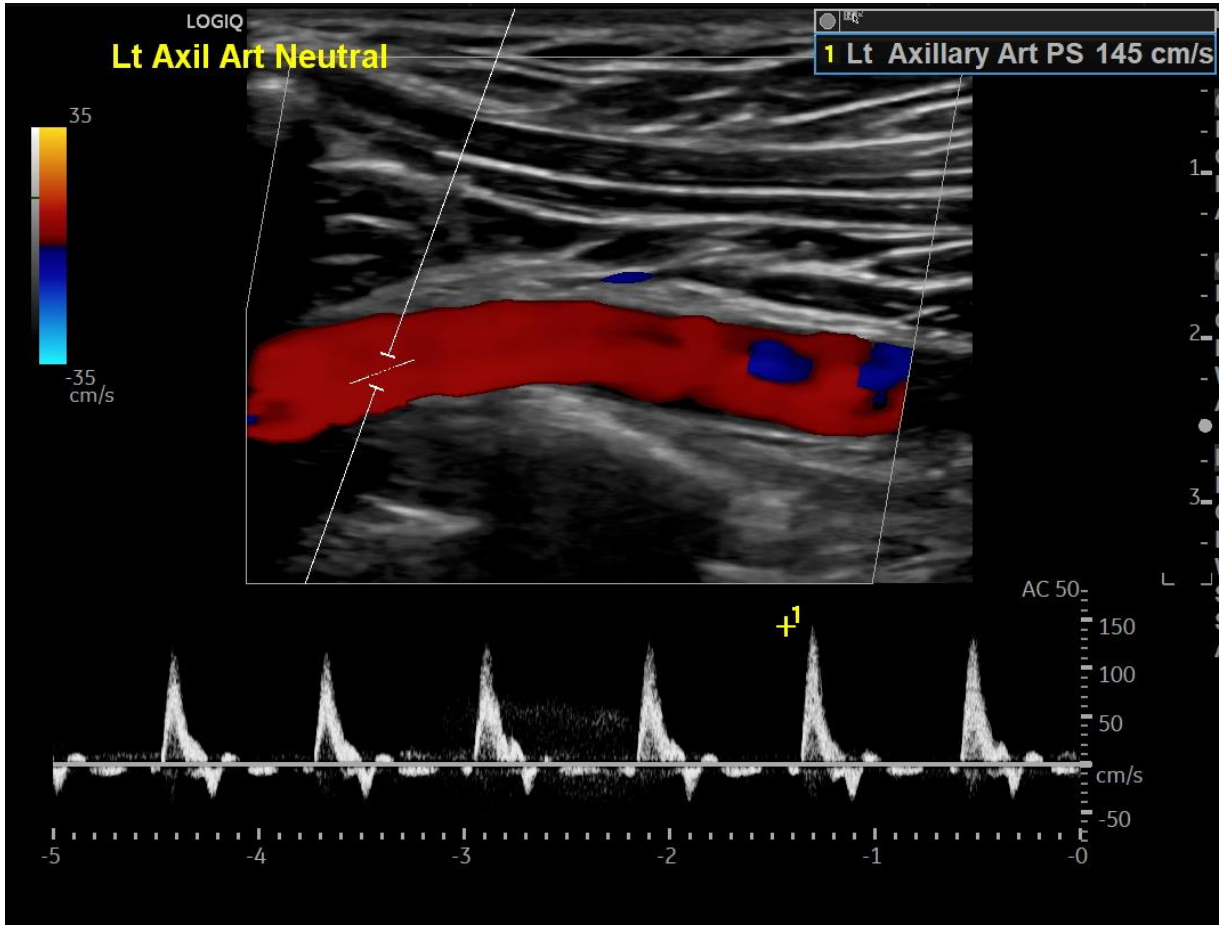


Comparison
"Normal" exam

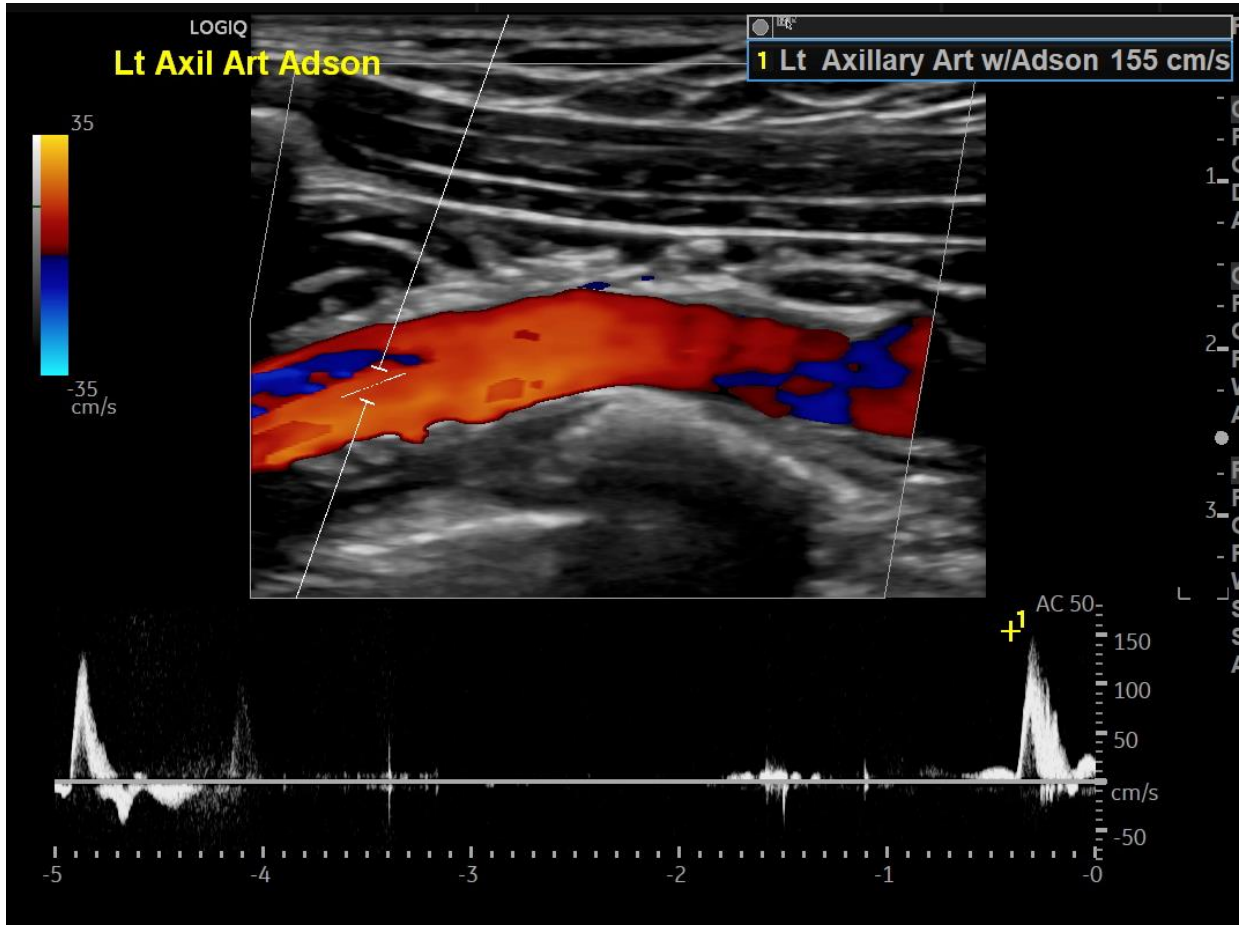
Cervical Spine Xray



Vascular Ultrasound



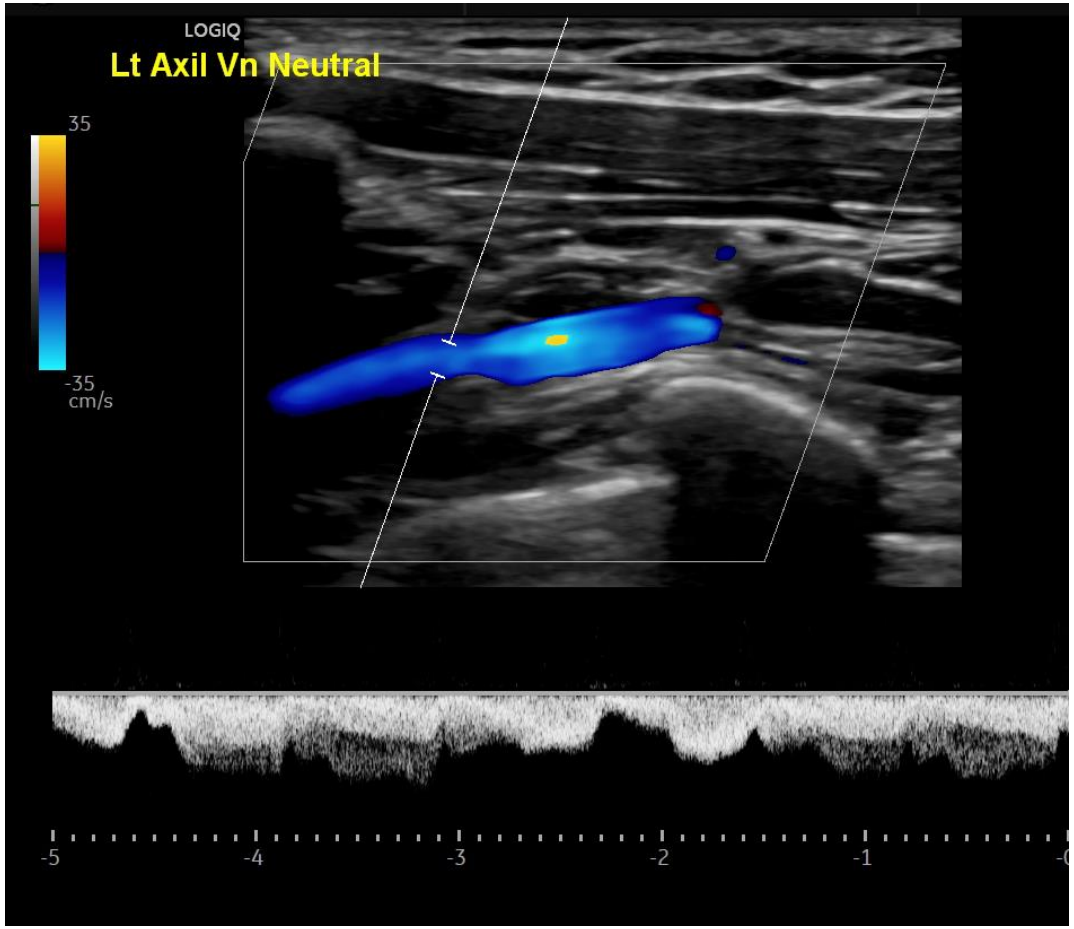
Neutral position



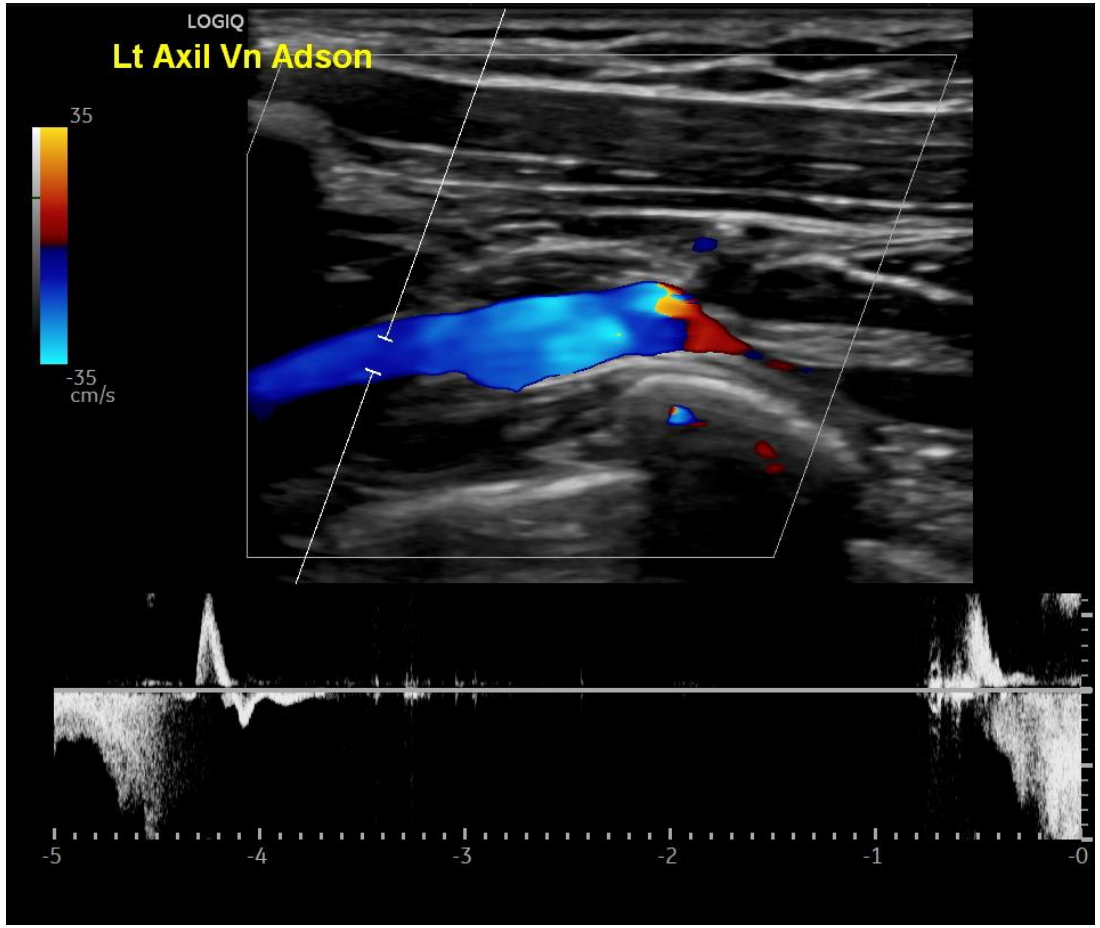
Provocative Maneuver

Arterial Evaluation

Vascular Ultrasound



Neutral position



Provocative Maneuver

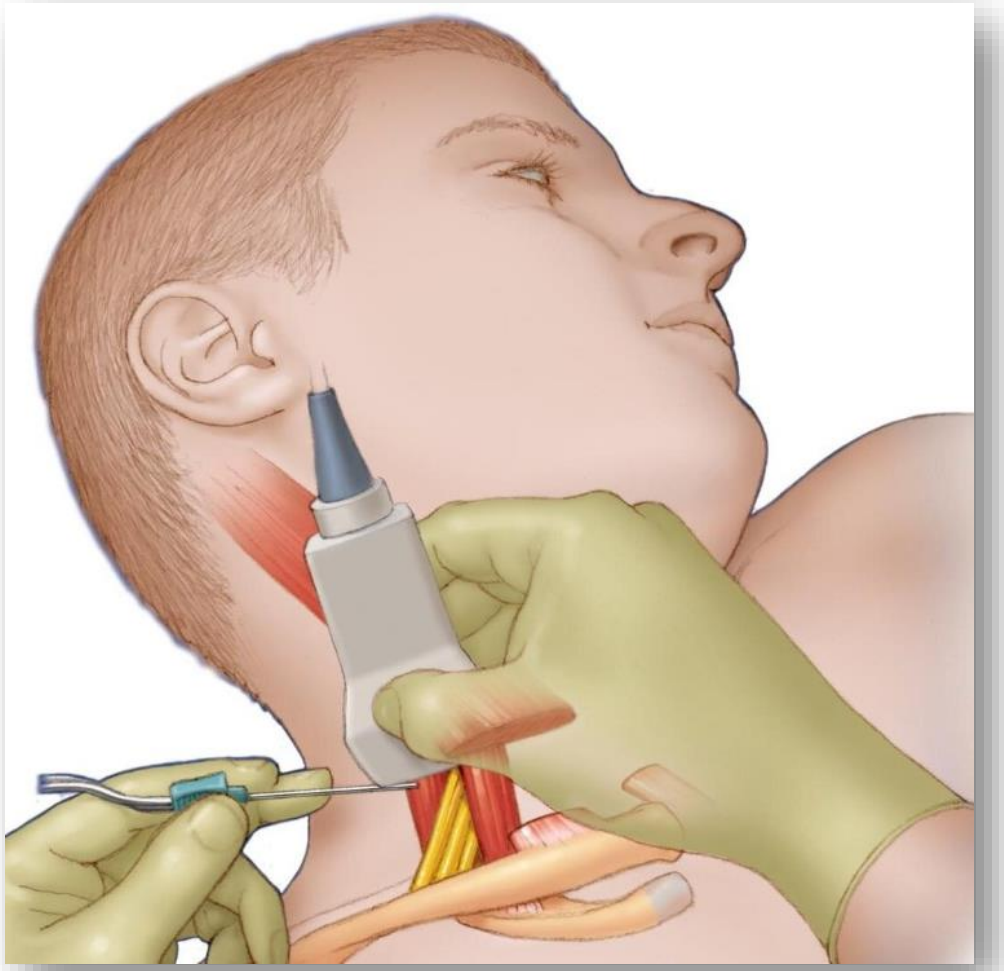
Venous Evaluation

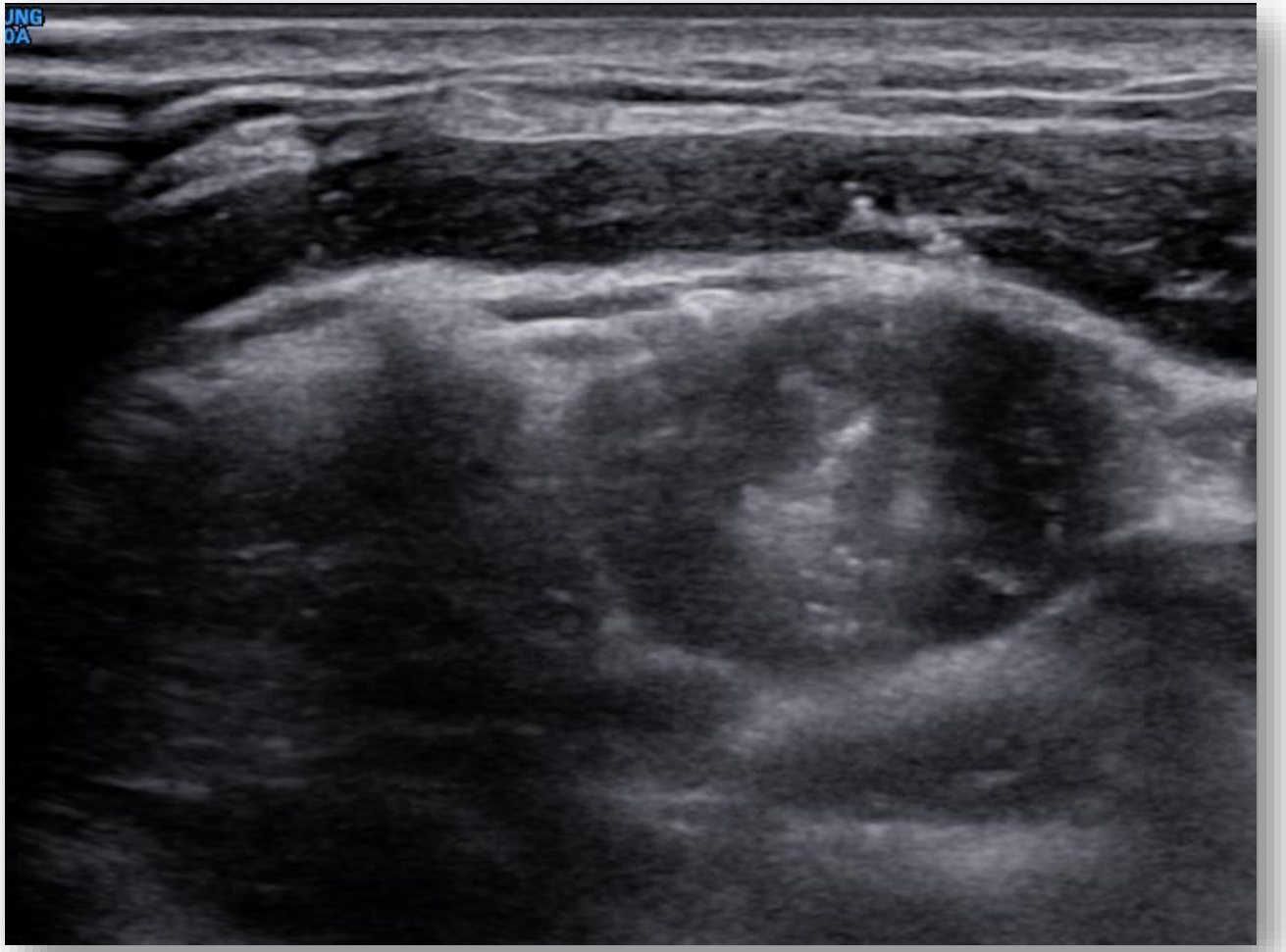
37 year-old right-handed female

- 2021 Gonda Vascular Center Referral TOS Clinic

Monday	Tuesday	Wednesday	Thursday	Friday
	Pain Med: Scalene inject			
	EMG			
	Neuro Eval			

US Guided Scalene Lidocaine Injection





Lidocaine: 22 ga needle; 2 mL injected (20 mg/mL)

37 year-old right-handed female

- 2021 Gonda Vascular Center Referral TOS Clinic

Monday	Tuesday	Wednesday	Thursday	Friday
		PMR eval	US neck	Vasc Med
		PT	Vasc Surg Eval	

Neurogenic TOS

What is the ***treatment***?

Physical Therapy

Goals:

- identify and alleviate compression at symptomatic anatomic sites
- Improve biomechanics
- Facility range of motion
- Exercises, passive and assisted
- Minimum 4 – 8 weeks

- ***Efficacy***: 20 – 30%

Surgery

Approaches

- Supraclavicular
- Infraclavicular
- Paraclavicular
- Transaxillary
- Posterior

Muscle resection

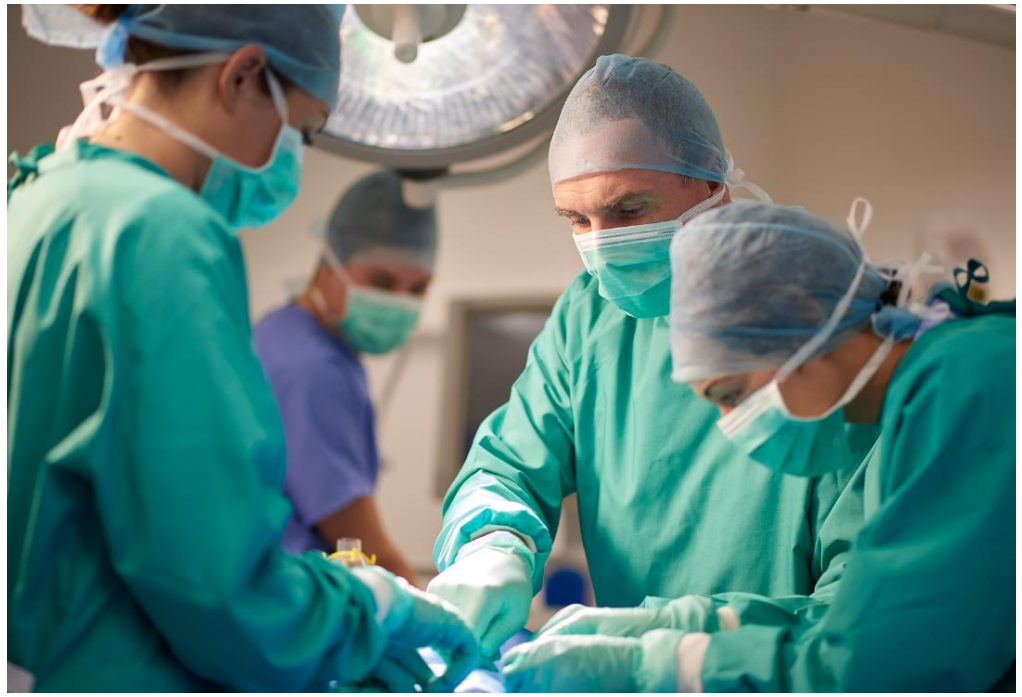
- Total scalenectomy
- Partial scalenectomy
- Subclavius
- Scalene minimus

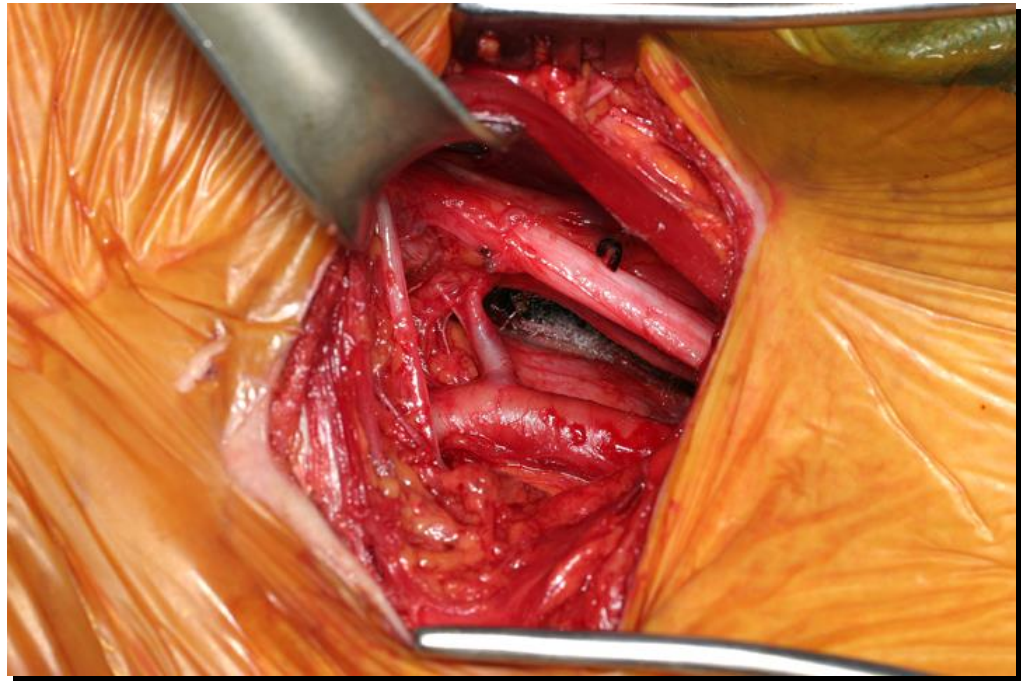
Rib resection

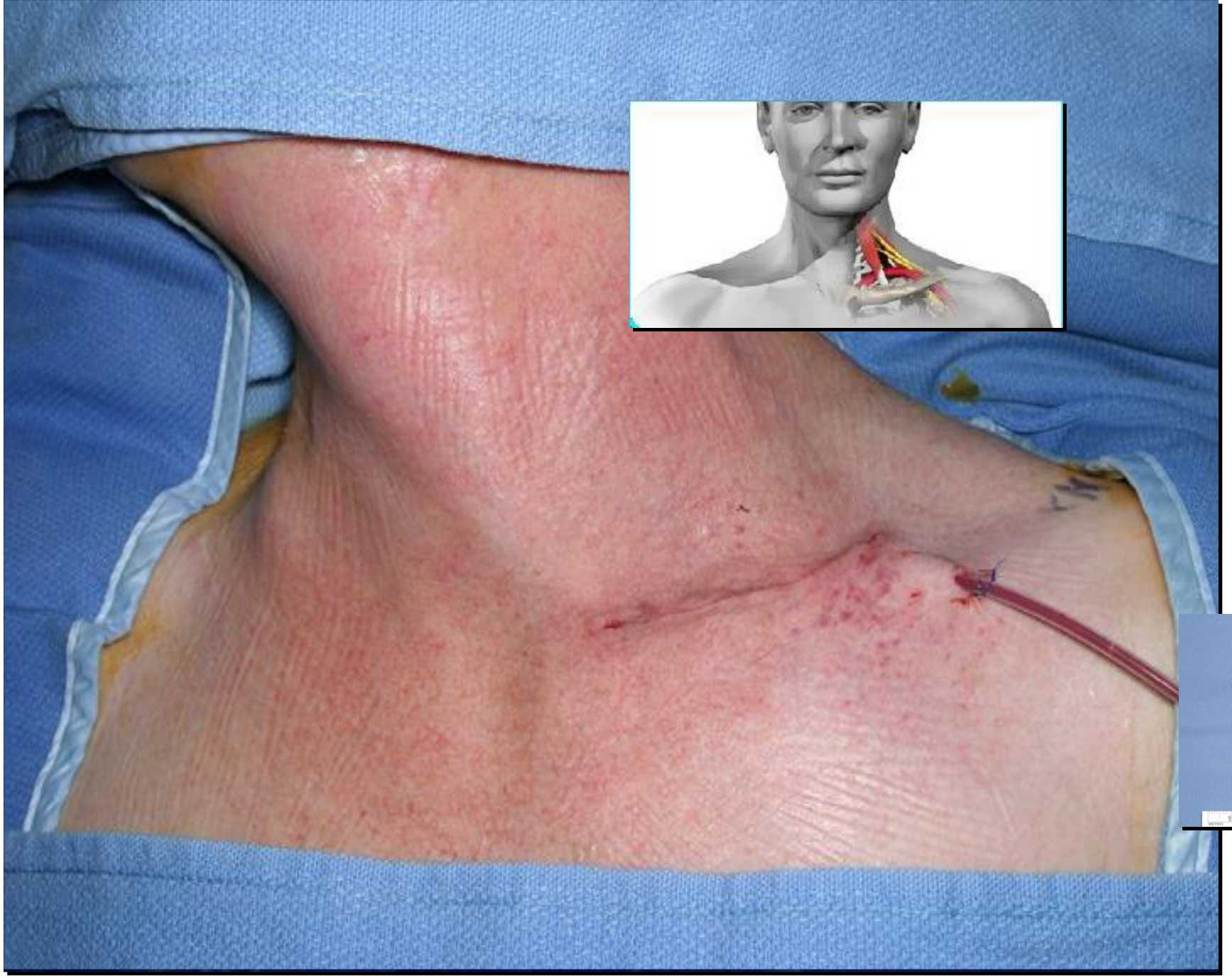
- Total
- Posterior
- Anterior
- Partial
- Transfers process

Other

- Claviculectomy
- Neurolysis
- Ligamentous band

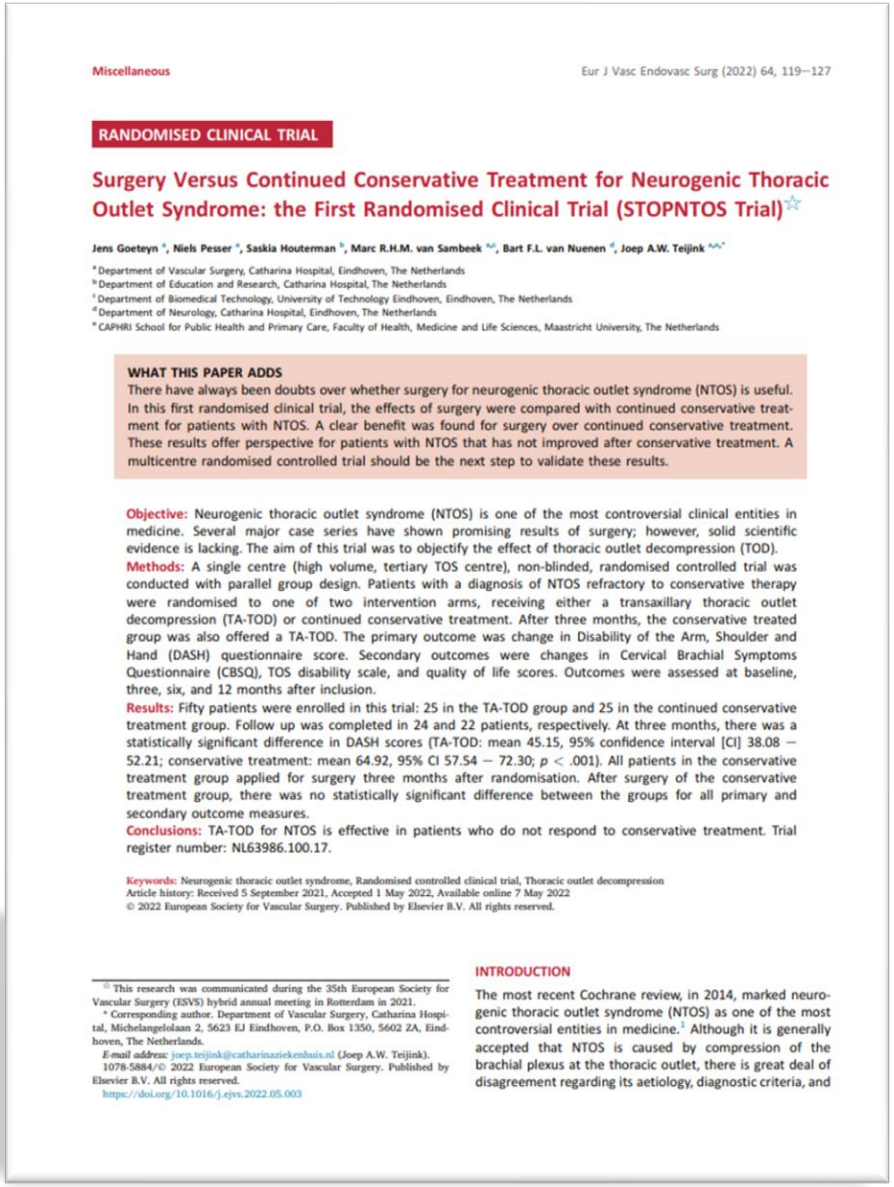






Neurogenic TOS

Which is better; ***PT*** or ***surgery***?



Miscellaneous

Eur J Vasc Endovasc Surg (2022) 64, 119–127

RANDOMISED CLINICAL TRIAL

Surgery Versus Continued Conservative Treatment for Neurogenic Thoracic Outlet Syndrome: the First Randomised Clinical Trial (STOPNTOS Trial)☆

Jens Goeteyn [a], Niels Pesser [a], Saskia Houterman [b], Marc R.H.M. van Sambeek [a,c], Bart F.L. van Nuenen [d], Joep A.W. Teijink [a,e,*]

[a] Department of Vascular Surgery, Catharina Hospital, Eindhoven, The Netherlands
[b] Department of Education and Research, Catharina Hospital, The Netherlands
[c] Department of Biomedical Technology, University of Technology Eindhoven, Eindhoven, The Netherlands
[d] Department of Neurology, Catharina Hospital, Eindhoven, The Netherlands
[e] CAPHRI School for Public Health and Primary Care, Faculty of Health, Medicine and Life Sciences, Maastricht University, The Netherlands

WHAT THIS PAPER ADDS

There have always been doubts over whether surgery for neurogenic thoracic outlet syndrome (NTOS) is useful. In this first randomised clinical trial, the effects of surgery were compared with continued conservative treatment for patients with NTOS. A clear benefit was found for surgery over continued conservative treatment. These results offer perspective for patients with NTOS that has not improved after conservative treatment. A multicentre randomised controlled trial should be the next step to validate these results.

Objective: Neurogenic thoracic outlet syndrome (NTOS) is one of the most controversial clinical entities in medicine. Several major case series have shown promising results of surgery; however, solid scientific evidence is lacking. The aim of this trial was to objectify the effect of thoracic outlet decompression (TOD).

Methods: A single centre (high volume, tertiary TOS centre), non-blinded, randomised controlled trial was conducted with parallel group design. Patients with a diagnosis of NTOS refractory to conservative therapy were randomised to one of two intervention arms, receiving either a transaxillary thoracic outlet decompression (TA-TOD) or continued conservative treatment. After three months, the conservative treated group was also offered a TA-TOD. The primary outcome was change in Disability of the Arm, Shoulder and Hand (DASH) questionnaire score. Secondary outcomes were changes in Cervical Brachial Symptoms Questionnaire (CBSQ), TOS disability scale, and quality of life scores. Outcomes were assessed at baseline, three, six, and 12 months after inclusion.

Results: Fifty patients were enrolled in this trial: 25 in the TA-TOD group and 25 in the continued conservative treatment group. Follow up was completed in 24 and 22 patients, respectively. At three months, there was a statistically significant difference in DASH scores (TA-TOD: mean 45.15, 95% confidence interval [CI] 38.08 – 52.21; conservative treatment: mean 64.92, 95% CI 57.54 – 72.30; $p < .001$). All patients in the conservative treatment group applied for surgery three months after randomisation. After surgery of the conservative treatment group, there was no statistically significant difference between the groups for all primary and secondary outcome measures.

Conclusions: TA-TOD for NTOS is effective in patients who do not respond to conservative treatment. Trial register number: NL63986.100.17.

Keywords: Neurogenic thoracic outlet syndrome, Randomised controlled clinical trial, Thoracic outlet decompression
Article history: Received 5 September 2021, Accepted 1 May 2022, Available online 7 May 2022

☆ This research was communicated during the 35th European Society for Vascular Surgery (ESVS) hybrid annual meeting in Rotterdam in 2021.

* Corresponding author. Department of Vascular Surgery, Catharina Hospital, Michelangelolaan 2, 5623 EJ Eindhoven, P.O. Box 1350, 5602 ZA, Eindhoven, The Netherlands.
E-mail address: joep.teijink@catharinaziekenhuis.nl (Joep A.W. Teijink).
1078-5884/
https://doi.org/10.1016/j.ejvs.2022.05.003

INTRODUCTION

The most recent Cochrane review, in 2014, marked neurogenic thoracic outlet syndrome (NTOS) as one of the most controversial entities in medicine.[1] Although it is generally accepted that NTOS is caused by compression of the brachial plexus at the thoracic outlet, there is great deal of disagreement regarding its aetiology, diagnostic criteria, and

STOP nTOS TRIAL

Inclusion: nTOS refractory to PT
Exclusion: Prior TOS surgery

46 patients → Surgical Decompression
46 patients → Physical Therapy

Primary Outcome: ***DASH survey***
Cross-over allowed at 3 months

Eur J Vasc Endovasc Surg 2022;64: 119

QuickDASH

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Do heavy household chores (e.g., wash walls, floors).	1	2	3	4	5
3. Carry a shopping bag or briefcase.	1	2	3	4	5
4. Wash your back.	1	2	3	4	5
5. Use a knife to cut food.	1	2	3	4	5
6. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
7. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
8. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5

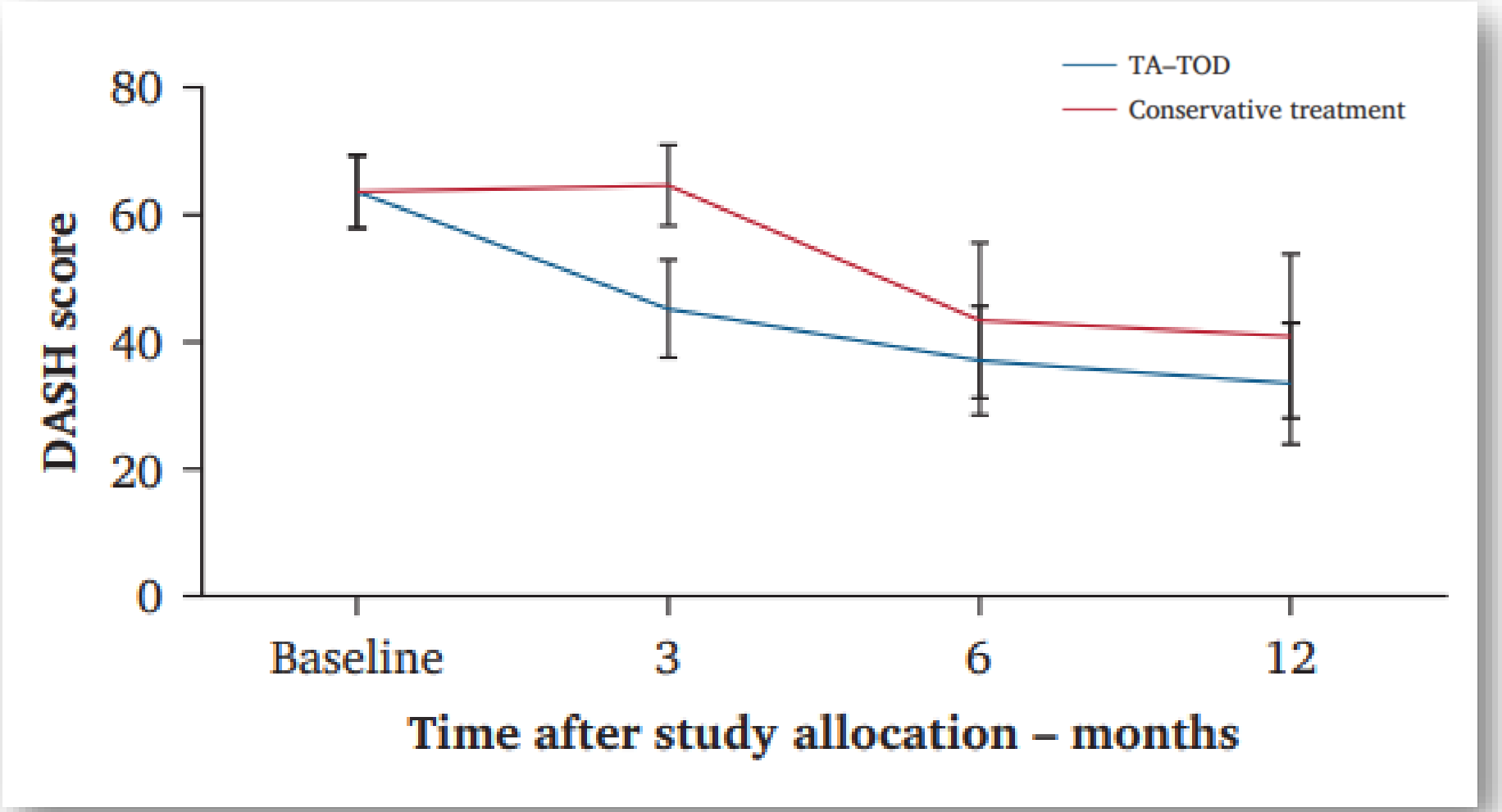
Please rate the severity of the following symptoms in the last week. *(circle number)*	NONE	MILD	MODERATE	SEVERE	EXTREME
9. Arm, shoulder or hand pain.	1	2	3	4	5
10. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
11. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

$$\left[\frac{\text{(sum of responses)}}{n} - 1 \right] \times 25 = \text{score}$$

Where n= number of completed responses
Minimum = 0
Maximum = 100

DASH Results*



P<0.001

* Recall: surgical cross over allowed at 3 months

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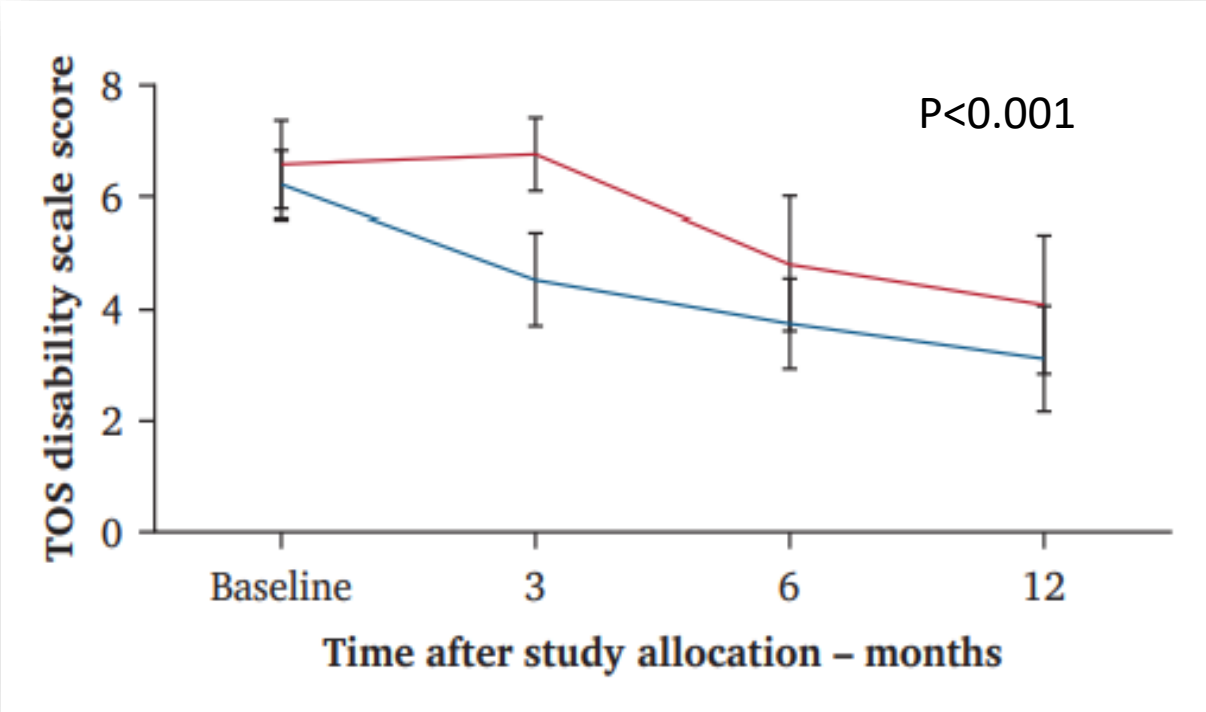
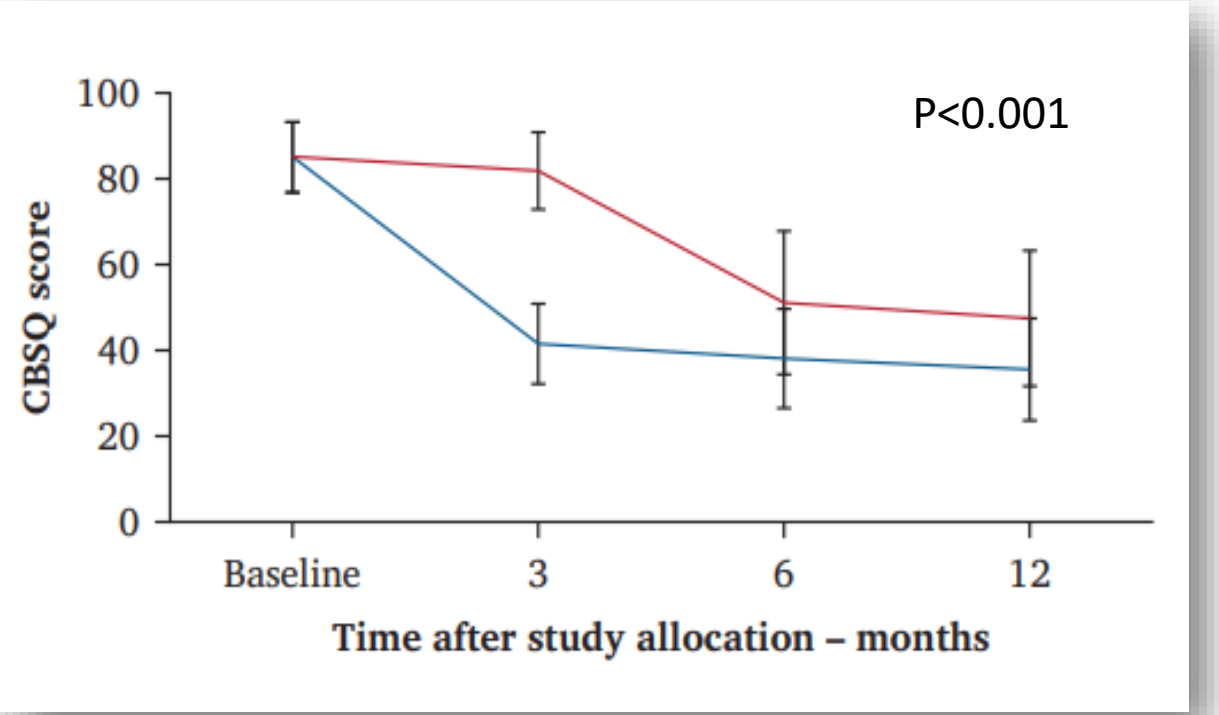
Secondary Outcome Results*

TOS Disability Score



Cervical Brachial Score



* Recall: surgical cross over allowed at 3 months

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STOP nTOS TRIAL Conclusions

- Surgical decompression significantly improved DASH, TOS Disability and CBSQ scores relative to continued PT.
- After 3 months, all conservative treatment patients crossed over to surgery.
- At 6 months, there was no difference between groups

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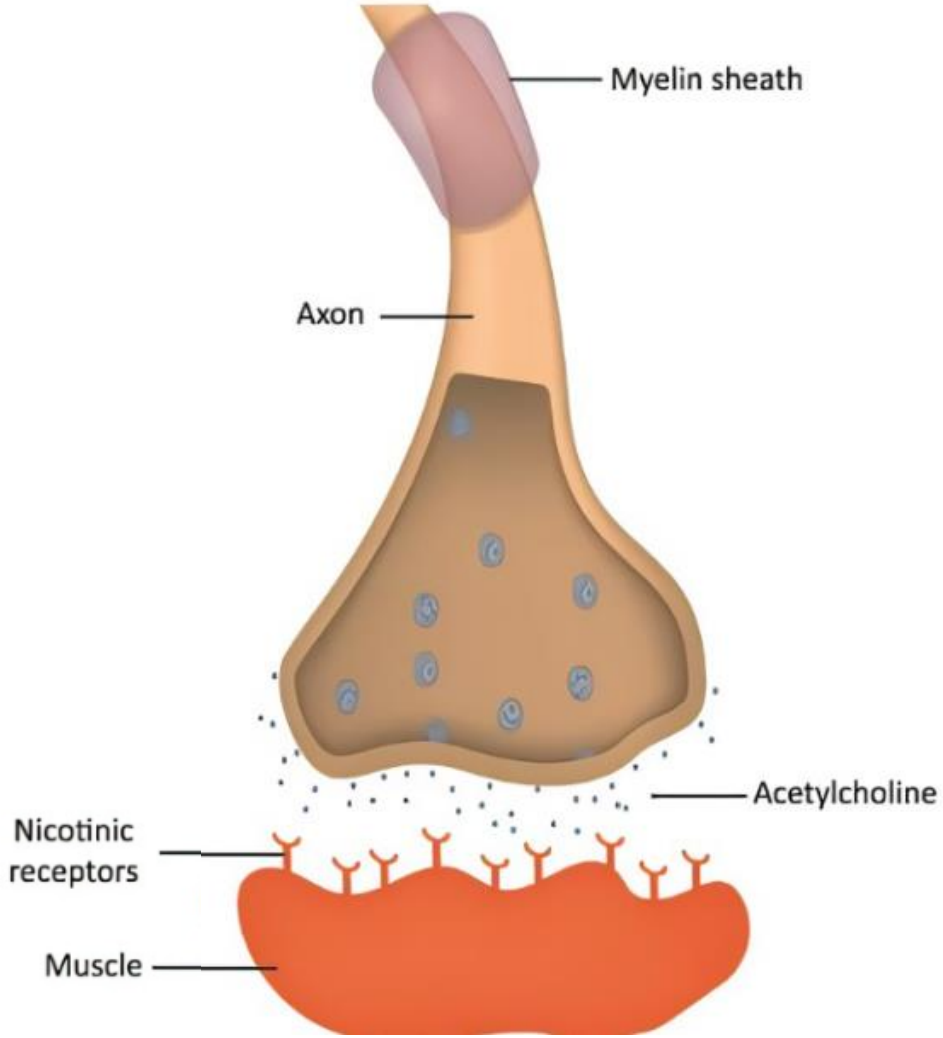
Neurogenic TOS

Are there ***any new treatment*** options?

Normal motor neuron function

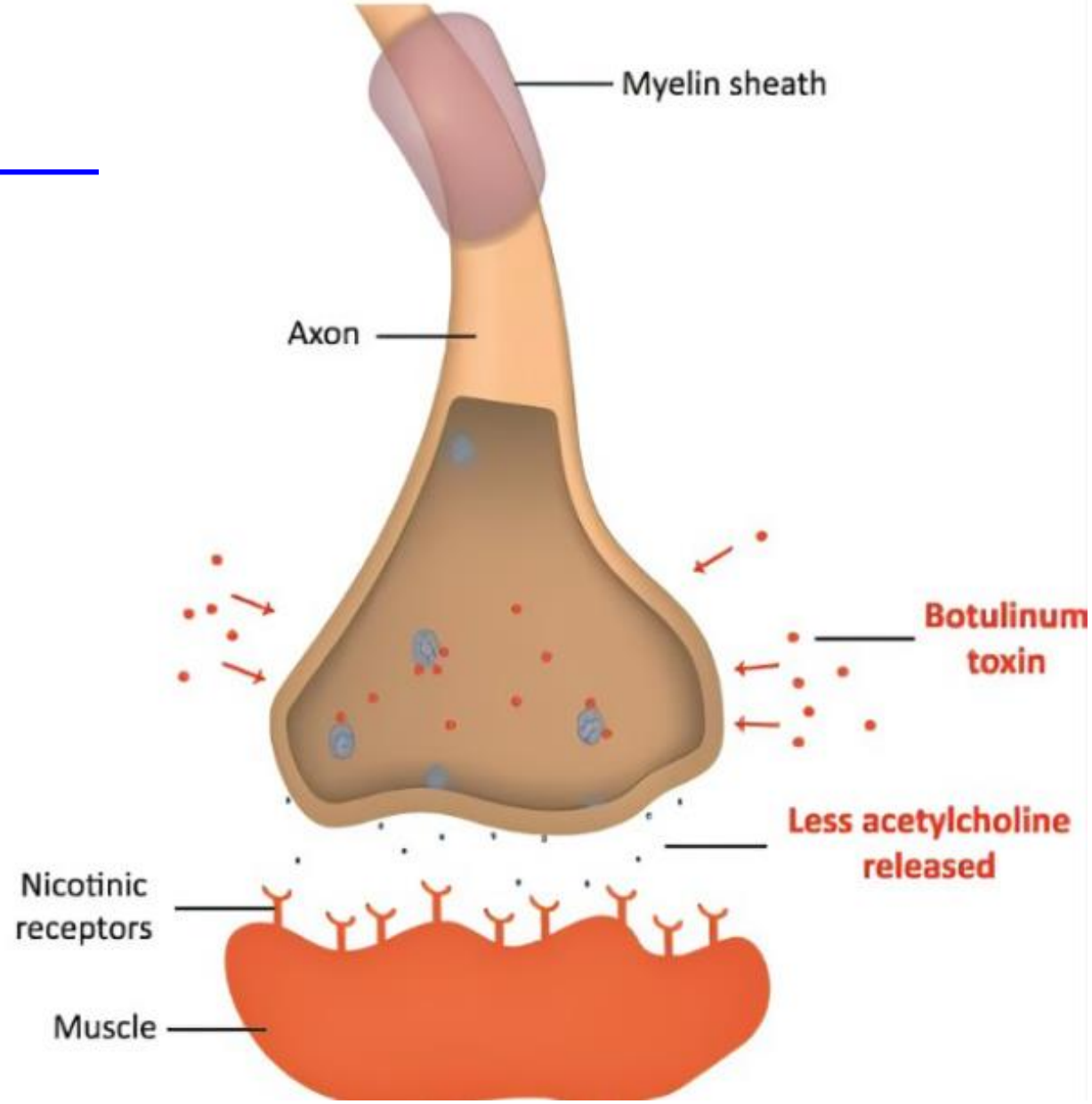
- Motor neurons (efferent neurons) carry signals from CNS to muscle cells.
- At neuromuscular junction, ***acetylcholine*** (neurotransmitter) is released into synaptic cleft
- Acetylcholine attaches to the nicotinic receptor resulting in muscle contraction



Botulinum Toxin

- Clostridium Botulinum
- BT blocks acetylcholine release
- Results in flaccid muscle paralysis

- 7 serotypes (A - G)
- BT-A serotype most often used for therapies
- Onset 2 – 3 days
- Offset 2 – 3 months
- Side effects: muscle atrophy



Neurogenic TOS

Are there ***any trials of Botox*** for nTOS?

PAIN® 152 (2011) 2023–2028

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Botulinum toxin injection for management of thoracic outlet syndrome: A double-blind, randomized, controlled trial

Heather C. Finlayson[a,b,*], Russell J. O'Connor[a,b], Penelope M.A. Brasher[c], Andrew Travlos[a,b]

[a] University of British Columbia, Department of Medicine, Division of Physical Medicine and Rehabilitation, British Columbia, Canada
[b] GF Strong Rehab Centre, Vancouver, British Columbia, Canada
[c] Centre for Clinical Epidemiology and Evaluation, Vancouver Coastal Health Research Institute, Vancouver, British Columbia, Canada

Sponsorships or completing interests that may be relevant to content are disclosed at the end of this article.

ARTICLE INFO

Article history:
Received 22 December 2010
Received in revised form 14 April 2011
Accepted 18 April 2011

Keywords:
Thoracic outlet syndrome
Botulinum toxin type A
Pain

ABSTRACT

We studied the effect of botulinum toxin type A (BTX-A) injections to the scalene muscles on pain in subjects with thoracic outlet syndrome (TOS) in this double-blind, randomized, parallel group trial with follow-up at 6 weeks, 3 months, and 6 months. Thirty-eight patients referred to physiatrists for management of TOS with BTX-A injection were included. One subject was lost to follow-up and all other subjects completed the trial. A 75-unit dose of BTX-A reconstituted with 0.75 cc of normal saline was injected to the anterior scalene (37.5 units) and middle scalene (37.5 units) muscles using electromyographic guidance. The primary outcome measure was pain as measured on a horizontal visual analog scale (VAS) 6 weeks-post-injection. Secondary outcomes were paresthesias measured on a VAS and function measured with the Disabilities of the Arm, Shoulder and Hand (DASH) and Short-form 36 (SF-36) questionnaires. For the primary outcome measure of VAS scores for pain at 6 weeks, the difference in the means adjusted for baseline VAS scores between placebo and BTX-A was 5.03 mm in favor of BTX-A (95% confidence interval −15.7 to 5.7, $P = .36$). Changes in secondary outcome measures were also not statistically significant. We conclude that BTX-A injections to the scalene muscles did not result in clinically or statistically significant improvements in pain, paresthesias, or function in this population of subjects with TOS.

1. Introduction

Thoracic outlet syndrome (TOS) has been defined as "upper extremity symptoms due to compression of the neurovascular bundle in the area of the neck just above the first rib [19]." The most common form is neurogenic TOS, which is believed to comprise more than 95% of patients with TOS [19]. TOS may occur as a result of compression of brachial plexus elements and/or subclavian vessels as they traverse the cervicoaxillary canal [24]. This impingement can occur at several sites; but the interscalene triangle between the anterior and middle scalene muscles, which may become hypertrophied, tense, and rigid, is frequently implicated [15,18]. In fact, scalenectomy is a common surgical intervention for TOS, either alone or in combination with first rib resection [8,24].

Nonsurgical techniques to decompress the interscalene space by relaxing the scalene muscles have included injections of anesthetic agents [1,11], steroids [11], and botulinum toxin type A (BTX-A) [3,5,9,23]. Of these interventions, only BTX-A injections have resulted in sustained symptom reduction as demonstrated in case reports [5,13] and case series [3,9,23].

BTX-A reduces contraction in injected muscles via focal chemodenervation. In addition to its role in the management of neurologic conditions such as spasticity and dystonia, it has been used in the treatment of musculoskeletal conditions including chronic low back pain, chronic neck pain, and myofascial pain syndromes [17].

Our primary objective was to determine the effectiveness of BTX-A injection to the scalene muscles on pain in subjects with TOS. Our secondary objectives were to determine the effectiveness of BTX-A injection on paresthesias and function. We hypothesized that BTX-A would decrease pressure on the neurovascular structures at the interscalene triangle by relaxing the scalene muscles, which would result in decreased pain, decreased paresthesias, and improved function. To our knowledge, this is the first randomized controlled trial of BTX-A for TOS.

2. Methods

2.1. Study design

Pain 2011;152: 2023

Study Hypothesis

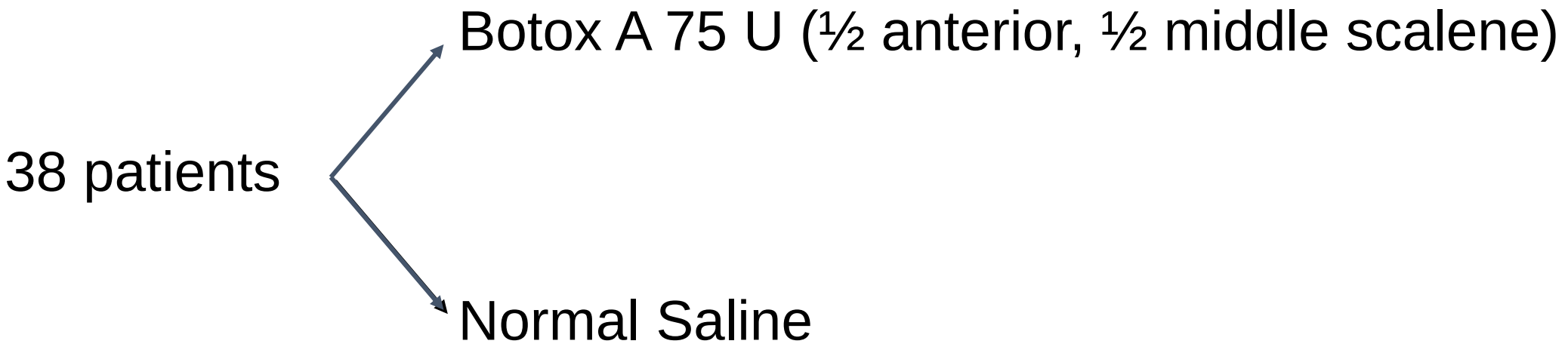
- BTX-A would ***decrease pressure*** on the neurovascular structures at the interscalene triangle by relaxing the scalene muscles, which would result in ***decreased pain***, ***decreased paresthesias***, and ***improved function***.

Pain 2011;152: 2023

Canadian Botox TOS Trial

Patients: Sx > 6 mos, EMG negative, Cervical spine imaging negative

(Sample size: 40 to detect 20 mm difference in VAS; assume 20% drop out)



1◦ endpoint composite: 100 – mm horizontal visual analogue scale (VAS)

Pain 2011;152: 2023

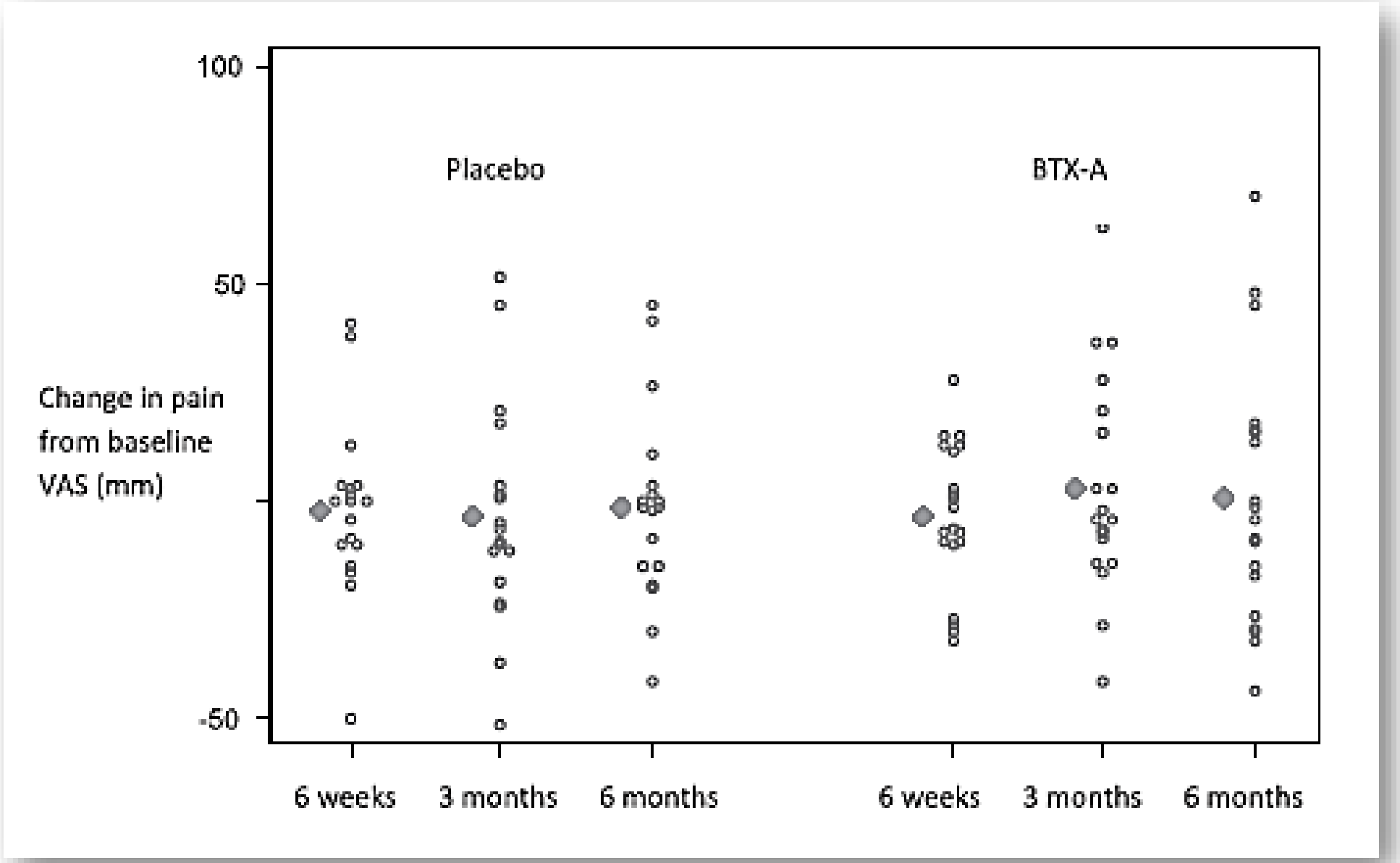
Subject selection (Diagnostic criteria for TOS)

3 of 4 criteria required for nTOS Diagnosis

- Pain or paresthesias involving the medial arm, forearm, and/or hand
- Symptoms aggravated with arm abduction
- Tenderness over the brachial plexus
- Positive EAST maneuver

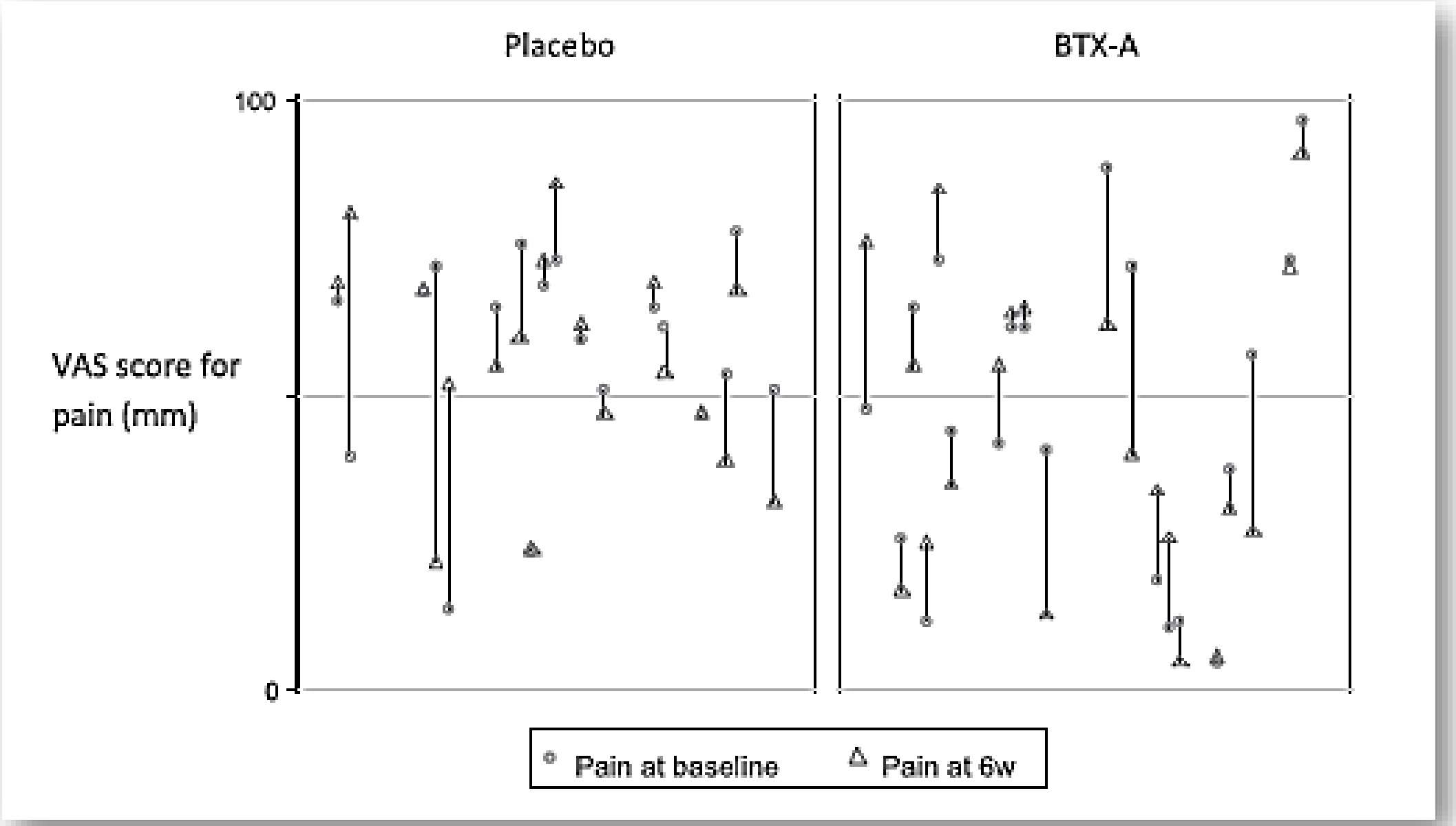
Pain 2011;152: 2023

Pain Outcome, ***No Difference*** at any time interval



Pain 2011;152: 2023

Pain Outcome per individual, ***No consistent change***



“Which group were you randomized to?”

Only 50% guessed correctly

Why was this a ***negative trial***?

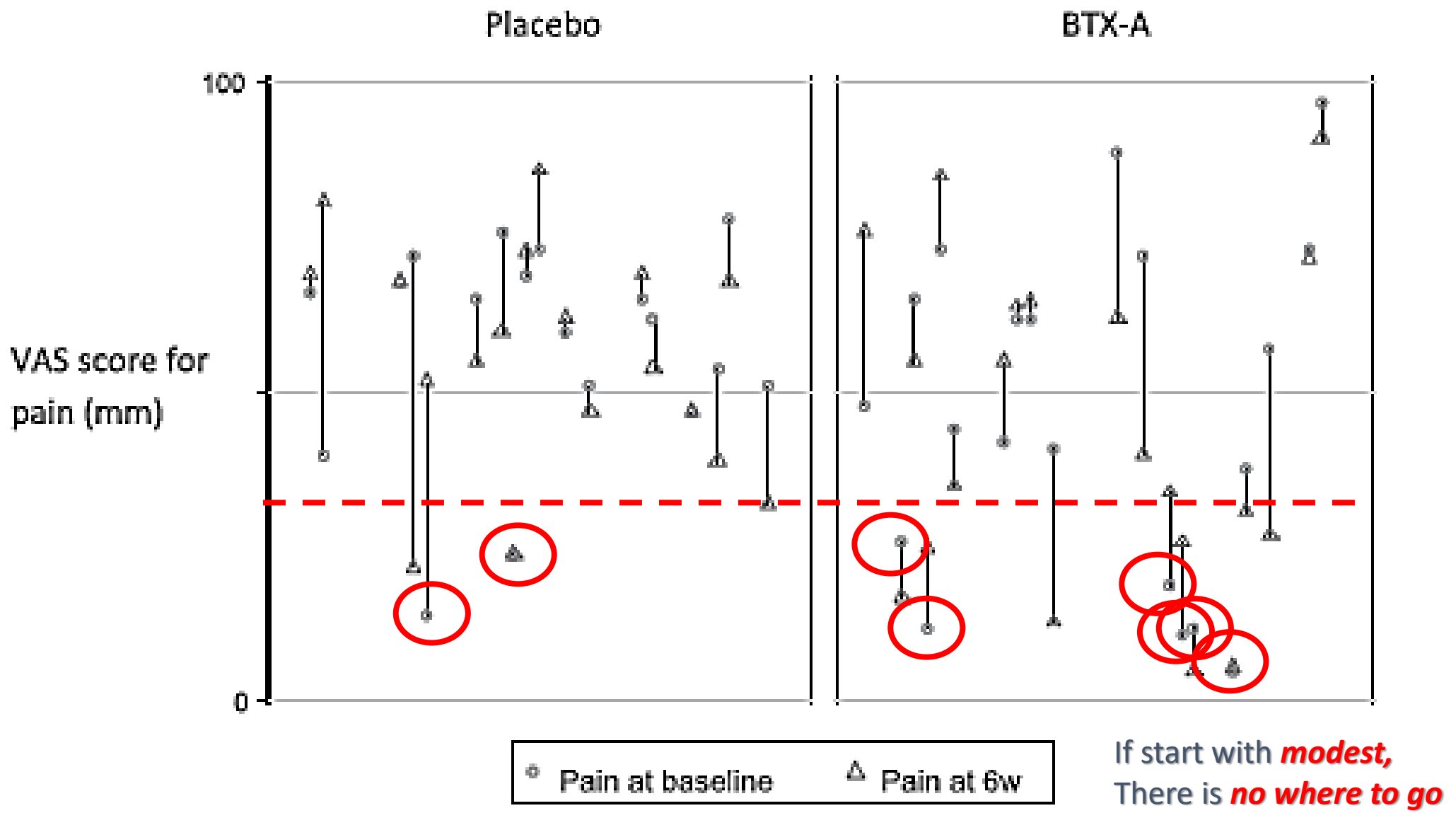
Demographics may have *Limited* study success

Table 1
Baseline demographic and clinical characteristics.

	BTX-A	Placebo	Total
Number	20	18	38
Mean age (SD)	36.8 (8.9)	38.7 (7.0)	37.7 (8.0)
Number of female subjects (%)	17 (85)	14 (78)	31 (82)
Median duration of symptoms in months (interquartile range)	48 (23–99)	18 (12–45)	27 (17–80)
Number involved in work-related claim (%)	3 (15)	4 (22)	7 (18)
Number involved in MVA-related claim (%)	9 (45)	11 (61)	20 (53)
Number involved in either work or MVA claim (%)	12 (60)	15 (83)	27 (71)
Dominant limb affected (%)	10 (50)	8 (44)	18 (47)
Both limbs affected (%)	3 (15)	1 (6)	4 (11)
Median pain VAS score (mm) (interquartile range)	46 (22–68)	63 (51–69)	
Number (%) with pain VAS <30 mm	6 (30)	2 (11)	
Median paresthesias VAS (mm) (interquartile range)	42 (23–70)	48 (43–65)	
Median DASH score (interquartile range)	39 (29–51)	45 (37–58)	
Median SF-36 physical sumscore (interquartile range)	38 (35–43)	38 (34–41)	
Median SF-36 mental sumscore (interquartile range)	43 (39–51)	35 (29–51)	

BTX-A, botulinum toxin type A; DASH, Disabilities of the Arm, Shoulder, and Hand questionnaire; MVA, motor vehicle accident; SF-36 Health Survey physical and mental health; VAS, visual analogue scale.

6 BTX and 2 placebo had ***only modest*** baseline pain (≤ 30 mm)



If start with ***modest,***
There is ***no where to go***

Summary

Subjects:

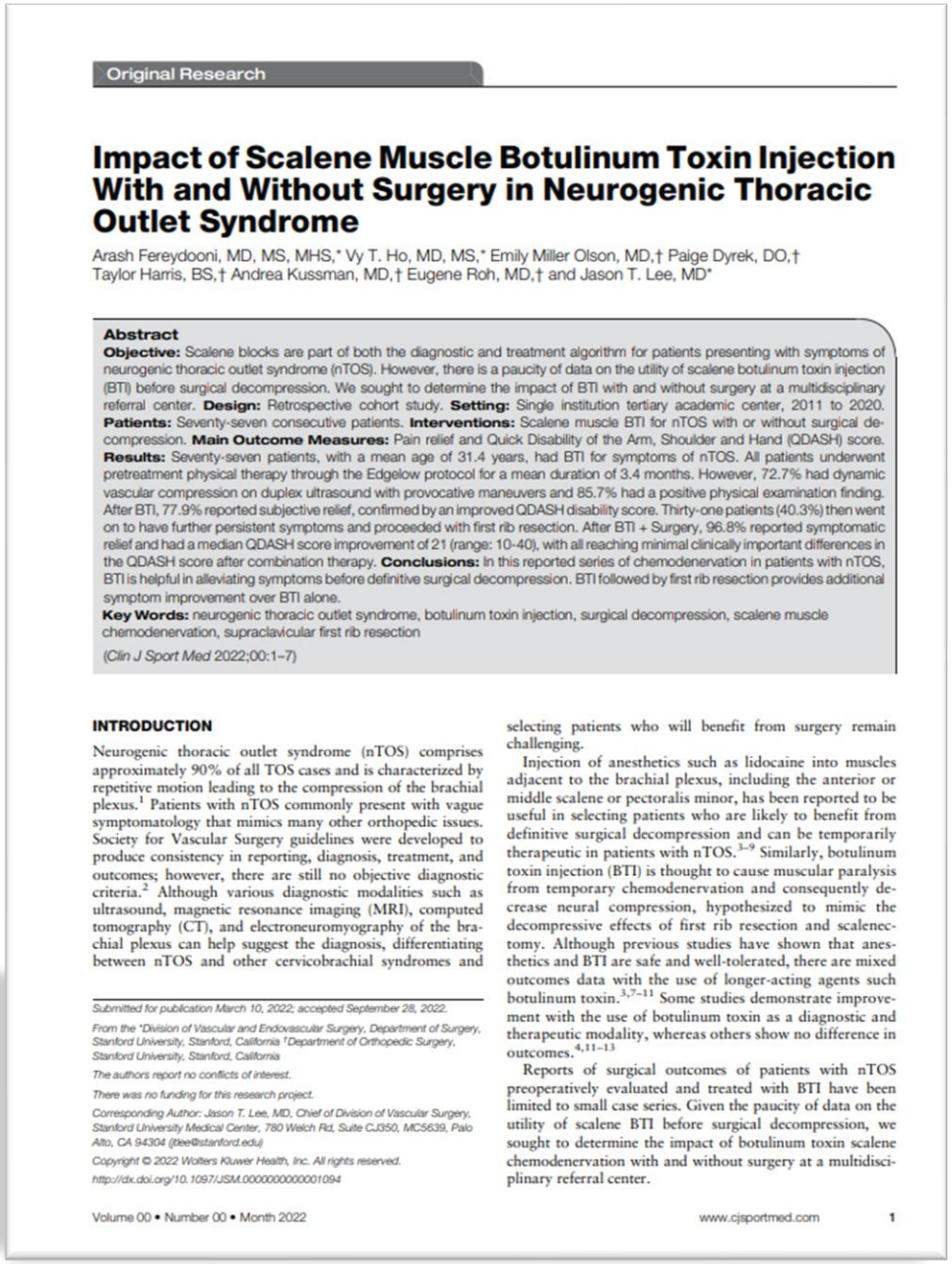
- Average symptoms duration 4 years (BTX) vs. 1.5 years (placebo)
- Chronic pain with central sensitization may have masked any benefit
- 27/38 subjects involved in workman's comp or MVA settlement

Study Methods

- Injection guidance by EMG (vs. US or CT)
- Muscle injection site (scalene vs. scalene plus pect minor plus subclavius)
- Dose 75 units, was this correct

Statistical Methods

- Powered for 20 mm reduction of VAS yet 20% had baseline < 30



Original Research

Impact of Scalene Muscle Botulinum Toxin Injection With and Without Surgery in Neurogenic Thoracic Outlet Syndrome

Arash Fereydooni, MD, MS, MHS,* Vy T. Ho, MD, MS,* Emily Miller Olson, MD,† Paige Dyrek, DO,† Taylor Harris, BS,† Andrea Kussman, MD,† Eugene Roh, MD,† and Jason T. Lee, MD*

Abstract

Objective: Scalene blocks are part of both the diagnostic and treatment algorithm for patients presenting with symptoms of neurogenic thoracic outlet syndrome (nTOS). However, there is a paucity of data on the utility of scalene botulinum toxin injection (BTI) before surgical decompression. We sought to determine the impact of BTI with and without surgery at a multidisciplinary referral center. **Design:** Retrospective cohort study. **Setting:** Single institution tertiary academic center, 2011 to 2020. **Patients:** Seventy-seven consecutive patients. **Interventions:** Scalene muscle BTI for nTOS with or without surgical decompression. **Main Outcome Measures:** Pain relief and Quick Disability of the Arm, Shoulder and Hand (QDASH) score. **Results:** Seventy-seven patients, with a mean age of 31.4 years, had BTI for symptoms of nTOS. All patients underwent pretreatment physical therapy through the Edgelow protocol for a mean duration of 3.4 months. However, 72.7% had dynamic vascular compression on duplex ultrasound with provocative maneuvers and 85.7% had a positive physical examination finding. After BTI, 77.9% reported subjective relief, confirmed by an improved QDASH disability score. Thirty-one patients (40.3%) then went on to have further persistent symptoms and proceeded with first rib resection. After BTI + Surgery, 96.8% reported symptomatic relief and had a median QDASH score improvement of 21 (range: 10-40), with all reaching minimal clinically important differences in the QDASH score after combination therapy. **Conclusions:** In this reported series of chemodenervation in patients with nTOS, BTI is helpful in alleviating symptoms before definitive surgical decompression. BTI followed by first rib resection provides additional symptom improvement over BTI alone.

Key Words: neurogenic thoracic outlet syndrome, botulinum toxin injection, surgical decompression, scalene muscle chemodenervation, supraclavicular first rib resection

(*Clin J Sport Med* 2022;00:1–7)

INTRODUCTION

Neurogenic thoracic outlet syndrome (nTOS) comprises approximately 90% of all TOS cases and is characterized by repetitive motion leading to the compression of the brachial plexus.[1] Patients with nTOS commonly present with vague symptomatology that mimics many other orthopedic issues. Society for Vascular Surgery guidelines were developed to produce consistency in reporting, diagnosis, treatment, and outcomes; however, there are still no objective diagnostic criteria.[2] Although various diagnostic modalities such as ultrasound, magnetic resonance imaging (MRI), computed tomography (CT), and electroneuromyography of the brachial plexus can help suggest the diagnosis, differentiating between nTOS and other cervicobrachial syndromes and selecting patients who will benefit from surgery remain challenging.

Injection of anesthetics such as lidocaine into muscles adjacent to the brachial plexus, including the anterior or middle scalene or pectoralis minor, has been reported to be useful in selecting patients who are likely to benefit from definitive surgical decompression and can be temporarily therapeutic in patients with nTOS.[3–9] Similarly, botulinum toxin injection (BTI) is thought to cause muscular paralysis from temporary chemodenervation and consequently decrease neural compression, hypothesized to mimic the decompressive effects of first rib resection and scalenectomy. Although previous studies have shown that anesthetics and BTI are safe and well-tolerated, there are mixed outcomes data with the use of longer-acting agents such botulinum toxin.[3,7–11] Some studies demonstrate improvement with the use of botulinum toxin as a diagnostic and therapeutic modality, whereas others show no difference in outcomes.[4,11–13]

Reports of surgical outcomes of patients with nTOS preoperatively evaluated and treated with BTI have been limited to small case series. Given the paucity of data on the utility of scalene BTI before surgical decompression, we sought to determine the impact of botulinum toxin scalene chemodenervation with and without surgery at a multidisciplinary referral center.

Submitted for publication March 10, 2022; accepted September 28, 2022.

*From the *Division of Vascular and Endovascular Surgery, Department of Surgery, Stanford University, Stanford, California †Department of Orthopedic Surgery, Stanford University, Stanford, California*

The authors report no conflicts of interest.

There was no funding for this research project.

Corresponding Author: Jason T. Lee, MD, Chief of Division of Vascular Surgery, Stanford University Medical Center, 780 Welch Rd, Suite CJ350, MC5639, Palo Alto, CA 94304 (jtlee@stanford.edu)

http://dx.doi.org/10.1097/JSM.0000000000001094

Retrospective (2011-2020)

Choreographed clinical care

- Initial PT minimum 2 months 3x/week
- Everyone received BTX-A first 50 U
- ***If BTX-A response***, then offered surgery
- DASH survey outcomes (improvement)
  - Significant > 67%
  - Moderate 34 – 66%
  - Mild 1 – 33%
  - No improvement

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Stanford Study

- 77 patients received BTX-A
- Median number of treatments 2 (range 1 – 4)
- 31 patients went on to have surgery
- 46 patients had BTX-A alone without surgery

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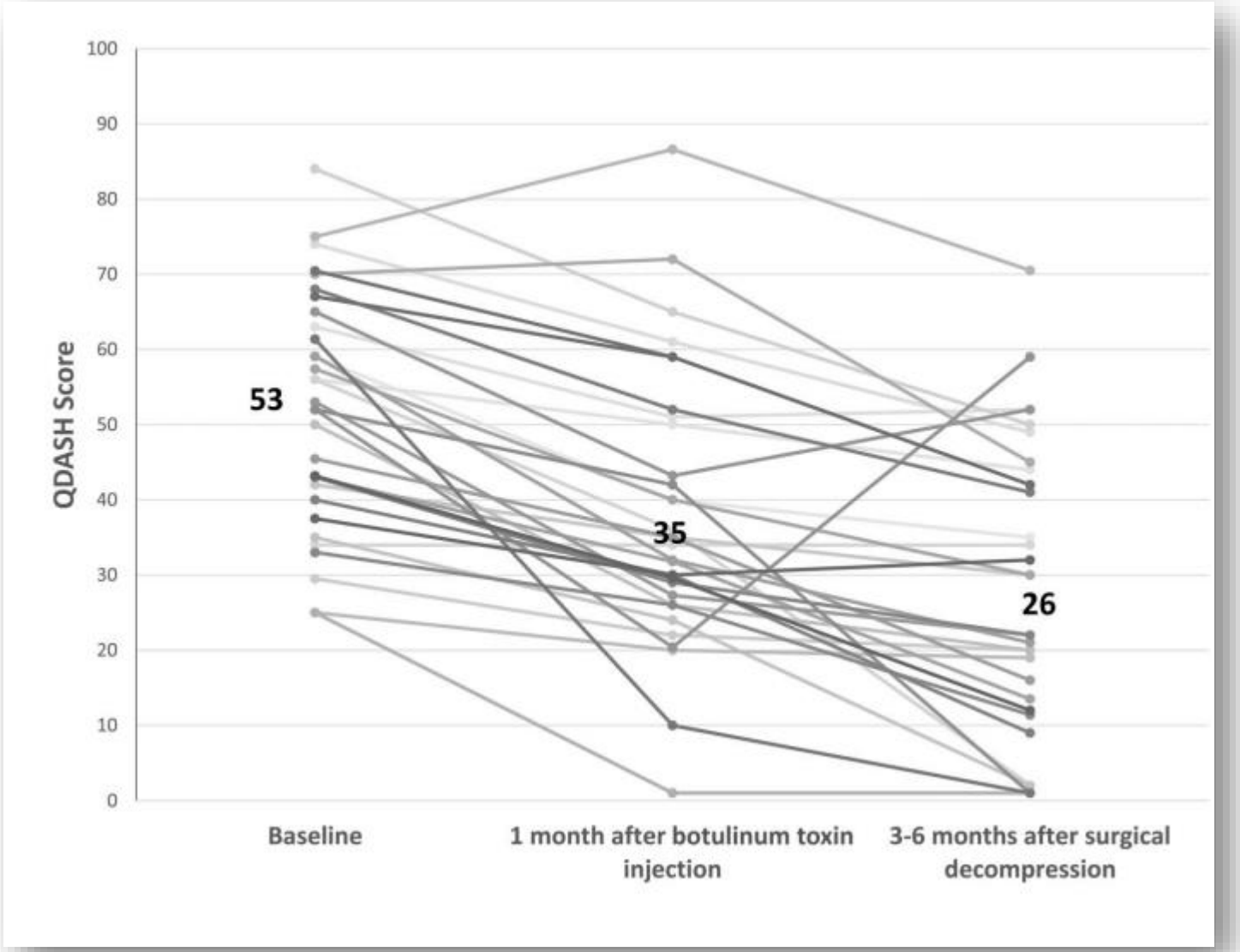
Surgical Outcomes



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Stanford Study Results

Variable	BTX-A	BTX-A + Surgery	P-Value
Relief after BTX	70%	90%	0.03
Mild	15%	10%	0.8
Moderate	22%	20%	
Significant	63%	70%	
DASH change	78%	81%	0.6

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Predictors of Symptom Relief

Univariate analysis

- Higher initial DASH score
- Younger age (p=0.008)
- Shorter symptom duration (p=0.03)

Multivariate analysis

- Females (OR 6.6; p<0.05)
- Positive examination findings (OR 9.0; p<0.05)

Abstract only: Eugene Roh; Stanford CA

Stanford Author Comments

- Used for both diagnosis and treatment
- Allows for temporary relief to facilitate PT
- Botox alone provided significant improvement in 63% (similar to others):

Torriani	66%
Rochlin	64%
Jordon	64%
Donahue	63%

- Dose is unclear (reported range 50 – 100 U)
- Symptom improvement is sustained for 2 – 3 months

37 year-old right-handed female

10/18/2021: Original consultation

12/8/2021: US guided injectate: 1.5 mL lidocaine ***BTX-A 25 units***

"Able to do PT for three months, the first six weeks was full physical therapy but has continued more limited physical therapy since. She is very happy with results and wanted to do another Botox injection. For the first 6 weeks after her injection, her symptoms were roughly a 0 to 2/10 after which they did spike some to roughly a 5 or 6 but now have settled to about a 3 – 4/10."

4/1/2022: US guided injectate: 1.5 mL lidocaine ***BTX-A 50 units***

37 year-old right-handed female

Dear Ryan,

Good news. The ***pain*** in my arm and shoulder/scap/rotator/pec area ***feels pretty under control***. For the first time. ***It's been such a long time with the pain, I hope it's not a fluke.*** But i believe lately the PT has kicked in. Scaling the exercises back a little, to focus on the tinier muscles, def helped reduce the flare. It's like the Botox allowed me to do any PT whatsoever, and that was the ticket. It was too painful pre-botox. So I got a little better, but felt like a plateau in May/June, and then threw in the celery juice and tweaked the exercises. And now i can do the nerve glides and exercises ***without pain***. Finally. ***And I can't believe i'm saying this but I don't think I need another botox shot***. It's like, a ***new day***. I am ***so grateful***, I can't articulate a proper thank you at the moment."

Summary Comments

- Neurogenic Thoracic Outlet Syndrome is a complicated disease entity.
  - Complicated to diagnose
  - Complicated to manage

- Physical Therapy alone is limited by both efficacy and implementation
- Surgery is not for everyone

- Botox therapy may facilitate PT implementation for many patients.
- Botox therapy may reduce the need for surgery in some patients.