

IN THE NAME OF GOD

Thoracic Outlet Syndrome

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Other names

□ According to the etiology of the compression:

Scalenus anticus syndrome

Costoclavicular syndrome

Hyperabduction syndrome

Cervical rib syndrome

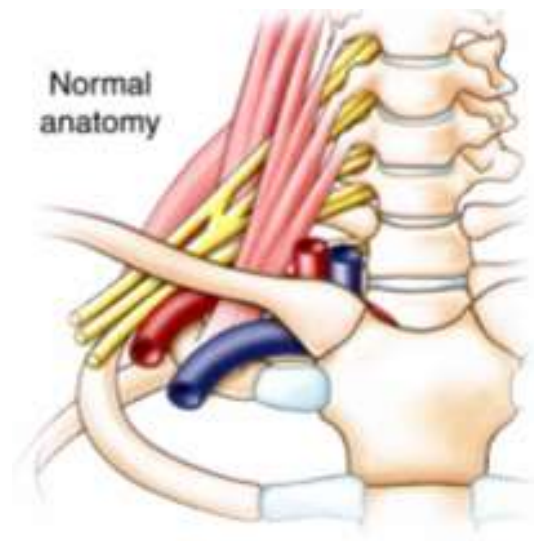
First rib syndrome

Incidence of TOS

3 – 80 cases per 1000 people

Anatomy of the Thoracic Outlet

- ✓ Upper mediastinum at the base of the neck
- ✓ ASM and MSM and the first rib (inferior)



Normal Physiology

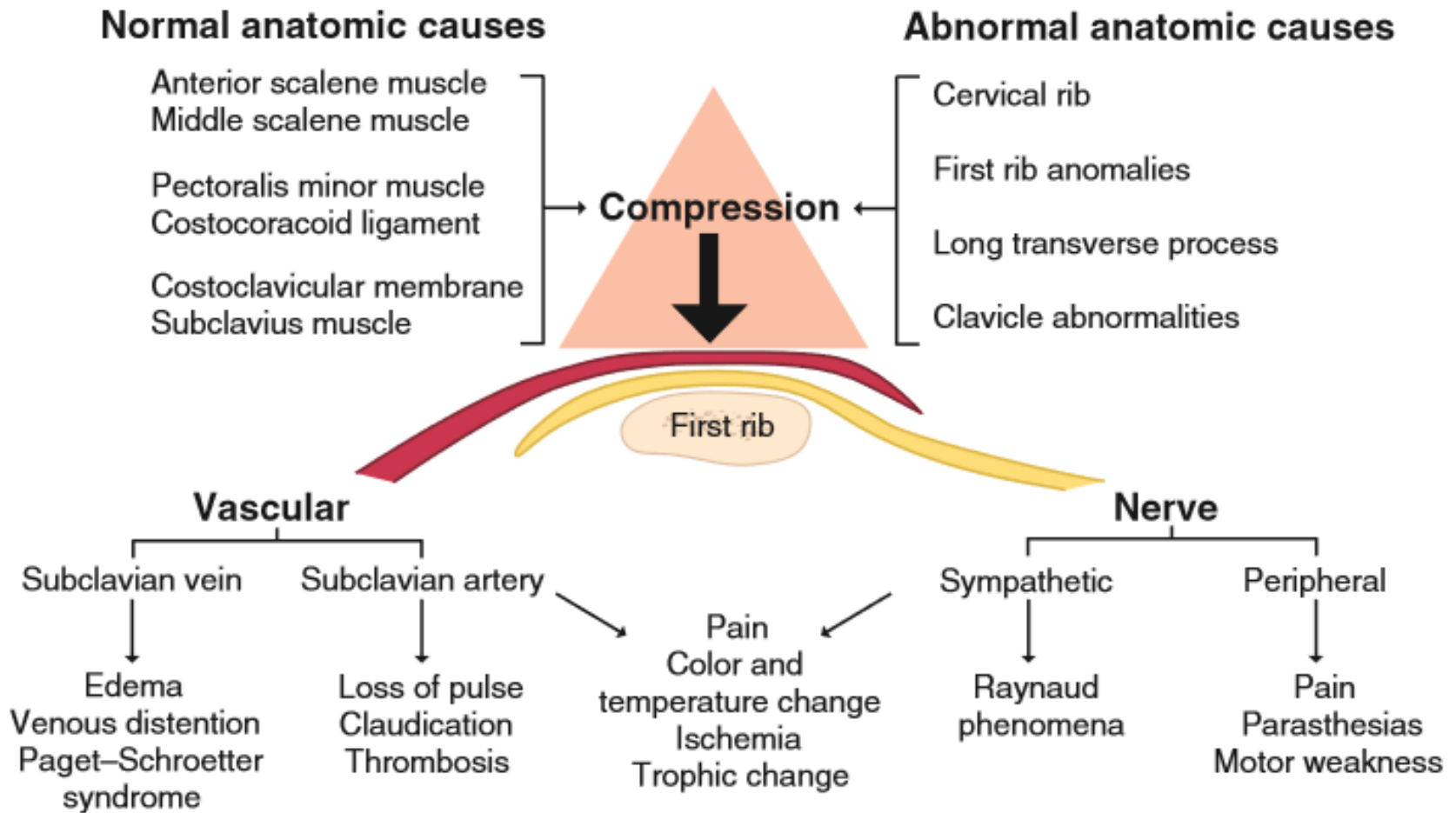
Arm elevation or abduction results in :

- Functional reduction in the caliber of the T.O

Because of posterior rotation of the clavicle and contraction of the scalene muscles

- Narrowing of the space between the clavicle and the first rib
- Contraction of pectoralis minor muscle

Compression factors in the thoracic outlet with the signs and symptoms produced



THE CLINICAL SYNDROME

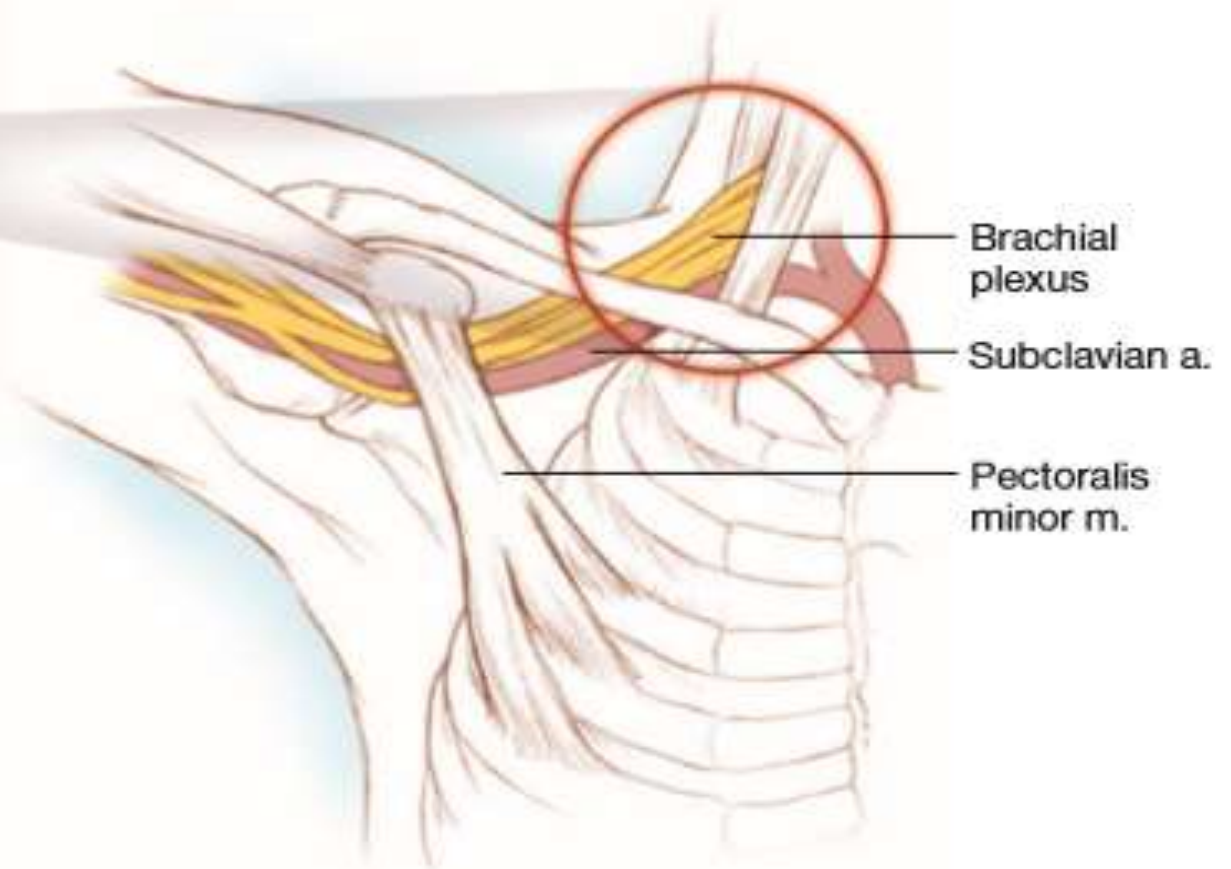
Signs and symptoms:

Paresthesias and aching pain of the neck, shoulder, and arm

The cause is thought to be :

compression of the brachial plexus and subclavian artery and vein as they traverse the **interscalene** triangle, the **costoclavicular** space, and the **subpectoral** (subcoracoid) tunnel

Compression of the brachial plexus results in pain and weakness in the affected upper extremity



THE CLINICAL SYNDROME

Compression of the brachial plexus and subclavian artery and vein :

1. Interscalene triangle
2. Costoclavicular space
3. Subpectoral (subcoracoid) tunnel

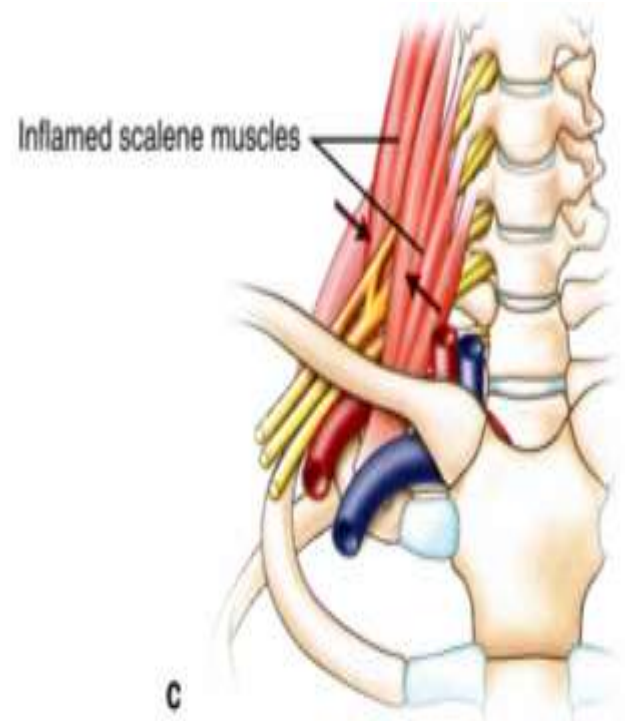
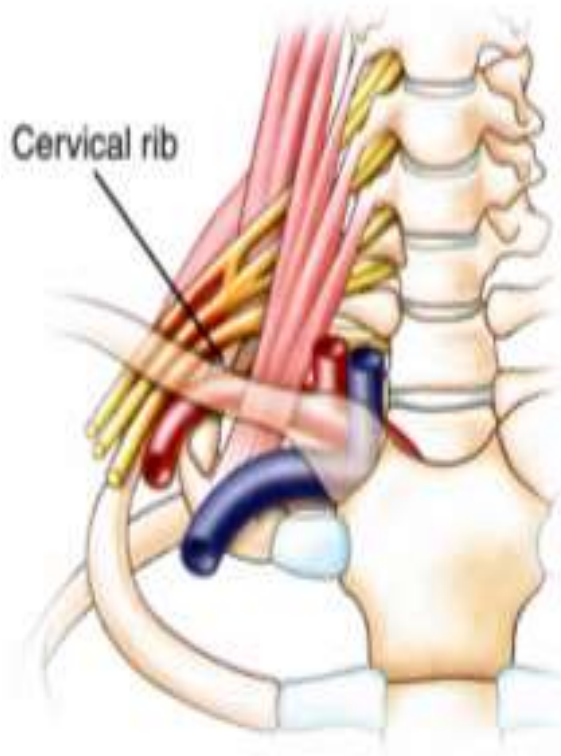
Compression or entrapment of the neurovascular structures may be caused by :

1. Congenitally abnormal structures such as :
 - ✓ Cervical ribs
 - ✓ Scalene muscle anomalies (scalene minimus muscle, sickle-shaped middle scalene)
 - ✓ Fibrous bands
2. Cervicothoracic tumors
3. Aneurysms

One or all the structures may be compressed, thus giving the syndrome a **varied clinical expression**

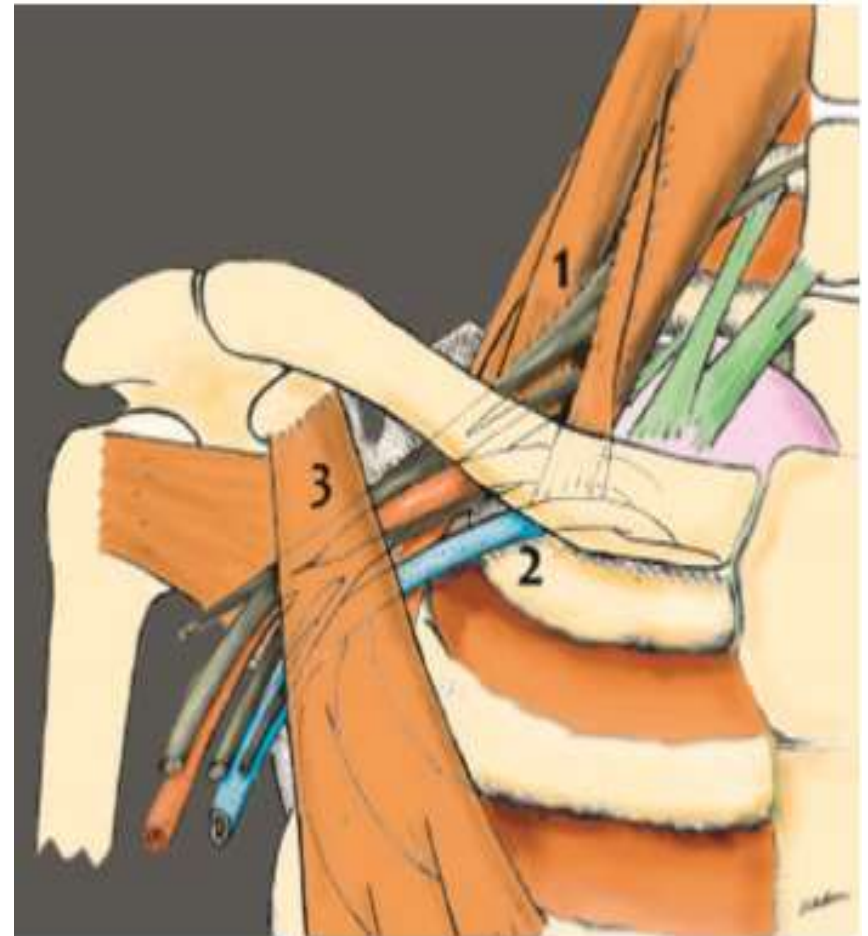
Other causes:

- Callus from a clavicular FX
- Scar (prior trauma, radiation therapy)
- Trauma, particularly cervical hyperextension (Whiplash)
- Chronic repetitive of the upper extremities (particularly in an out-front or overhead position) → Chronic spasm, inflammation, and contracture and thickening of scalene muscles



The 3 main sites implicated in neurovascular compression in TOS include:

- (1) Interscalene triangle
- (2) Costoclavicular space
- (3) Subpectoral tunnel



TOS is seen most commonly :

In women between **25 - 50** years of age

SIGNS AND SYMPTOMS

- ❑ Compression of neural structures accounts for most of them
- ❖ **Paresthesias** of the upper extremity → radiating into the distribution of the ulnar nerve (may be misdiagnosed as tardy ulnar palsy)
- ❖ **Aching** and **incoordination** of the affected extremity : common findings
- ❖ If the pain persists, abnormal position of the shoulder girdle to relieve compression or entrapment of the neurovascular structures may be observed

- ❖ If **vascular compression** exists : edema or discoloration of the arm may be noted
- ❖ Venous or arterial thrombosis → **rare**
- ❖ **Rarely**, the symptoms of TOS are caused by **arterial aneurysm**, and auscultation of the supraclavicular region reveals a **bruit**

Classification

- Arterial TOS : less than 1%
- Venous TOS : 5%
- Neurogenic TOS : most common

Arterial TOS

- ✓ Less than **1%**
- ✓ **Almost always** presents as forearm or hand claudication or upper extremity ischemic symptoms
- ❖ **P/E** : diminished or absent wrist pulses
- ❖ Occlusion of radial and/or ulnar arteries or their palmar or digital branches
- ❖ Rest pain or gangrene of the fingers (arterial embolic)

Arterial TOS

- Decreased Blood pressure in the affected arm when compared with the opposite arm of more than 20 mmHg may also be present

Venous TOS

- ✓ Approximately **5%**
- ✓ **Also termed:** Paget-Schroetter syndrome or effort thrombosis of the axillosubclavian vein
- ✓ **Presentation:** Aching pain distributed diffusely throughout a swollen, ruborous upper extremity
- ❖ **If more chronic:** Pain and swelling may be less prominent

Venous TOS

P/E:

- Acute: arm swelling and discoloration
- In later stages: prominent vein(upper arm and around the shoulder)

Neurogenic TOS

☐ Most common

❖ **Almost always** have a **prior traumatic events:**

1. Cervical hyperextension= whiplash injury
2. Fall on an outstretched arm
3. An object falling on the head or the shoulder
4. History for a repetitive stress injury
(occupational)

Workplace risk factors for neurogenic TOS:

Sustained effort with upper extremity or extremities out-front or overhead :

- Drywall hangers
- Dental hygienists
- Beauticians
- Hairdressers
- Grocery checkers
- Shelf stockers
- Clerical workers engaged in prolonged keyboarding

Maladaptive posture in Neurogenic TOS

Head flexed on the neck and the shoulders
down and forward

Symptoms of neurogenic TOS

- **Few** or **no** symptoms with the arm in a **neutral** position
- **Onset** of pain and paresthesias with the **arms** placed in an **out-front, overhead, or abducted** posture
- Elevational arm aching, particularly proximally around the shoulder, the axilla, and upper arm, associated with numbness and tingling out the arm, distal weakness, limitation in ROM

Symptoms of neurogenic TOS

- Paresthesias in **lower** trunk(C8-T1)
- 80% : pain and paresthesias radiating along the **ulnar** nerve distribution (often: small and ring finger)
- Result upward traction on the first rib by the scalene muscles, thus selectively impacting the inferior aspects of the brachial plexus

Symptoms of neurogenic TOS

- ❑ **Painless atrophy** of the **hand** primarily involving **APB** (abductor policis brevis) with lesser atrophy of the **interossei** and **hypothenar** muscles **known as Gilliat- Sumner hand**

Pain in neurogenic TOS

- ❖ Pain is not the primary symptom of true nTOS ,however , the patient may complain of **diffuse, dull** pain in the neck, shoulder, axillary region and arm which may worsen with overhead activities and repetitive use of arm

Other symptoms of neurogenic TOS:

- Headache, primarily occipital
- Facial or jaw pain or pain around ear
- Muscle pain particularly around neck, shoulder, scapula and upper arm
- Limited ROM
- Muscle tenderness (anterior and lateral neck)

Neurogenic TOS

TABLE 39.1 Clinical Elements that Suggest Neurogenic Thoracic Outlet Syndrome

- Inability to drive with the hands elevated in the normal 10 o'clock/
2 o'clock position on the steering wheel
- Problems with grooming (shampooing the hair or use of a hairdryer)
- Awakening at night with pain or numbness in the affected arm(s)
- “Drop attacks”: the tendency to drop things, often without recognizing
that grip strength has diminished
- Inability to carry out sustained overhead activities, for example,
changing multiple light bulbs in the ceiling
- Loss of handwriting legibility (with involvement of the dominant upper
extremity)
- Inability to remove a tight jar lid

Diagnostic criteria for nTOS according of the Society of Vascular Surgery (SVS) : 2016

3 of the 4 following criteria:

1. Local Findings: a history of symptoms consistent with irritation/inflammation at the scalene triangle (pain at the chest wall, axilla, upper back, shoulder, trapezius, neck, or head); exam findings including pain on palpation of the scalene muscle

2. Peripheral Findings: a history of arm or hand symptoms consistent with central nerve compression (numbness, pain, paresthesias, vasomotor changes, weakness, muscle wasting); exam in which these peripheral symptoms are reproduced by palpation of the scalene muscles or by provocative maneuvers

3. Absence of other reasonably likely diagnoses including cervical disk disease, shoulder disease, carpal tunnel disease, chronic regional pain syndrome

4. Response to a scalene muscle block

nTOS is common in :

- Violinists
- Individuals with heavy computer usage
- Assembly line workers
- Athletes with overhead arm motion in their sport (swimmers, baseball pitchers, weightlifters, volleyball players)

Neurogenic TOS

- **Positive Tinel sign**

Palpation over brachial plexus at the scalene triangle → neurotic sensation in supraclavicular fossa, axilla, out the arm

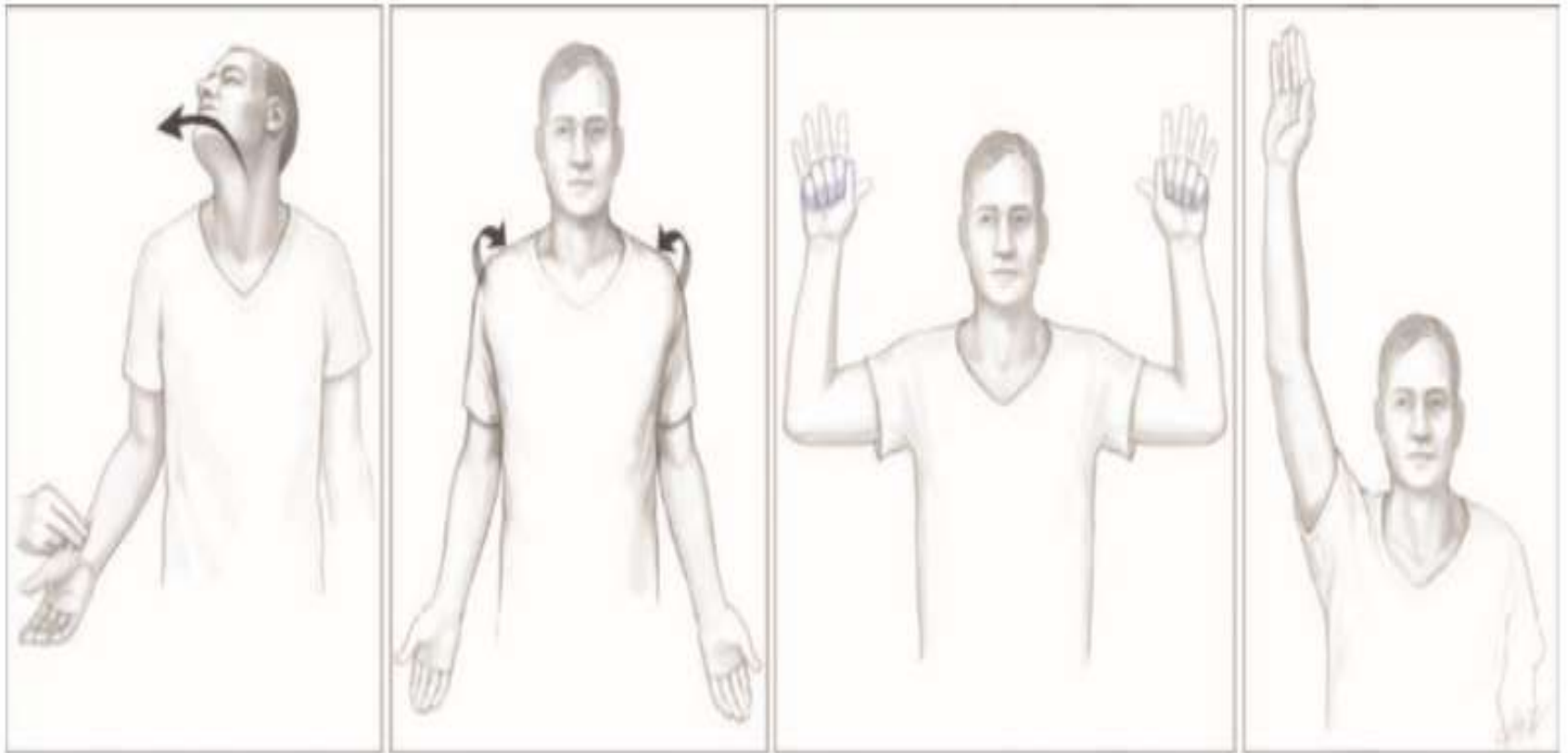
- Tenderness over pectoralis minor tendon attachment at the coracoid process
- Rarely, intrinsic hand muscle atrophy (**Gilliat – Sumner hand**)

The symptoms of TOS may be elicited by various maneuvers :

By the criteria proposed above, an important component of the exam is pain over the scalene triangle, as is reproduction of symptoms with **palpation of the scalene muscle** or **by provocative maneuvers**.

1. Adson test
2. Costoclavicular test (**military position, shoulder brace position**)
3. Roo elevated arm stress test(**Hands-up = AER**)
4. Wright test (hyperabduction test)

A. Adson test, B. Costoclavicular test, C. Roos test, D. Wright test



A

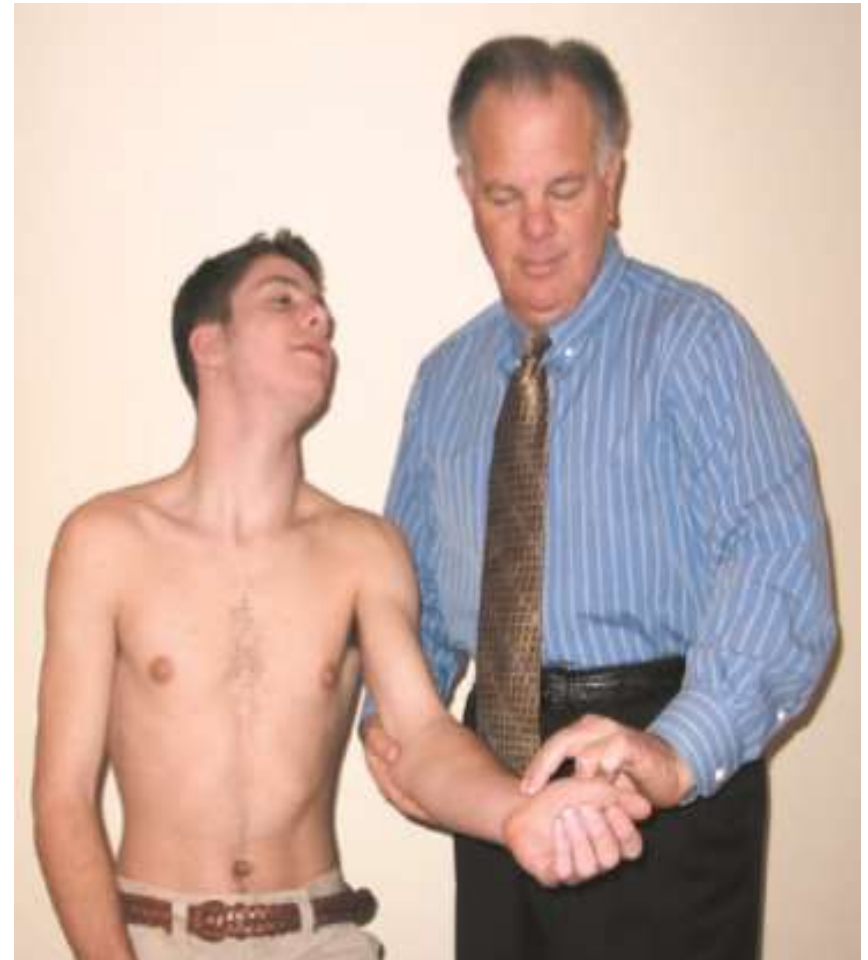
B

C

D

Adson (Scalene) test :

- ❖ Palpating the **radial pulse** on the affected side with the patient's **neck extended** and the **head turned toward the affected side**
- A diminished pulse suggests thoracic outlet syndrome



Adson (Scalene) test :

- ❑ The Adson (or scalene) test: **contracts** the **ASM** and **MSM**, resulting in a **decrease** in the interscalene triangle and intensifying any preexisting compression of the subclavian artery and brachial plexus



Adson Test

More than 30 % of the **asymptomatic** population may have a **positive** Adson test

Elevated arm stress test = Hands-up

Roos or Abduction/ External Rotation (**AER**)

Patient hold his or her arms over the head and open and close the hands.(or Arm 90 abd + elbow 90 flex)

Normally, patients without TOS can perform this maneuver for **approximately 3 minutes**, whereas those suffering from TOS experience the onset of symptoms **within 30 seconds**

Roos or Abduction/ External Rotation (AER)

☐ Positive test :

1. Numbness or pain will occur in the hands and forearms
2. Within 30 seconds



The military or costoclavicular test or shoulder brace position

- Retraction of the shoulders **backward** and **downward**, which may result in pulse obliteration at the wrist
- Narrows the costoclavicular space by narrowing the area between the clavicle and first rib



The hyperabduction (or Wright) test

- ❖ The arms
hyperabducted to **180**
degrees and **externally**
rotated
- Compression is
suspected if there is a
decrease in **radial pulse**



Spurling test

- ❖ **Not** a provocative test for neurogenic TOS
- ❖ Is important in the evaluation of other DDX (cervical radiculopathy due to disc, scar, or arthritis)

Which one is better for Neurogenic TOS?

- **More than 30 %** of the **asymptomatic** population may have a **positive** Adson test
- Similar results (Adson test) hold for **military** position
- **The AER test (hands- up) has a high sensitivity and much better specificity for Neurogenic TOS**

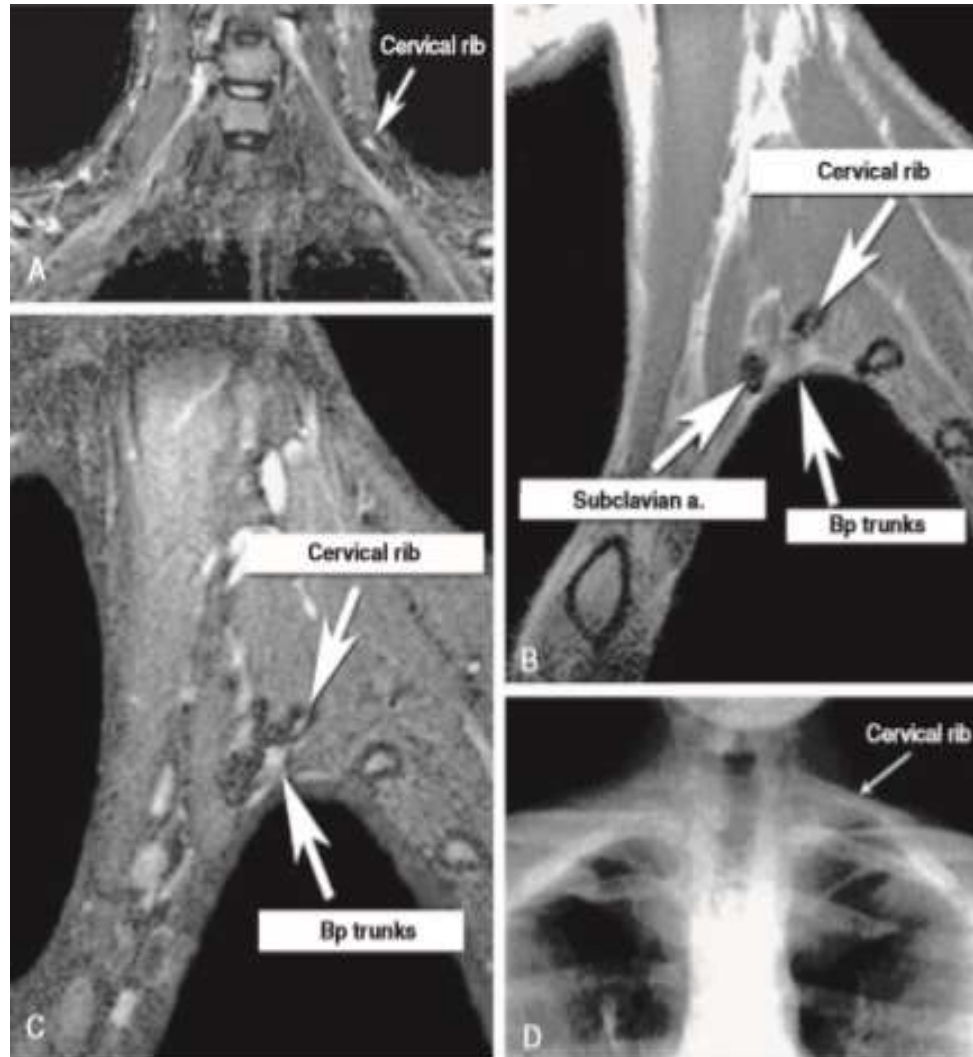
Diagnostic Test

- ❖ Plain radiographs of the cervical spine (cervical ribs or overly elongated transverse processes, callus of clavicular Fx)
- ❖ Chest radiography with apical lordotic views to rule out Pancoast's tumor.
- ❖ MRI of the cervical spine (lesions of the cervical spinal cord and exiting nerve roots, cervical ribs and fibrous adhesions)
- ❖ If the diagnosis is still in doubt, MRI of the brachial plexus is indicated to search for an occult pathologic process, including primary tumors of the plexus and aberrant scalene muscles
- ❖ Ultrasonography
- ❖ EMG/NCV
- ❖ Screening laboratory tests: CBC, ESR, ANA, blood chemistry

A, Coronal T2-weighted MRI (cervical rib)

B and **C**, Sagittal T1- and T2-weighted MRI at the level of the interscalene triangle shows the close proximity of the cervical rib to the lower trunk of the brachial plexus (Bp).

D, Plain chest film shows the left cervical rib.



Diagnostic Tests

- ✓ Doppler (arterial & venous TOS)
- ✓ CT scan
- ✓ Catheter-directed arteriography
- ✓ EMG/NCV : neurogenic TOS
- ✓ EMG-guided **interscalene** injection (in neurogenic TOS)

EMG/NCV in neurogenic TOS

1. True Neurogenic TOS → Rarely

❖ From direct trauma to brachial plexus (stab or gunshot wound)

Pattern : **Reduction** in **median motor** and **ulnar sensory** nerve amplitude

2. Non specific or disputed Neurogenic TOS:

Much more common

Pattern : **Almost always normal**

EMG/NCV in Non specific or disputed Neurogenic TOS: **Almost always normal, why?**

- Tender et al:

Compression occurs much more **centrally**, at the level of cervical nerve **roots** and proximal brachial plexus **trunks**, an area that is **difficult to assess via nerve conduction testing**

EMG & cervical rib and nTOS

- EMG results suggestive of nTOS or hand atrophy are found in only about 1% of those with the syndrome
- A cervical rib is present in only 5% to 9% of nTOS

EMG-guided **interscalene** injection (in neurogenic TOS)

- ✓ Temporary scalene muscle inactivation
- ✓ Injection: bupivacaine or botulinum toxin A
- ✓ 90% sensitivity and specificity for neurogenic TOS
- ✓ Reduction in pain and paresthesias, headache
- ✓ Improvement in flexibility and ROM
- ❖ Bupivacaine: onset → a few minutes
last → 15 min to several hours
- ❖ Botox: onset → 48-72 hr.
last → 1-4 months

Note

1. There is no test that is pathognomonic for Ntos
2. EMG is performed to rule out ulnar nerve entrapment and carpal tunnel syndrome

DIFFERENTIAL DIAGNOSIS

- ❑ Diseases of the cervical spinal cord
- ❑ Diseases of the bony cervical spine
- ❑ Diseases of the cervical disk
- ✓ Syringomyelia
- ✓ Tumor of the cervical spinal cord
- ✓ Tumor of the cervical nerve root as it exits the spinal cord (e.g., schwannoma)
- ✓ Pancoast's tumor (in the absence of clear antecedent trauma, especially if the patient has a history of tobacco use)
- ✓ Lateral herniated cervical disk
- ✓ Metastatic tumor
- ✓ Cervical spondylosis
- ✓ Rarely, infection involving the apex of the lung

DIFFERENTIAL DIAGNOSIS

- ✓ Raynaud syndrome (phenomenon)
- ✓ CRPS
- ✓ Lymphedema
- ✓ Multiple sclerosis
- ✓ Cubital tunnel syndrome (ulnar nerve)
- ✓ CTS (median nerve)
- ✓ Migraine
- ✓ Fibromyalgia
- ✓ Polymyositis
- ✓ Temporal arteritis
- ✓ Polymyalgia rheumatica

DIFFERENTIAL DIAGNOSIS

- Initial trauma e.g., whiplash injury

NOTE :

The diagnosis of neurogenic TOS should not be invoked until *at least 3-6 months* after the initial traumatic events

Neurogenic pectoralis minor syndrome (nPMS)

- Has a similar presentation to nTOS
- In nPMS, the anatomic site of brachial plexus compression is the retropectoral space
- Pectoralis minor tenotomy is an effective treatment for this condition.
- Based on P/E findings and response to lidocaine muscle blocks, nTOS can be differentiated from nPMS, although some patients will have compression at both sites (“double crush syndrome”).(Adult chest surgery/ Sugarbaker/ 2020)

Treatment of arterial TOS

- Arterial TOS : 2 goals
 1. Relief of distal limb ischemia
 2. Eradication of more proximal embolic source that resulted in the distal extremity ischemia
- Repair of the proximal subclavian arterial lesion
- Catheter- directed thrombolysis
- Open arterial thrombectomy
- **Sympathectomy**

Venous TOS

- Systemic anticoagulation
- Catheter- directed axillosubclavian vein thrombolysis (if the onset of symptoms is recent)
- Balloon angioplasty
- Venous stenting not be performed at this site (high **stent Fx** between the “hammer” and “anvil” formed by the **clavicle** and **first rib**)
- Surgery (T.O decompression)

Treatment (neurogenic TOS)

➤ Physical Modalities

➤ Drug Therapy

➤ Invasive Therapy

➤ Surgery

❑ The **initial** treatment of nTOS nearly always begins with **nonsurgical therapy**, considered the **standard of care for most cases**

Physical Modalities

- ✓ The **primary** treatment for TOS : rational use of **physical therapy** to maintain function and palliate pain
- ✓ Postural training, abdominal breathing, stretching and relaxing the scalene muscles
- ✓ Shoulder abnormalities, including subluxation and adhesive capsulitis, must be aggressively treated
- ✓ Occupational therapy to assist in activities of daily living is important to **avoid** further deterioration of function

Physiotherapy

- **Resistances** exercises → exacerbate scalene muscle contracture → **no benefit** from PT
- Initially, **most** patients are treated conservatively with **physical therapy**, except those with vascular problems

Goals of physical therapy

- “open up” the space between the clavicle and first rib :
 1. Improve posture
 2. Strengthen the shoulder girdle
 3. Loosen the neck muscles

“open up” the space between the clavicle and first rib is accomplished by :

- Pectoralis stretching
- Strengthening the muscles between shoulder blades
- Assumption of good posture
- Active neck exercises, including chin tuck, flexion, rotation, lateral bending, and circumduction
- Behavior modification
- Ergonomic correction
- Relaxation exercises
- Massage therapy
- Biofeedback

Drug Therapy

Gabapentin

First-line pharmacologic treatment for the neuritic pain of TOS

- **The initial dose** : 300 mg at bedtime **for 2 nights**
- **Increase dose** : in 300-mg increments given in equally divided doses **over 2 days**, as side effects allow, until **pain relief** is obtained or a **total dosage of 2400 mg/day** is reached
- At this point, if the patient has experienced partial pain relief, blood values are measured, and the drug is **carefully titrated upward using 100-mg tablets**
- **Rarely** is a dosage **greater than 3600 mg/day** required
- Potential side effects : dizziness, sedation, confusion, rash

Carbamazepine

Is useful in patients who do not obtain pain relief with gabapentin

Confusion and **anxiety** have surrounded its use

Before starting the drug: CBC, U/A, chemistry profile

Should be initiated **slowly** if the pain is not out of control at a **starting dose** of **100** to **240** mg at bedtime **for 2 nights**

Increased : **100-** to **200-mg** increments given in equally divided doses **over 2 days**, as side effects allow, until pain relief is obtained **or a total dosage of 1240 mg/day** is reached

Carbamazepine

- ❖ Careful monitoring of laboratory parameters is **mandatory** to avoid the **rare** possibility of a life-threatening **blood dyscrasia**, and at the **first sign of blood count abnormality or rash, the drug should be discontinued**
- ❖ Failure to monitor patients started on carbamazepine can be disastrous, because **aplastic anemia** can occur
- ❑ **NOTE : When pain relief is obtained, the patient should be kept at that dosage of carbamazepine for at least 6 months before considering tapering of the medication**

The patient should be instructed that **under no circumstances** should the drug dosage be **changed** or the drug **refilled** or **discontinued** without the physician's knowledge

Side effects: dizziness, sedation, confusion, rash, **blood dyscrasia (rare)**

Pregabalin

- ❖ A reasonable alternative to gabapentin and is better tolerated in some patients
- ✓ Starting dose: **50** mg **three times** a day
- ✓ Increase dose : upward to **100** mg **three times** a day as side effects allow
- ❖ Is excreted primarily by the **kidneys**, the dosage should be decreased in patients with compromised renal function

Baclofen

- May be of value in some patients who **fail to** obtain relief with gabapentin or carbamazepine
- Baseline laboratory tests should be obtained before starting baclofen
- The patient should be cautioned about potential adverse effects, which are the same as those associated with carbamazepine and gabapentin

Baclofen

- ✓ Starting dose : **10-mg** dose at bedtime **for 2 nights**
- Then increased in **10-mg** increments given in equally divided doses **over 7 days**, as side effects allow, until pain relief is obtained or a total dosage of 80 mg/day is reached
- ❑ Side effects : significant **hepatic** and **CNS**, including weakness and sedation
- As with carbamazepine, careful monitoring of laboratory values is indicated

NOTE :

When treating individuals with any of these drugs, the physician should make sure that the patient knows that **premature tapering** or **discontinuation** of the medication may lead to the **recurrence of pain**, which will be more difficult to control

Drug therapy

NSIADs can be used

Invasive Therapy

Brachial Plexus Block

- With L.A and steroid is an excellent adjunct to drug treatment
- ❖ This technique rapidly relieves pain while medications are being titrated to effective levels

L.A injection into scalene muscles

- Into the **ASM** alone **or** into **both** the ASM and MSM
- The injection relaxes the muscle or muscles elevating the first rib and mimics the effects of first rib resection or scalenectomy
- **Technique** : blind (not recommended)
Fluoroscopy, US- guided (is preferred)

L.A injection into scalene muscles

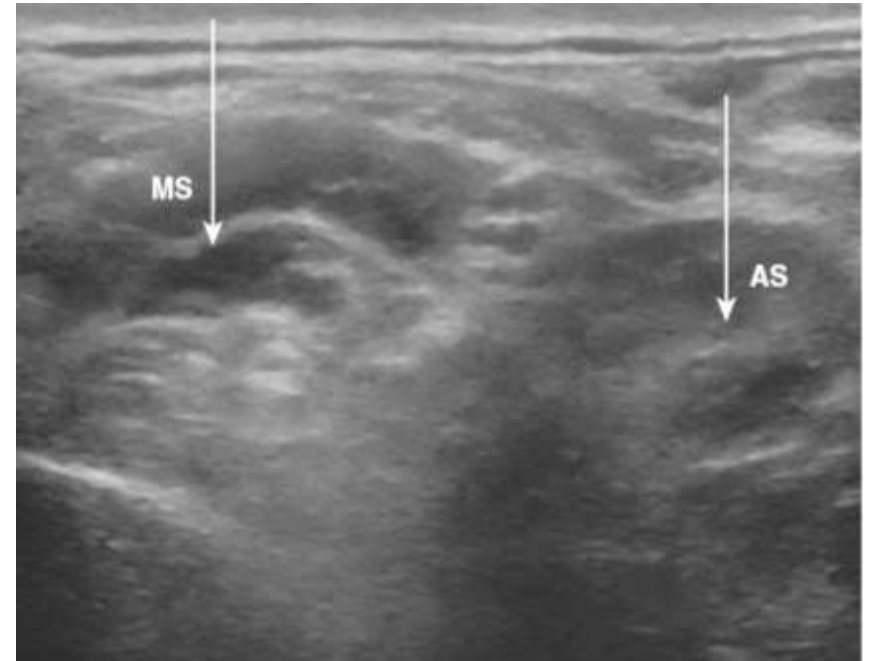
US- guided

Out-of-plane : is preferable (to avoid injection of L.A into brachial plexus).

In-pane :

**Medial to lateral for the
ASM**

Lateral to medial for MSM



L.A injection into scalene muscles

- ✓ 2 cc of Marcaine 0.25 % per muscle
- ✓ Into the ASM alone or into both
- ✓ Relief of symptoms : within 15 – 30 minutes
- ✓ Last : for days or weeks
- ✓ Either series of injections can be performed 2 to 3 weeks apart if the relief is prolonged
- ✓ It may last **up to 4 weeks** when a series of injections are performed

Botulinum toxin A = Scalene muscle chemodenerivation

- ✓ Intramuscularly under EMG or US-guided control
- ✓ Subjects who have previously responded positively to a diagnostic scalene muscle block with L.A.
- ✓ 12 – 15 units per muscle
- ✓ Symptoms are relieved for 1-4 months (mean 3 months)
- ✓ Can repeat

Results of studies on Botox A injection for scalene muscle

Jordan et al. ³⁷	Scalene	Prospective, open label	Botox (12-15 units per muscle)	64% of patients had >50% pain reduction for at least 1 mo
Jordan et al. ³⁸	Scalene	Retrospective	Botox A (12-15 units per anterior/middle scalene); fluoroscopy/EMG guidance compared with ultrasound/EMG guidance	Results comparable: 91% good results with ultrasound and 81% with fluoroscopy
Christo et al. ³⁹	Scalene	Prospective	Botox (20 units) into the scalene muscle	Significant relief of pain for 3 mo

Botulinum toxin A = Scalene muscle chemodenervation

- No FDA approval
- Tachyphylaxis to botox in some patients
- A positive block has a >90% positive predictive value for a favorable outcome of operative intervention
- Into the **ASM** or into **other muscles along the upper thorax and chest wall** to reduce the symptoms of neurogenic TOS

Trigger points injections

TPIs can be used

Surgery

- ❑ In the **absence** of demonstrable disease (e.g., a cervical rib), the **outcome** of surgical treatment for TOS is **dismal**, regardless of the technique chosen
- ❑ In patients with a clear cause of their symptoms who have failed to achieve relief from more conservative therapies, however, the judicious use of surgical treatment may be a reasonable last step

COMPLICATIONS AND PITFALLS

- ❖ The pain and dysfunction of TOS are difficult to treat Physical therapy should be the primary modality in any well thought out treatment plan.
- ❖ In general, the pain of TOS **responds poorly to opioid analgesics, and these drugs should be avoided**
- ❖ The careful use of adjuvant analgesics may help palliate the pain and allow the patient to participate in physical therapy
- ❖ Correct diagnosis is crucial, because stretch injuries and contusions of the plexus may respond with time, but plexopathy secondary to tumor or avulsion of the cervical roots requires aggressive treatment

THANKS FOR YOUR ATTENTION