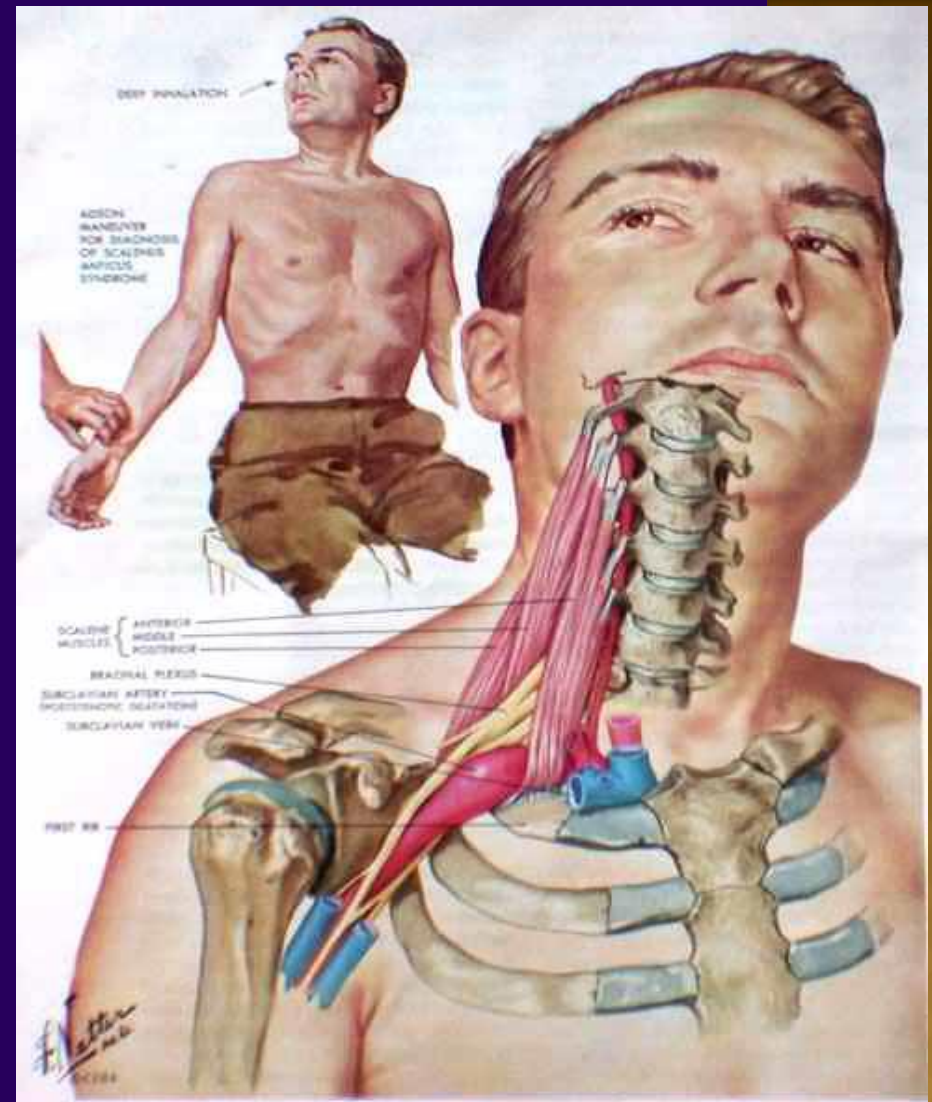


THORACIC OUTLET SYNDROME

By

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TOS

- Combination of upper extremity symptoms and signs resulting from compression of the neurovascular bundle in thoracic outlet area.

- Neurovascular bundle at the thoracic outlet :

- Brachial plexus (C5-T1)
- Subclavian vein
- Subclavian artery

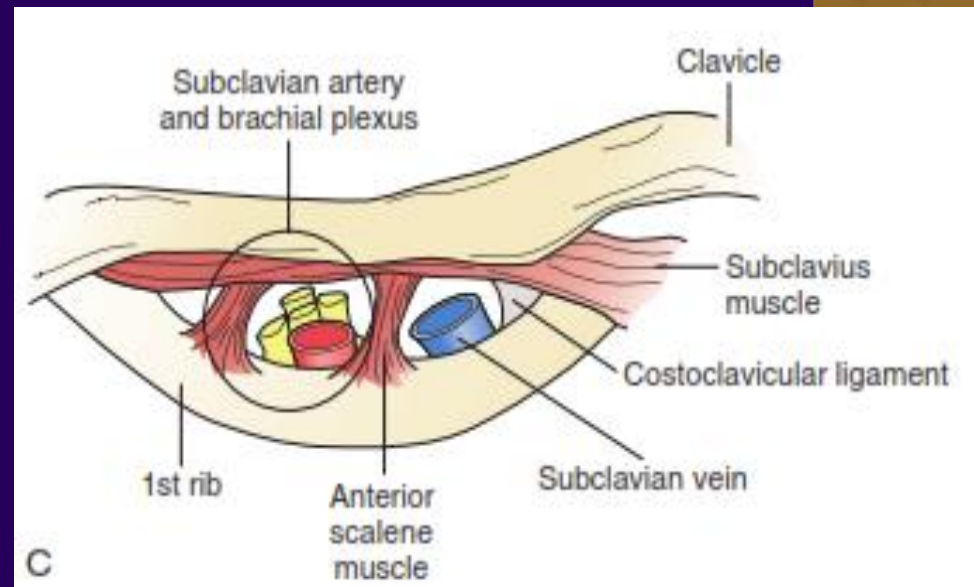
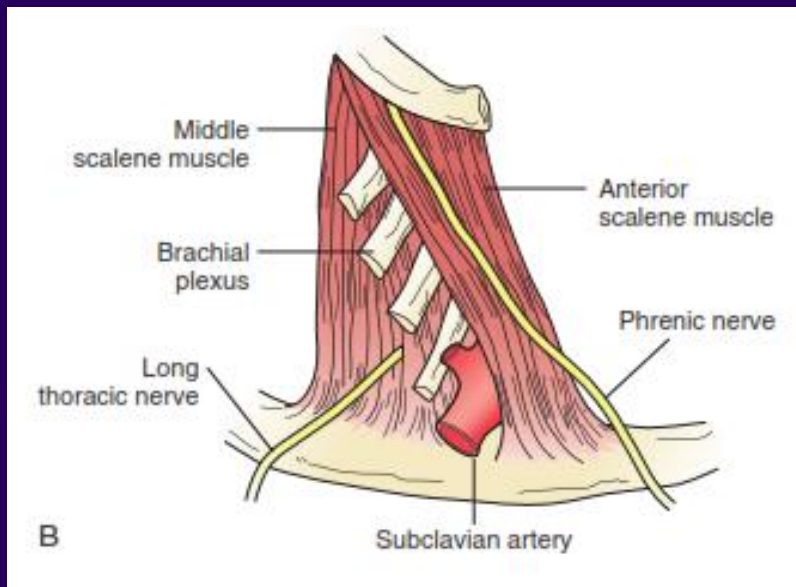
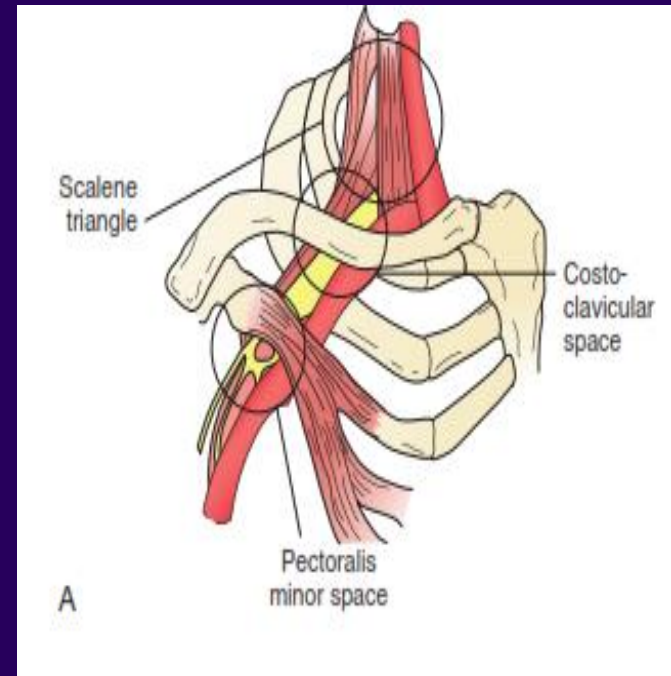


Types of Thoracic Outlet Syndrome

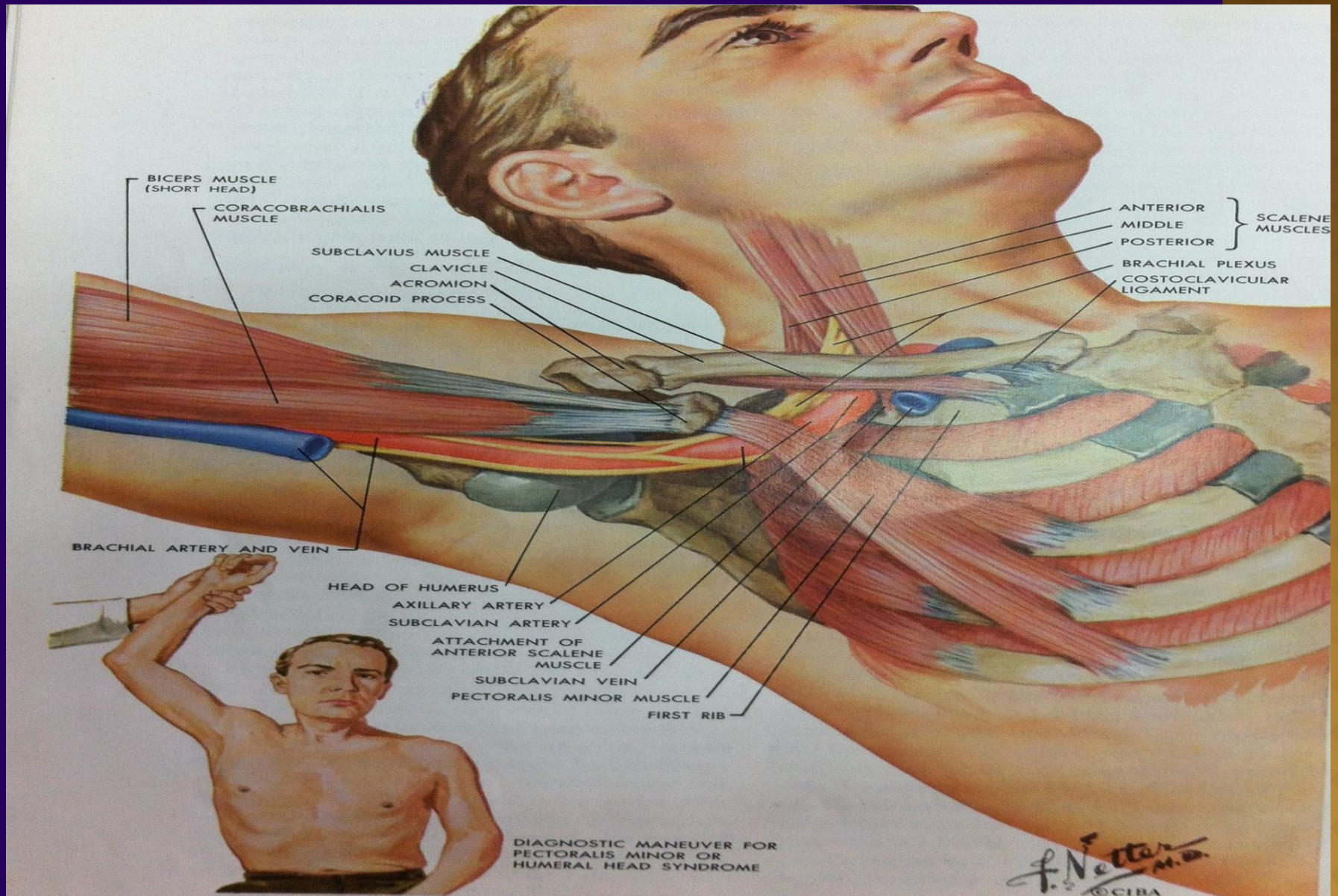
- ❑ Neurogenic (nTOS) - 95%
- ❑ Venous (vTOS) - 2-3%
- ❑ arterial (aTOS) - 1%

Anatomy

- Scalene triangle
- Costoclavicular space
- Pectoralis minor space



Anatomy



Anatomic Variations

○ Scalene Muscles

- Scalene muscle width: Wide vs. narrow triangle
- Congenital bands/ligaments
- Splitting of Anterior Scalene around C5 and C6

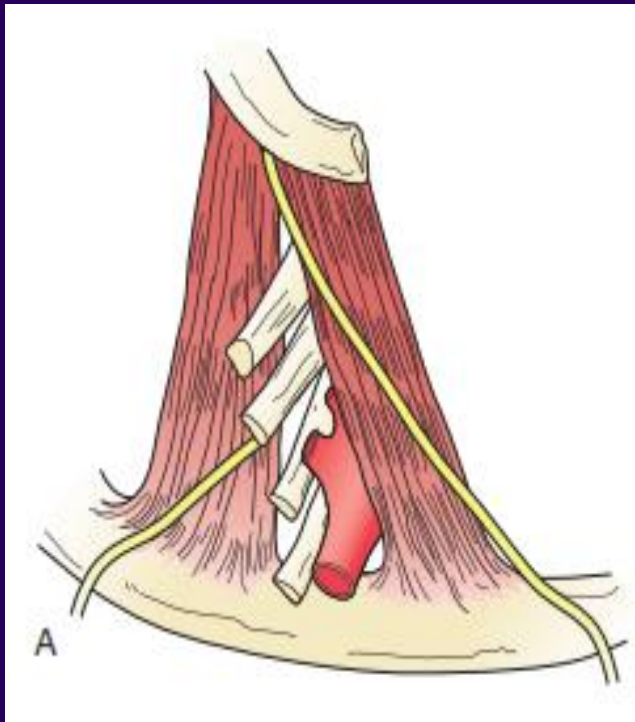
- Scalene Minimus Muscle, 25-55%

It arises from transverse processes of lower vertebrae, runs in front of C8 and T1 behind the subclavian artery

- Firm Tendinous Posterior Aspect of Anterior Scalene Muscle.
- Interdigitating Scalene Muscle fibers, 75%

Anatomic Variations

○ Scalene Muscles



Anatomic Variations

○ Cervical Rib:

□ Incidence: 0.74%

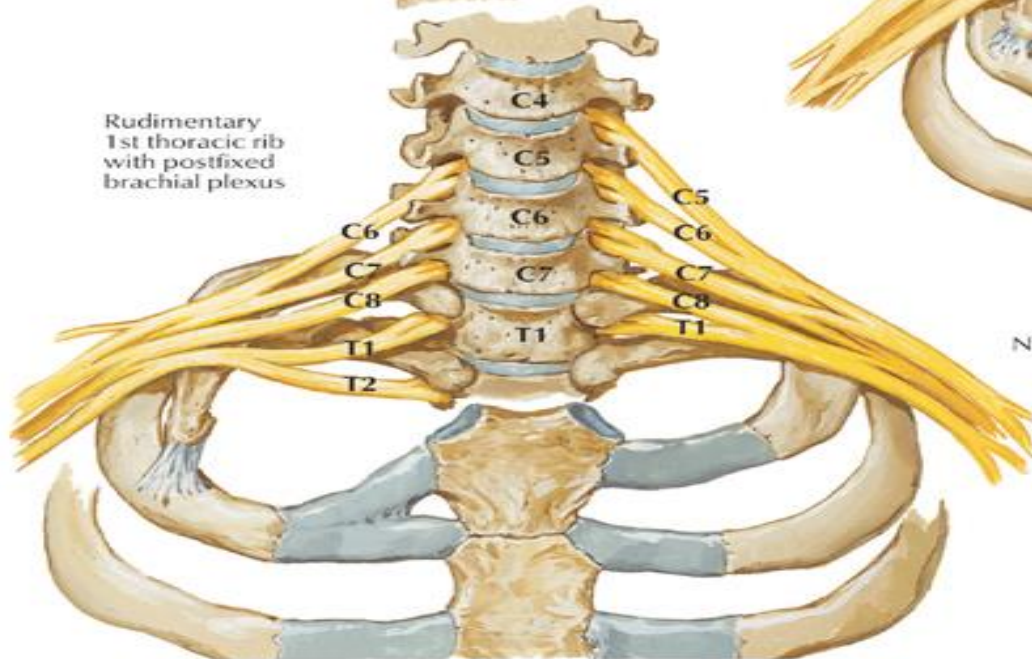
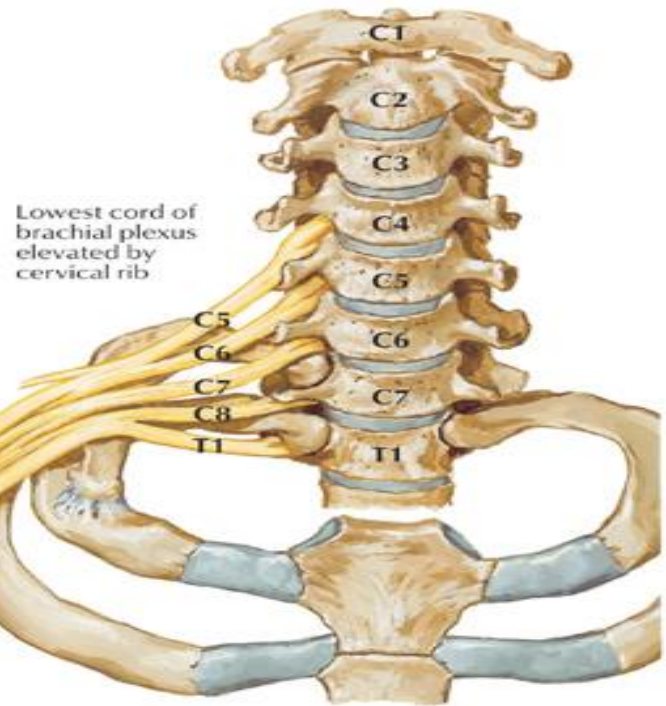
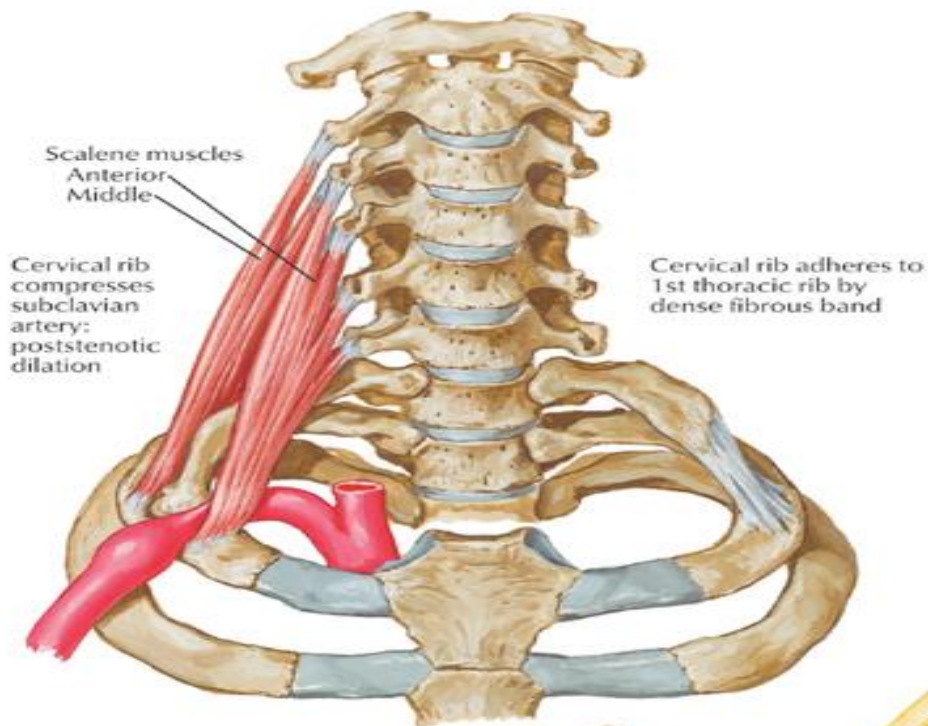
□ More common in females

□ It is narrow and it lies higher than normal first rib

□ It arises from the transverse process of C7

□ 30% is complete cervical rib which is articulating with first rib by a true joint

□ 70% is incomplete with tight facial band to the first rib

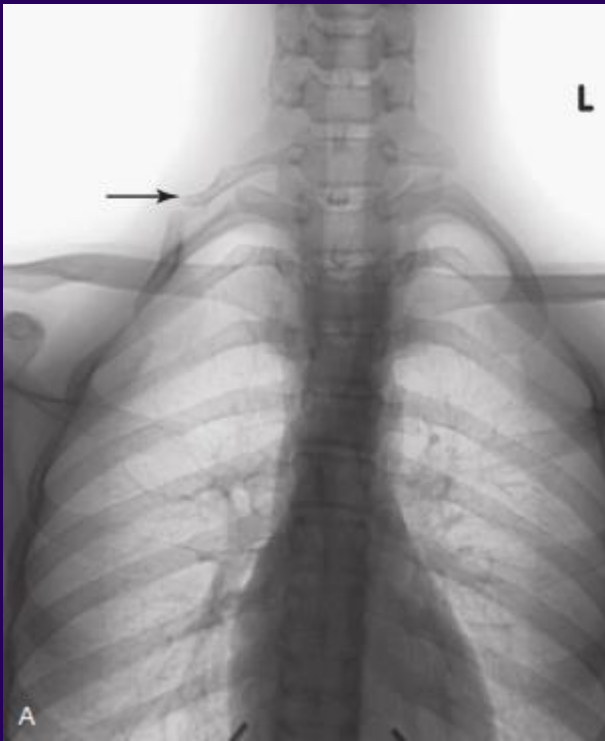


Normal morphology

Note: Cervical rib also often asymptomatic

Anatomic Variations

○ Cervical Rib



Anatomic Variations

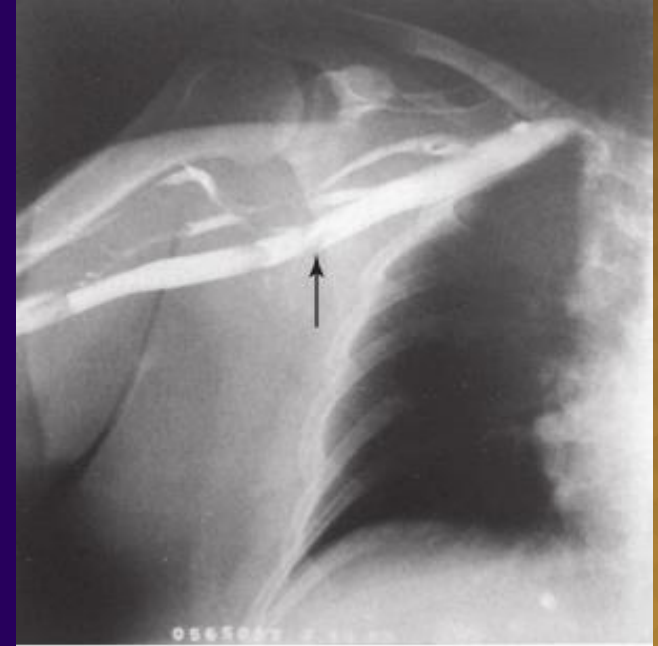
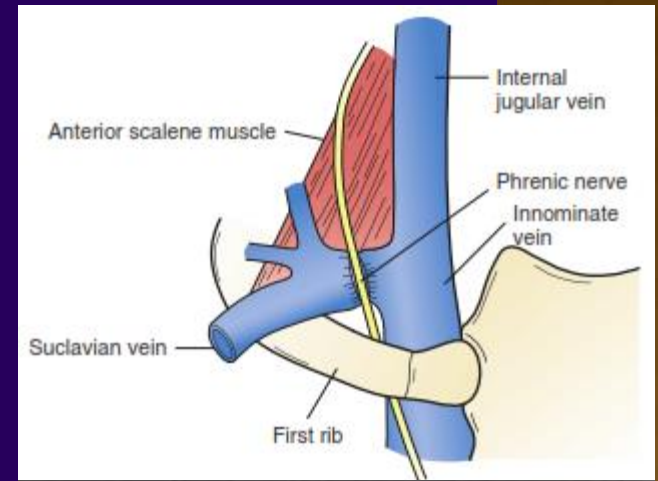
Anomalous 1st Rib:

- ❑ Incidence: 0.76%
- ❑ Equal in male and female
- ❑ It is narrow and it lies higher than normal first rib, it arises from the transverse process of T1



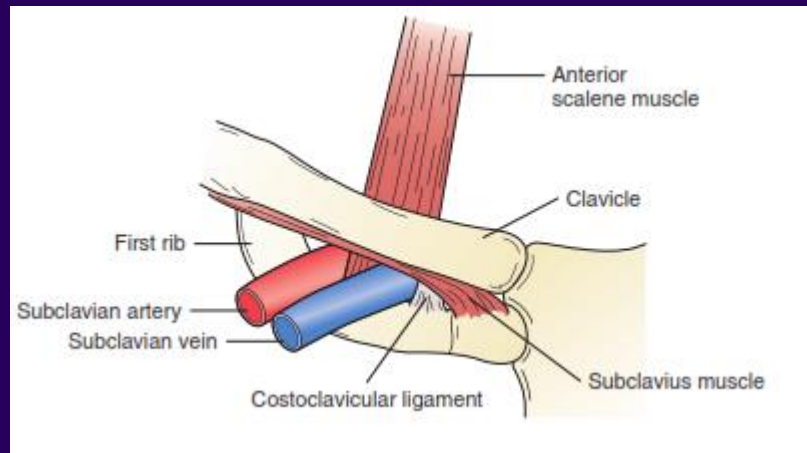
RELATIONSHIP OF SUBCLAVIAN VEIN AND ANTERIOR SCALENE MUSCLE TO THE PHRENIC NERVE

- ❑ THE PHRENIC NERVE USUALLY RUNS POSTERIOR TO THE SUBCLAVIAN VEN EXCEPT IN 5-7% OF INDIVIDUALS WHERE IT RUNS ANTERIOR TO IT
- ❑ It arises from C4
- ❑ Single in 87 % of the time
- ❑ Double or triple in 13% of individuals
- ❑ It descends 84% of the time from lateral to medial to the medial side of ant. Scalene m. and 16% remains on the lateral side



RELATIONSHIP OF THE SUBCLAVIAN VEIN AND THE COSTOCLAVICULAR LIGAMENT

- ❑ The subclavian vein lie on top of the first rib and it is touched medially by the costoclavicular ligament and superiorly by the subclavius tendon
- ❑ Anatomical Variations may lead to the development of subclavian vein obstruction



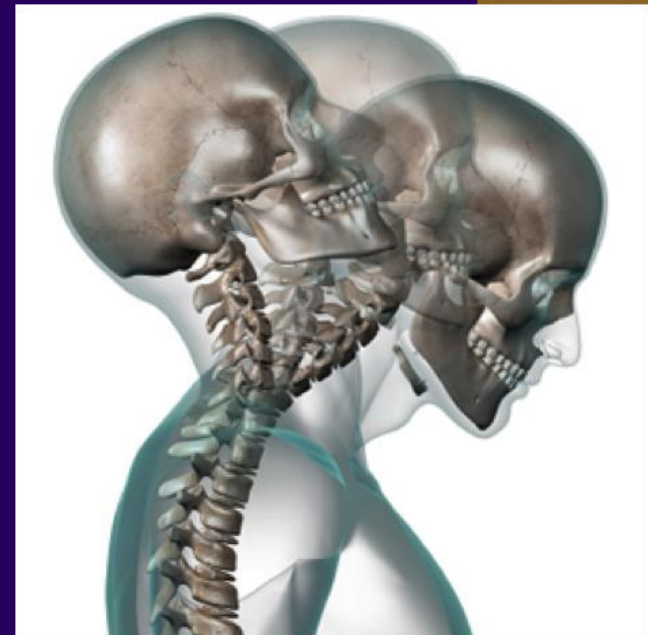
Epidemiology

- 20-50yo
 - <5% teenagers
 - 10% over 50
 - Rarely >65
- 70% female
 - 70% cervical ribs occur in females

Neurogenic TOS

○ Etiology

- Hyperextension neck injury (whiplash)
- Falls on slippery floors
- These patients were asymptomatic till stretching and tearing in the scalene muscle
- Scalene muscle swelling
- Symptoms
- Scalene muscle healing and fibrosis



Neurogenic TOS

○ Symptoms

- Pain, parathesias, numbness, weakness Throughout affected hand/arm ,Not localized to peripheral nerve distribution
- Extension to shoulder, neck, upper back not infrequently
- “Upper plexus” disorders - radial and musculocutaneous nerve distributions
- “Lower plexus” disorders - median and ulnar nerve distributions
- Headache, referred pain to the occiput
- Perceived muscle weakness ,Actual weakness and atrophy are rare

Neurogenic TOS

○ Pectoralis minor syndrome

- Compression of neurovascular bundle under the pec minor muscle tendon
- Pain over anterior chest and axilla
- Fewer head/neck symptoms
- Consider pec minor tenotomy with thoracic outlet decompression

Venous TOS

○ Etiology

- Developmental anomalies of costoclavicular space
- Repetitive arm activities - throwing, swimming, overhead activities



Axillary-subclavian venous occlusion: The morbidity of a nonlethal disease

Peter Gloviczki, M.D., Francis J. Kazmier, M.D. and Larry H. Hollier, M.D.,
Rochester, Minn.

○ Acute occlusion

- Young healthy patients 20-40 y
- Men are more affected than women
- Pain , Tightness
- Discomfort during exercise
- Edema
- Cyanosis
- Increased venous congestion
- Tenderness over the axillary vein
- Venous Gangrene is extremely rare

Paget-Schroetter syndrome

- ⦿ Effort thrombosis of axillary-subclavian vein
- ⦿ Associated with TOS in some cases
- ⦿ Rare disorder that occurs in 2 per 100,000 individuals per year
- ⦿ Upper extremity DVT accounts for 2-4 % of all cases of DVT

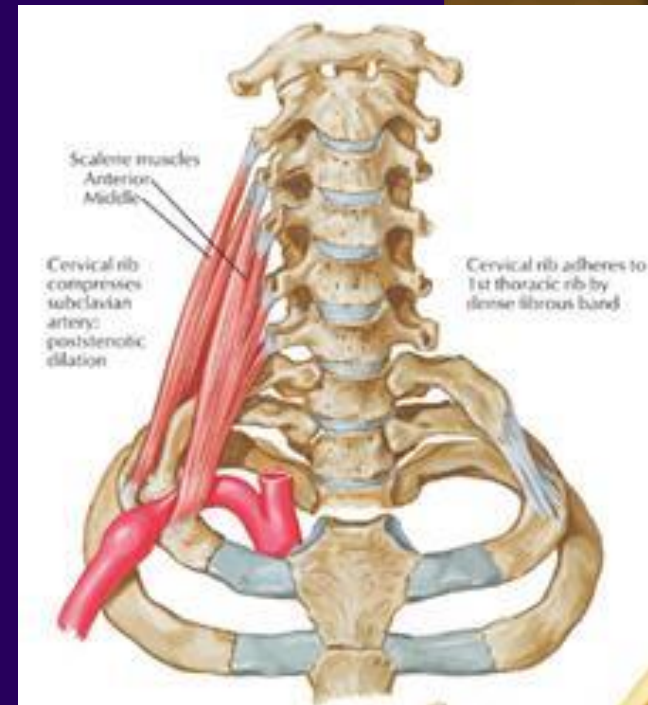
Arterial TOS

□ Etiology

- Cervical or anomalous first rib
- Anomalous anterior scalene insertion

□ Pathophysiology

- Arterial compression resulting in post-stenotic dilatation or aneurysm
- Distal embolization of thrombus



Arterial TOS

○ Symptoms

- Digital or hand ischemia
- Cutaneous ulcerations
- Forearm pain with use
- Pulsatile supraclavicular mass/bruit

Table 127-2

Scher Staging Classification of Arterial Thoracic Outlet Syndrome Complications

Stage	Arterial Complication	Treatment
Stage 0	Asymptomatic subclavian artery compression	No treatment indicated
Stage I	Stenosis of subclavian artery with minor post-stenotic dilatation; no intimal disruption	Decompression of the thoracic outlet
Stage II	Subclavian artery aneurysm with intimal damage and mural thrombus	Decompression of the thoracic outlet Subclavian artery reconstruction
Stage III	Distal embolization from subclavian artery disease	Thrombolysis or thromboembolectomy Decompression of the thoracic outlet Vascular reconstruction

Diagnosis and Treatment

Diagnosis

- “the most accurate diagnosis of TOS...must rely on a careful history and thorough, appropriate physical examination”
 - David B Roos, MD
- No single diagnostic test has sufficient specificity to prove or exclude the diagnosis

History

- ⦿ Neck trauma preceding onset of symptoms
- ⦿ Repetitive stress injury
- ⦿ Occipital headaches
- ⦿ Pain over trapezius, neck, shoulder, chest
- ⦿ Specific disabilities regarding work and daily activities
- ⦿ Exertional arm pain

Differential Diagnosis nTOS

Condition	Differentiating Features
Carpal tunnel syndrome	Hand pain and paresthesias in the median nerve distribution, positive findings on nerve conduction studies
Ulnar nerve compression	Hand pain and paresthesias in the ulnar nerve distribution, positive findings on nerve conduction studies
Rotator cuff tendinitis	Localized pain and tenderness over the biceps tendon and shoulder pain on abduction; positive findings on MRI; relief from NSAIDs, local steroid injections, or arthroscopic surgery
Cervical spine strain/sprain	Posttraumatic neck pain and stiffness localized posteriorly along the cervical spine, paraspinal tenderness, relief with conservative measures over a period of weeks to months
Fibromyositis	Posttraumatic inflammation of the trapezius and parascapular muscles; tenderness, spasm, and palpable nodules over affected muscles; may coexist with TOS and persist after surgery
Cervical disk disease	Neck pain and stiffness, arm weakness, and paresthesias involving the thumb and index finger (C5-C6 disk); improvement in symptoms with arm elevation; positive findings on CT or MRI
Cervical arthritis	Neck pain and stiffness, arm or hand paresthesias infrequent, degenerative rather than posttraumatic, positive findings on spine radiographs
Brachial plexus injury	Caused by direct injury or stretch; arm pain and weakness, hand paresthesias; symptoms constant, not intermittent or positional; positive findings on neurophysiologic studies

Differential Diagnosis aTOS

BOX 127-1

DIFFERENTIAL DIAGNOSIS OF ARTERIAL THORACIC OUTLET SYNDROME

Embolization from other sources

- Cardiac
- Aortic arch
- Hypothenar hammer syndrome
- Acquired or congenital coagulopathies

Vasculitis

- Takayasu's arteritis
- Giant cell arteritis

Radiation arteritis

Connective tissue disorders

- Marfan syndrome
- Ehlers-Danlos type IV
- Pseudoxanthoma elasticum

Arterial dissection

Atherosclerotic upper extremity disease

Thromboangiitis obliterans

Traumatic

- Humeral head compression of axillary artery
- Circumflex humeral artery pseudoaneurysm (baseball pitchers)

Physical Exam

- Pulse exam
- Listen for bruits
- Edema/cyanosis/collateral veins
- Tenderness over scalene muscles (trigger points) or pectoralis minor
- Reduced sensation to very light touch in fingers
- Provocative maneuvers

Adson Test

- With the patient seated, arms at the sides, the radial pulse is palpated and the examiner listens for bruits above the clavicle
- Elevate arm and turn the chin both toward and away from the involved side
- A positive test results in diminished radial pulse, bruit, and numbness and tingling
- Up to 50% of healthy volunteers have a positive test - unreliable for diagnosis of TOS



EAST

- ⦿ Elevated arm stress test
- ⦿ Hold “surrender” position for 3 minutes while opening/closing hands



EAST



EAST

- nTOS
 - Heaviness, progressive weakness, numbness
 - Tingling in fingers, progressing up arm
- vTOS
 - Cyanotic arm with distended forearm veins
- aTOS
 - Ischemic, cramping pain

Modified Upper Limb Tension Test

The patient is asked to abduct both arms to 90 degrees with the elbows extended. The patient is then progressively asked to dorsiflex both wrists. A positive test will elicit symptoms on the ipsilateral side. A subsequent maneuver is carried out by having the patient laterally flex the head on each side. A positive test will elicit symptoms on the contralateral side.

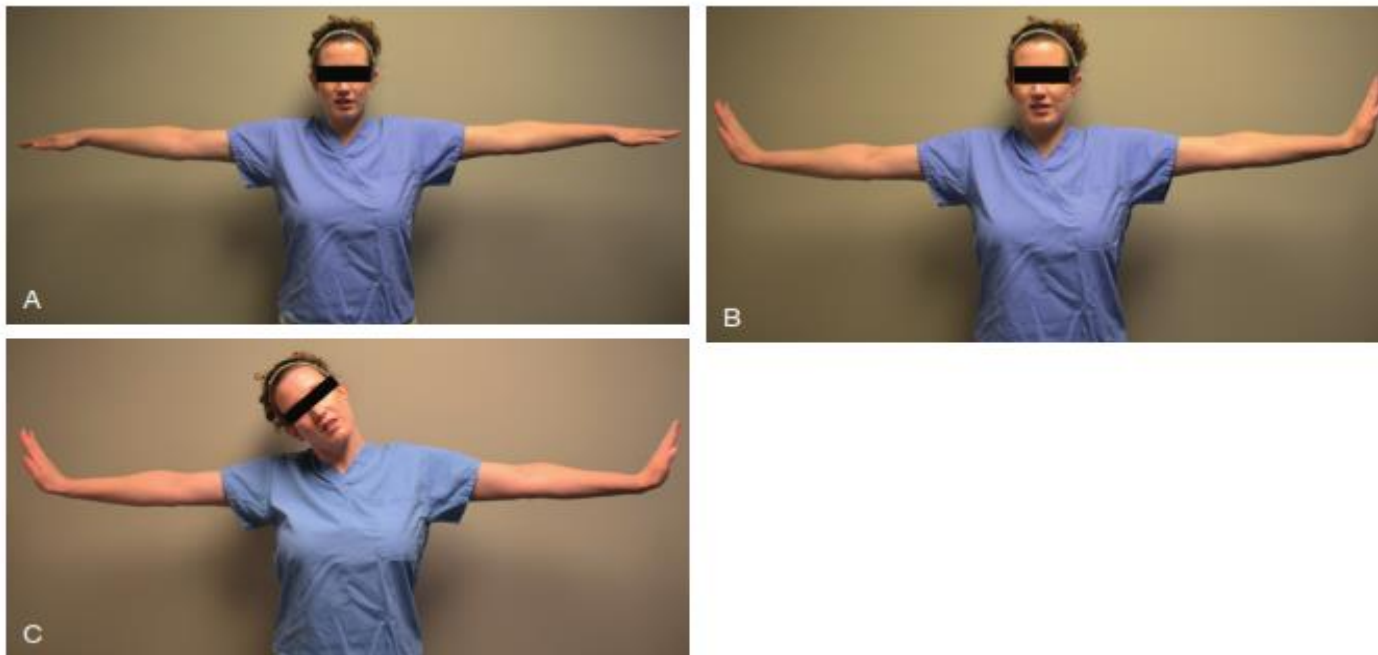


Figure 125-10 Upper limb tension test, modified from Elvey. Each maneuver progressively stretches the brachial plexus. **A**, Arms abducted to 90 degrees with the elbows extended. **B**, Wrists dorsiflexed. **C**, Head tilted ear to shoulder.

Imaging

○ Xrays

- Cervical rib
 - Elongated C7 transverse process
 - Hypoplastic 1st rib
 - Callous formation from clavicle or 1st rib fracture
 - Pseudoarthrosis of 1st rib
- Unable to image soft tissue anomalies and fibromuscular bands - seen only at time of surgery

Imaging

- CT/MRI usually negative but can rule out other pathologies
- MR neurography - newer technology to detect localized nerve function abnormality

Imaging

- aTOS
 - Segmental arterial pressures
 - CTA, MRA, Angiography
- vTOS
 - Duplex U/S
 - CTV, MRV, Venography
- Use positional maneuvers during the studies
- Consider bilateral studies

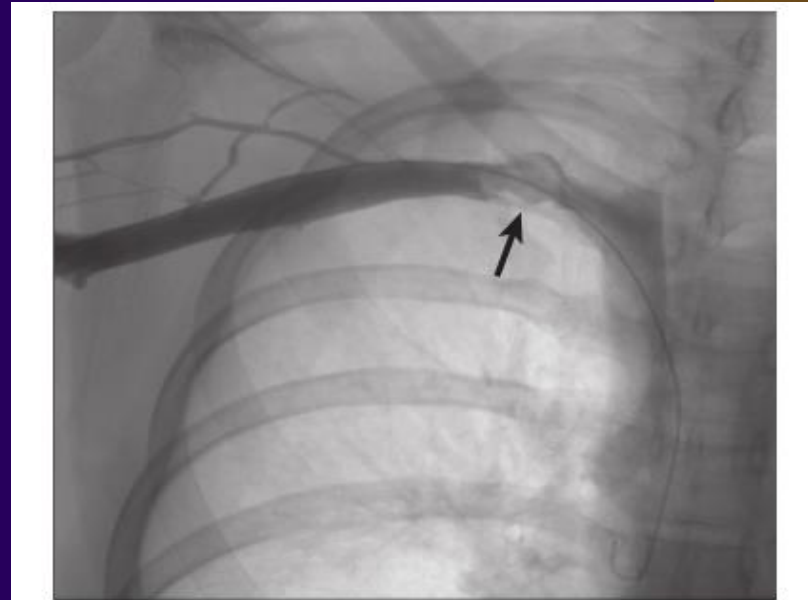


Figure 128-2 Venogram revealing an acute primary subclavian-axillary vein thrombosis.

EMG/NCS

- Reduction in NCV to $<85\text{m/s}$
- Positive results
 - Aid in evaluation of other conditions
 - Poor prognostic factor if truly nTOS - indicate advanced neural damage
- Negative results
 - Exclude other conditions
 - May still be nTOS

Electrophysiology Testing

- Medial antebrachial cutaneous nerve (MAC)
 - Lowest branch of inferior trunk of brachial plexus
 - More sensitive to compression than other branches
- Higher sensitivity and specificity than EMG/NCS

Scalene muscle block

- Most useful when diagnosis is unclear
- Correlation between relief of symptoms after block and successful outcome after surgical decompression

Treatment nTOS

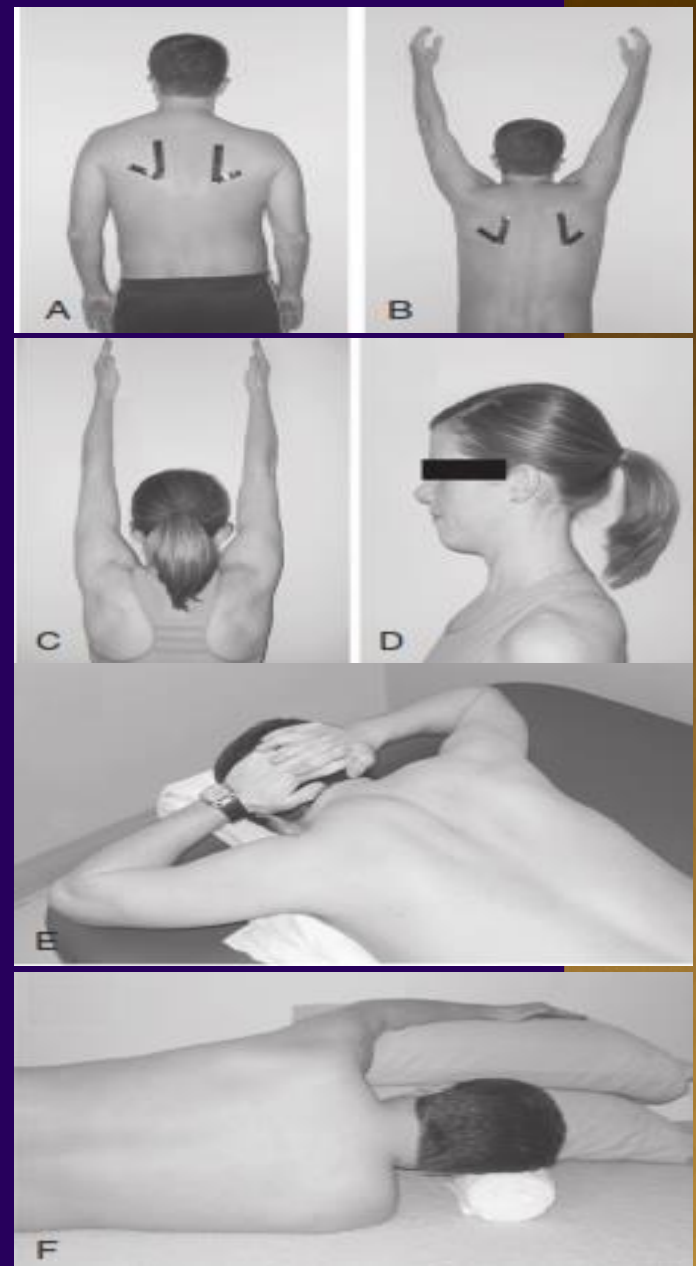
- Physical therapy
- Physical therapy
- Physical therapy
 - Therapist must have experience in evaluation and treatment of nTOS
 - 20-30% of patients respond, do not require surgical treatment



Treatment nTOS

○ Physical therapy

Figure 126-3 Physical therapy for neurogenic thoracic outlet syndrome. **A**, An example of postural assessment, including scapular depression with an increased slope of the right shoulder girdle. **B**, Implementing an exercise to improve a scapular depression fault. **C**, Upper trapezius muscle recruitment while standing facing a wall. **D**, Addressing cervical spine alignment. **E**, Strengthening the middle trapezius musculature. **F**, Exercises addressing overhead mechanics initiated in a gravity-lessened position. **G**, Sitting with the arms supported helps take weight off the shoulder girdle.



Treatment nTOS

- If no improvement after several months
 - Live with symptoms
 - Surgical decompression

Surgical Treatment

○ Transaxillary approach

■ Advantages

- Limited field of operative dissection
- Cosmetically placed incision
- Achieve 1st rib resection and anterior scalenectomy
- Removal of anomalous ligaments and fibrous bands

■ Disadvantages

- Incomplete exposure of entire scalene triangle
- Difficulty achieving complete anterior and middle scalenectomy or brachial plexus neurolysis
- Limited if vascular reconstruction is needed

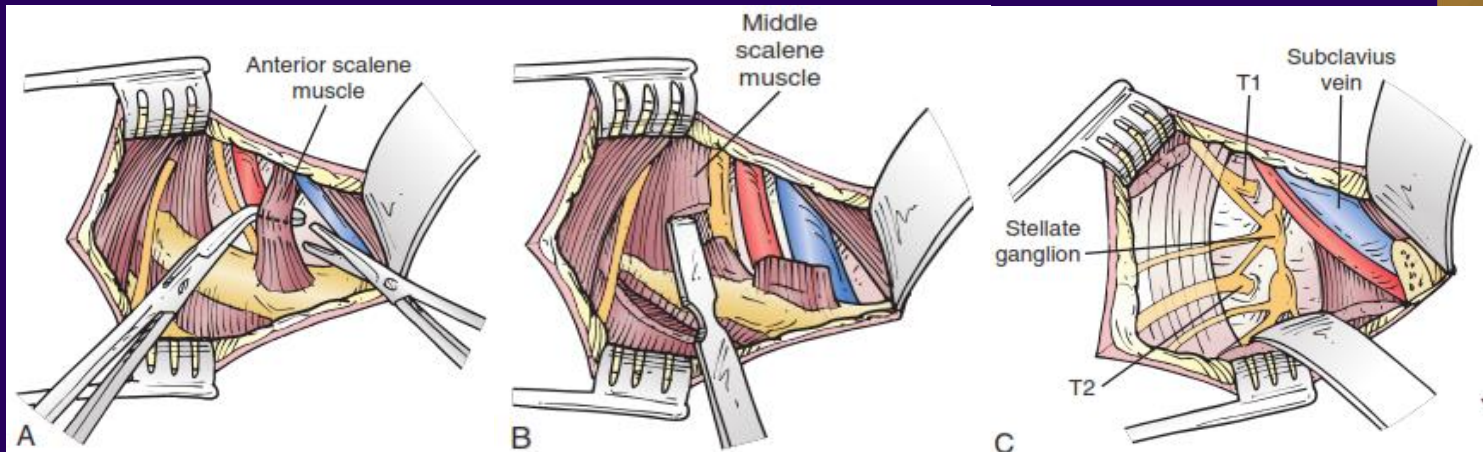
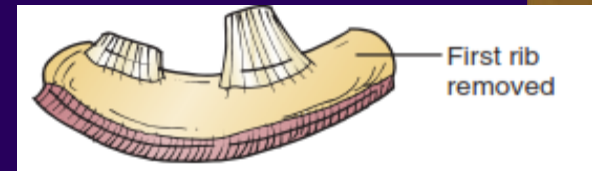
Surgical Treatment

- Transaxillary approach

Anaesthesia

Position

Incision



Surgical Treatment

- Supraclavicular approach
 - Advantages
 - Wide exposure of all anatomic structures
 - Permits complete resection of anterior and middle scalenes as well as brachial plexus neurolysis
 - Allows resection of cervical ribs and anomalous 1st ribs
 - Vascular reconstruction is possible

Surgical Treatment

○ Supraclavicular approach

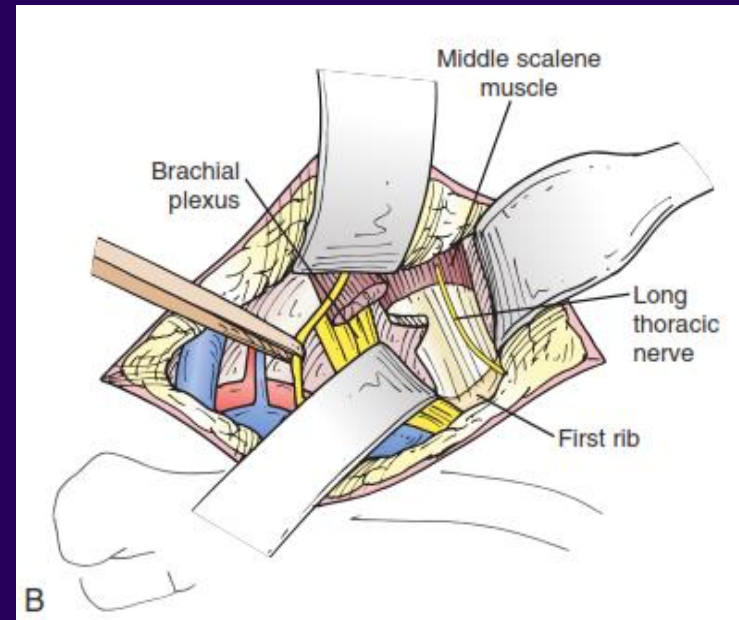
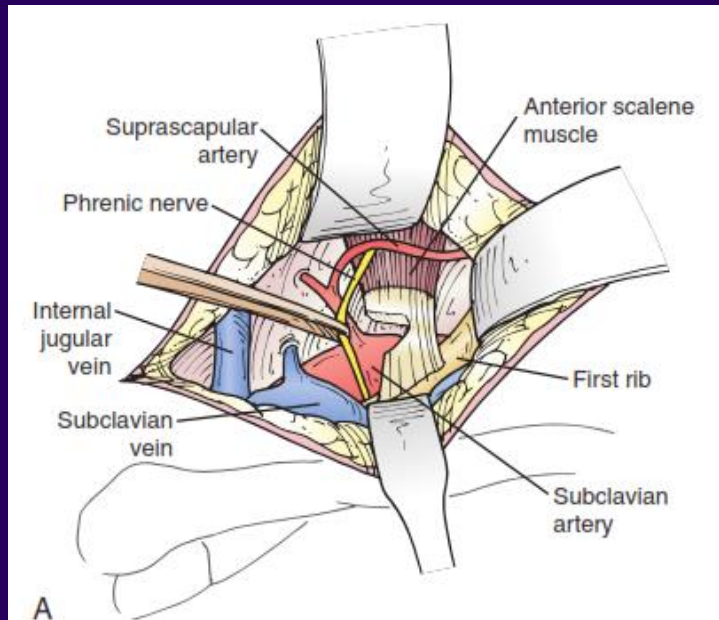


Figure 127-6 **A**, Operative view of the supraclavicular approach to thoracic outlet decompression. After mobilization of the scalene fat pad, the phrenic nerve should be identified and carefully elevated before the anterior scalene muscle is divided. **B**, The long thoracic nerve should be identified and protected during division of the middle scalene muscle. **C**, Attachments are freed by an extraperiosteal approach to prevent recurrent symptoms from reossification of the periosteal bed. **D**, Division of the first rib should be performed under direct vision to minimize the possibility of damage to the brachial plexus. After the first rib is divided just distal to the tubercle, the divided rib can be held as a lever to aid in clearing the overlying vessels. (From Valentine RJ, et al: *Anatomic exposures in vascular surgery*, ed 2, Philadelphia, 2003, Lippincott Williams & Wilkins.)

Surgical Treatment

○ Supraclavicular approach

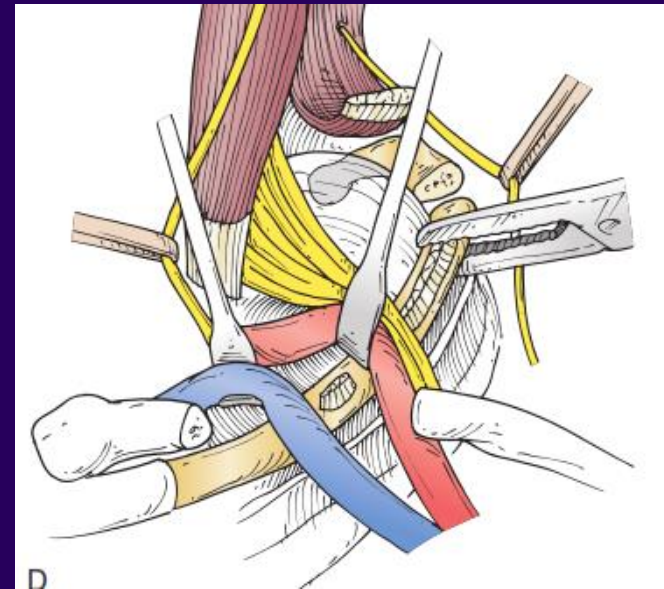
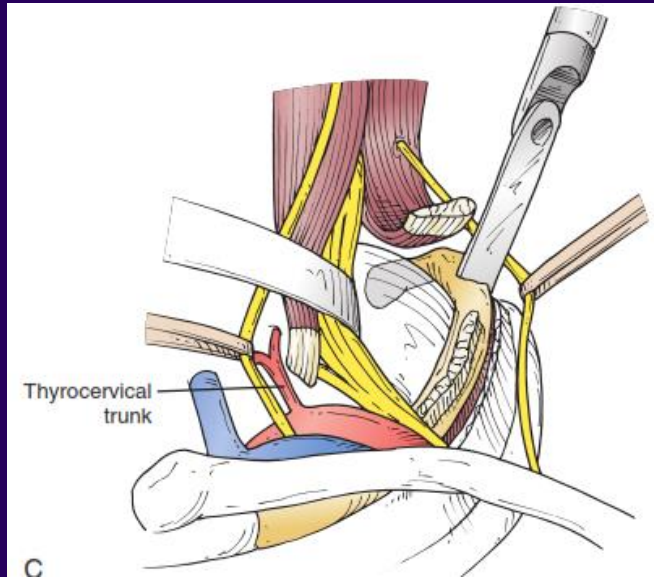


Figure 127-6 **A**, Operative view of the supraclavicular approach to thoracic outlet decompression. After mobilization of the scalene fat pad, the phrenic nerve should be identified and carefully elevated before the anterior scalene muscle is divided. **B**, The long thoracic nerve should be identified and protected during division of the middle scalene muscle. **C**, Attachments are freed by an extraperiosteal approach to prevent recurrent symptoms from reossification of the periosteal bed. **D**, Division of the first rib should be performed under direct vision to minimize the possibility of damage to the brachial plexus. After the first rib is divided just distal to the tubercle, the divided rib can be held as a lever to aid in clearing the overlying vessels. (From Valentine RJ, et al: *Anatomic exposures in vascular surgery*, ed 2, Philadelphia, 2003, Lippincott Williams & Wilkins.)

Surgical Treatment

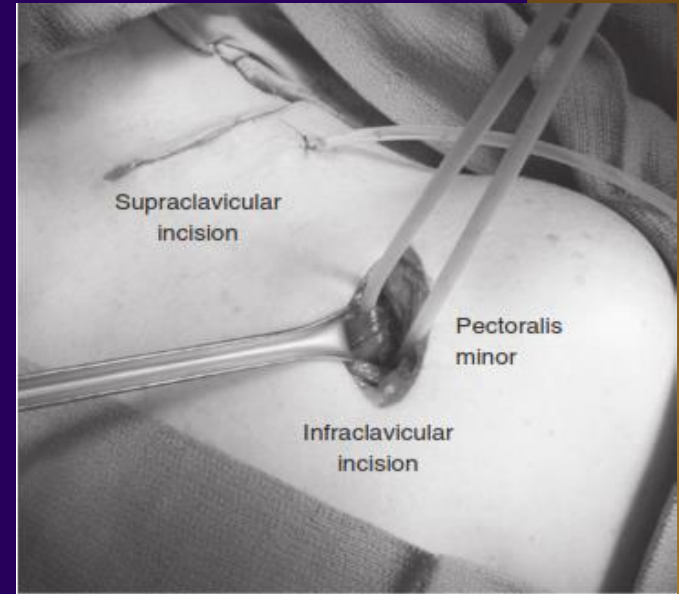
○ Adjunctive procedures

■ Pectoralis minor tenotomy

When there is evidence on physical examination of brachial plexus nerve irritation at the subpectoral space(hyperabduction syndrome)

Division of pec. Minor tendon inferior to its insertion on the coracoid process

■ Cervical sympathectomy



Treatment vTOS

- Catheter-directed thrombolysis
- Anticoagulation
- Surgical decompression with intraoperative venography and subclavian vein PTA

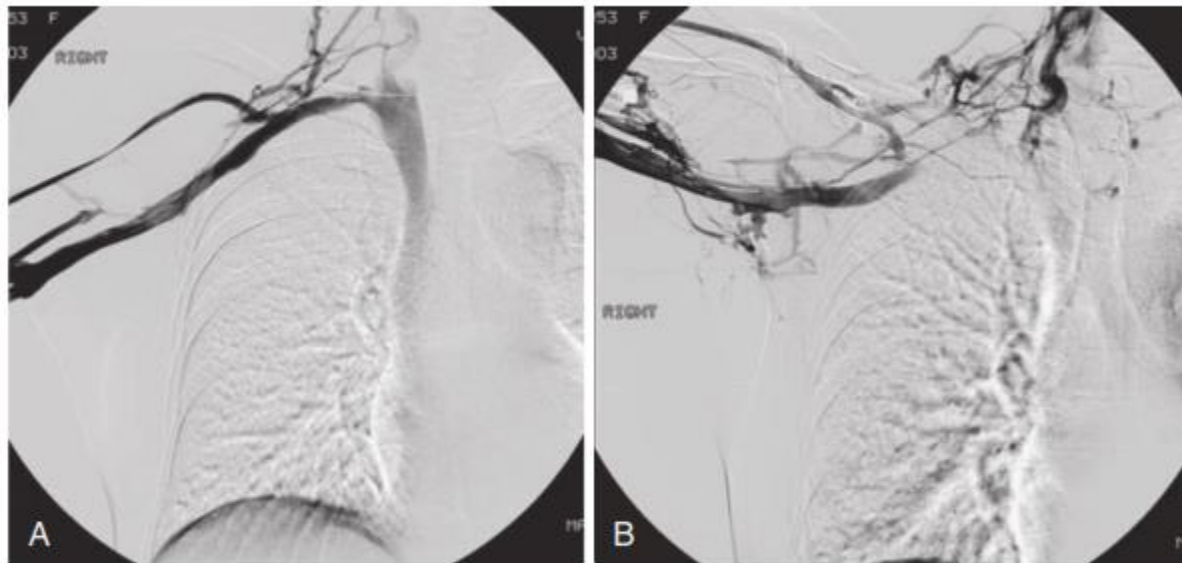


Figure 128-3 Venogram of the subclavian-axillary vein after successful thrombolysis with the extremity in full adduction (A) and in full abduction (B).

Treatment vTOS

- Catheter-directed thrombolysis
- Anticoagulation
- Surgical decompression with intraoperative venography and subclavian vein PTA



Figure 128-4 Venogram of the subclavian-axillary vein before **(A)** and after **(B)** thrombolysis.

Treatment vTOS

- The radial force associated with either self-expandable stents or balloon expandable stents is not adequate to compensate for the compressive force between the first rib and clavicle:
- Stent deformation, fracture, thrombosis
- Stents have no role in the treatment of vTOS before surgical decompression

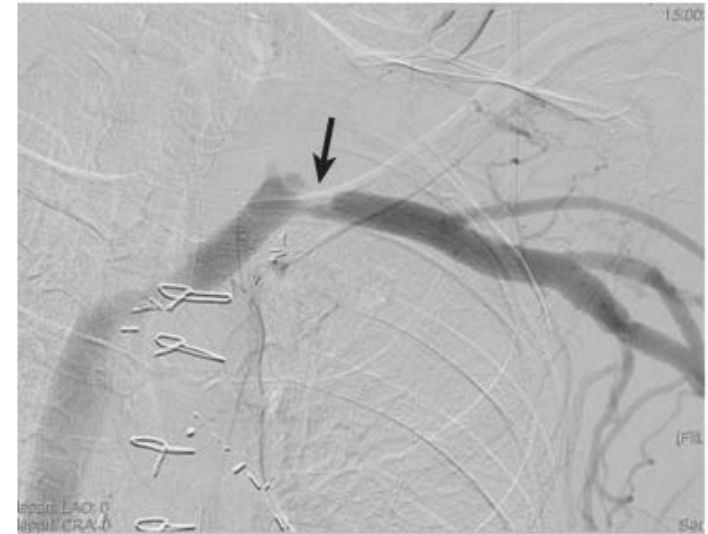


Figure 128-5 Deformed balloon-expandable stent 6 weeks after treatment of primary subclavian-axillary thrombosis.

Treatment vTOS

- Surgical decompression with surgical management of the subclavian vein

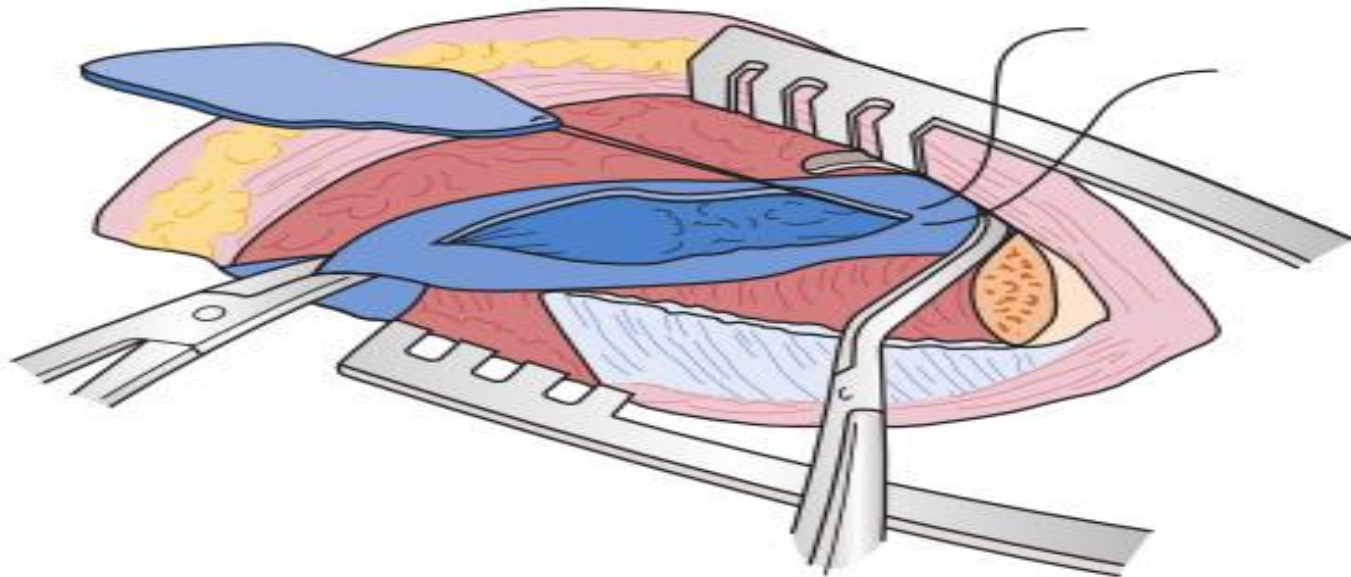


Figure 128-7 Infraclavicular approach. The saphenous vein patch is laid over the strictured segment of the vein. The key to success is complete mobilization of the subclavian vein by detaching it anteriorly from the sternum until the vein is easily exposed in the operative field. This allows sufficient margin for placement of the medial clamp between the site of the stricture and normal innominate vein.

Treatment aTOS

○ Medical treatment:

No rule except for asymptomatic patients with simple compression

○ Principles of Surgical treatment:

- Relieving the arterial compression
- Removing the source of embolus
- Restoring the distal circulation

Treatment aTOS

Aneurysm of the subclavian artery:

Is defined as an increase in diameter greater than two times the diameter of the adjacent segment of the artery

Post-stenotic dilatation associated with TOS:

Is defined as an increase in the diameter of the artery of less than twice the diameter of the adjacent segment of the artery

Treatment aTOS

Table 127-2		Scher Staging Classification of Arterial Thoracic Outlet Syndrome Complications
Stage	Arterial Complication	Treatment
Stage 0	Asymptomatic subclavian artery compression	No treatment indicated
Stage I	Stenosis of subclavian artery with minor post-stenotic dilatation; no intimal disruption	Decompression of the thoracic outlet
Stage II	Subclavian artery aneurysm with intimal damage and mural thrombus	Decompression of the thoracic outlet Subclavian artery reconstruction
Stage III	Distal embolization from subclavian artery disease	Thrombolysis or thromboembolectomy Decompression of the thoracic outlet Vascular reconstruction

Complications

- Injury to
 - Subclavian artery/vein
 - Brachial plexus
 - Phrenic nerve
 - Long thoracic nerve
 - Thoracic duct
 - Sympathetic chain
 - Intercostal brachial cutaneous nerve (axillary)
- Pneumothorax
- Lymph leakage

Conclusions

- ⦿ nTOS most common
- ⦿ nTOS most difficult to diagnose
- ⦿ Treatment
 - Physical therapy
 - Anterior scalene block
 - Informed consent prior to surgery

Conclusion

- ⦿ “A surgeon recognizing nTOS should not be dissuaded by the impression that these problems are frequently associated with psychiatric overtones, dependency on pain medications, and ongoing litigation”
 - ⦿ Rutherford’s Vascular Surgery 7th Edition

Thank you.