

Brachial plexopathies

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Focal neuropathies

EMG laboratory, University hospital Turku

	men	women	total
Lumbar radiculopathy	191 (21%)	250 (24%)	441 (23%)
CTS	140 (15%)	273 (27%)	413 (21%)
Ulnar neuropathy	98 (11%)	56 (6%)	154 (8%)
Cervical radiculopathy	96 (11%)	55 (5%)	151 (8%)
Plexus brachialis	61 (7%)	39 (4%)	100 (5%)
Morton's metatarsalgia	11 (1%)	86 (8%)	97 (5%)
Peroneal nerve lesion	66 (7%)	27 (3%)	93 (5%)
Radial nerve lesion	36 (4%)	42 (4%)	78 (4%)
Median nerve lesion	39 (4%)	17 (2%)	56 (3%)
Meralgia paresthetica	16 (2%)	15 (2%)	31 (2%)
Sciatic nerve lesion	15 (2%)	14 (1%)	29 (2%)
Lumbosacral plexus	20 (2%)	19 (2%)	39 (2%)

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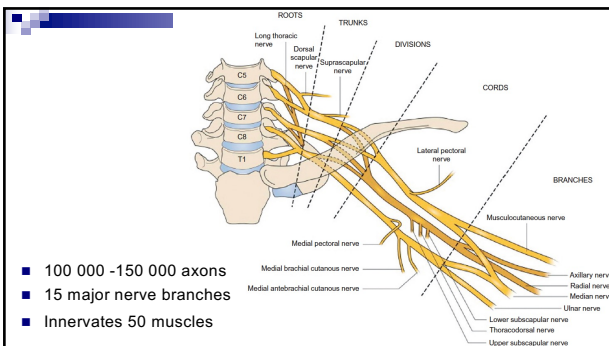
Outline

- Anatomy
- Causes of brachial plexopathies
- EMG in brachial plexopathies
- Cases

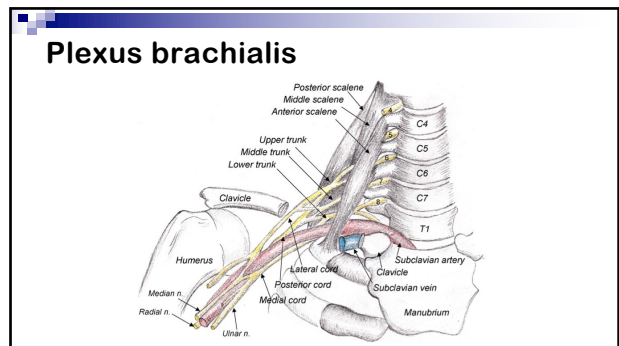
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Anatomy

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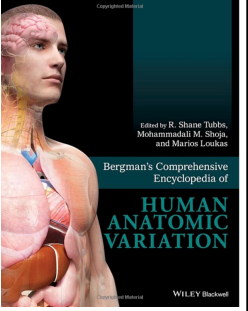
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Different parts of the plexus

- **Supraclavicular part**
 - Spinal nerves C5-Th1
 - Trunks (upper, middle and lower)
 - Segmental organization (myotomes, dermatomes)
 - 90% of plexopathies
- **Infraclavicular part**
 - Cords
 - Organized according to peripheral nerves
 - 10% of plexopathies

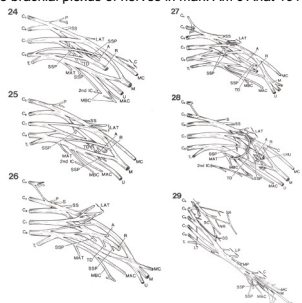
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Tubbs, Shoija and Loukas
Bergman's Compendium of Human Anatomic Variation
 Wiley Blackwell 2014



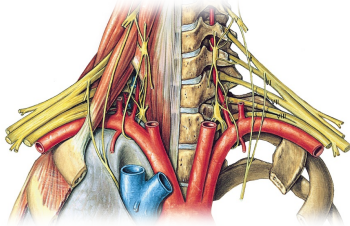
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Kerr AT. The brachial plexus of nerves in man. Am J Anat 1918;23:285-395



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Surrounding structures



1. **Clavicle**
 1. Deformed fracture
2. **1st rib**
 1. Anomalous cervical rib
3. **Arteries**
 1. Catheterization
 2. Thrombosis
4. **Lymph nodes**
 1. Metastasis
5. **Lung**
 1. Cancer (Pancoast tumor)
6. **Scalene muscles**
 1. Scalenus anterior syndrome (????)

Putz and Pabst (ed) Sobotta. Atlas of Human Anatomy, 20 th edition. Urban & Schwarzenberg

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Causes of brachial plexopathies

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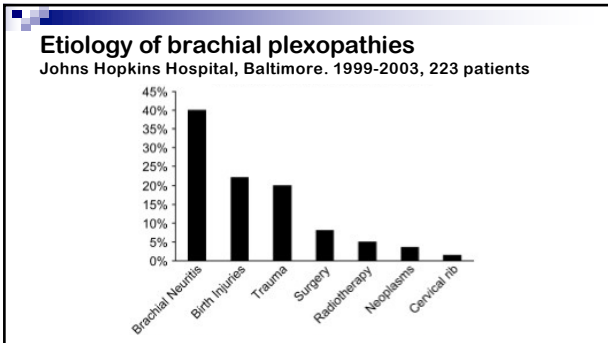
Original Article

Journal of
CLINICAL NEUROMUSCULAR DISEASE
 Volume 9, Number 1
 September 2007

Brachial Plexopathies: Etiology, Frequency, and Electrodiagnostic Localization

Ajit R. Mogbekar, MB, BS, Abhay R. Mogbekar, MB, BS, Necdet Karli, MD, and Vinay Chaudhry, MD, FRCP

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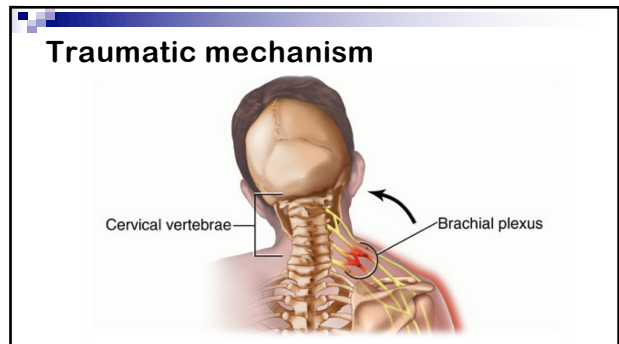
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- ### Causes of brachial plexopathies
- Parsonage-Turner sdr (plexus neuritis, neuralgic amyotrophy)
 - Trauma
 - Obstetric injuries (Erb's palsy)
 - Chronic entrapment (thoracic outlet syndrome, TOS)
 - Temporary compression
 - Iatrogenic
 - Surgery, especially surgery for TOS
 - Anesthesia, particularly local anesthesia in the plexus
 - Radiation therapy
 - Catheterization of the arteries
 - Cancer and metastatic infiltration

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Trauma

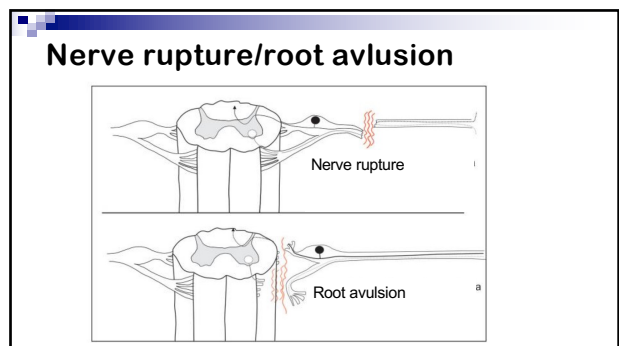
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- ### Traumatic mechanisms
- Injury to the shoulder in motorcycle accidents
 - 95% men
 - Median age 28 years
 - Truncus superior
 - Shoulder luxation
 - Timely reposition is important to minimize the injury
 - Often also axillary nerve involved
 - Stabbing with knife
 - Bullet wounds

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Root avulsion

- Spinal nerves C5, C6, C7
 - Anchored extraforaminally to transverse processes
 - Less prone to avulsion
- Spinal nerves C8 and Th1
 - Anchored to the spinal cord
 - Tend to avulse more easily

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Treatment of traumatic plexopathies

- Early treatment preferable
 - After 3 weeks scar tissue
 - Later reconstruction at 12 weeks is still possible
- In Sweden treatment is concentrated
 - Södersjukhuset
 - Norrlands universitetssjukhus

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Erb's palsy

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Erb's palsy – shoulder dystocia



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Incidence of Erb's palsy

- 0.5-2/1000 childbirths
- Number has decreased during the last decades

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Mechanisms

- Shoulder dystocia present in around 50%
- Traction forces applied externally
- 2-4% of Erb's palsies occur following caesarean section
 - During caesarian section similar traction forces

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Risk factors

- Large babies (>4500 g)
- Wide shoulders
- Mother has diabetes
- Previous Erb's palsy
- Twins
- If three risk factors - the risk for Erb's palsy is 8% (50 x times)
- NNT for Cesarean sections in mothers with 3 riskfactors to save one patient is 150

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Patterns

- C5 and C6
 - Classical Erb's palsy, 50%
- C5, C6 and C7
 - Erbs palsy +, 35 %
- C5-Th1 with sparing of finger flexion
- C5-Th1 and Horner's syndrome
- C8-Th1 and Horner's syndrome
 - Klumpkes palsy, very rare

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Prognosis

- 60% good
 - Return of elbow flexion at 2 months is a good sign
 - Usually, good recovery in 3-4 months
- 30% moderate
- 10% poor
 - Horner's syndrome
 - Total palsy without improvement in the first week
 - Paresis with no improvement in the first 6 months
 - Avulsion of spinal nerve
- Aberrant reinnervation
- Apraxia

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Surgery of Erb's palsy

- Significance of surgery not clear
- Usually at three months
 - Total palsy
 - Severe palsy with no improvement
- Repair of damaged nerves
- Transposition of nerves to denervated muscles
 - Intercostal nerve to musculocutaneous nerve
- Reattaching muscles to new sites

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Note

- Sometimes you will find in patients referred for EMG with inactive, old upper plexus lesions
 - May be sequelae of Erb's palsy the patient is not aware of
 - Have patient as mother about function of arm in neonatal period

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Temporary compression

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Temporary compression

- During coronary by-pass surgery
 - 5-7 % of patients have plexus lesion
 - Lower trunk is affected
- During general anesthesia
 - Arm is supinated and abducted more than 90 degrees
- Acute compression due to backpacks, especially lean soldiers

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Chronic compression - Entrapment "Thoracic outlet syndrome" - TOS

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Thoracic outlet syndrome - TOS

- Second most published entrapment syndrome
- Cotroversial classification
- Diagnostic criteria unclear, no generally accepted criteria
- No controlled therapeutic studies

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Thoracic outlet syndrome - TOS

- True neurogenic
 - Objective findings
 - Incidence 1/1000 000 per year
- Vascular
 - Venous
 - Arterial
- Disputed
 - Symptoms without objective findings

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Chronic mechanical compression

- Following fracture of the clavicle
- Anomalous cervical rib
- Poorly documented syndromes – **neuromythology!**
 - Pectoralis minor syndrome
 - Scalenus anterior syndrome

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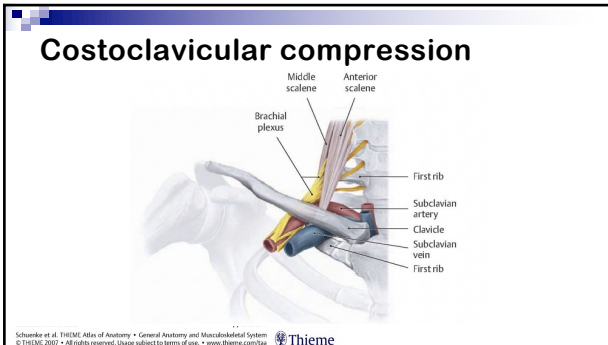
Cervical rib or ligament

The diagram illustrates the anatomical structures of the thoracic outlet. It shows the cervical rib originating from the C7 vertebra and passing over the first rib. The scalene muscles (anterior, middle, and posterior) are shown originating from the cervical vertebrae and inserting into the first rib. The brachial plexus and subclavian vessels (artery and vein) are shown passing between the first rib and the clavicle. Labels include: Scalene muscle insertion, Cervical rib, C7, Anterior scalene, Brachial plexus, Subclavian artery, Brachio-cephalic trunk, Sternum, First rib, and Costal cartilage.

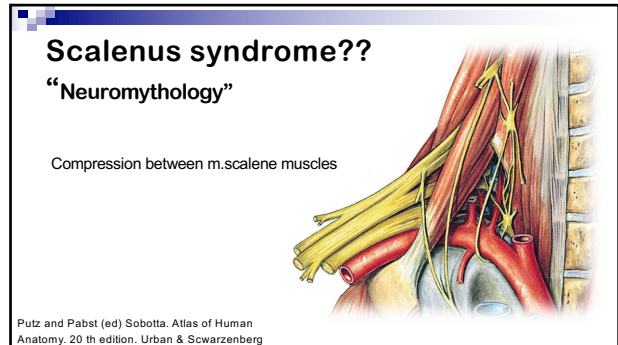
- 0.3% of people
- 75% women

Schuenke et al. Thieme Atlas of Anatomy • General Anatomy and Musculoskeletal System
© Thieme 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/thi

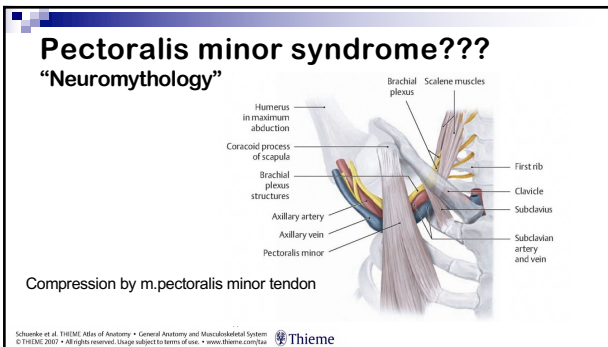
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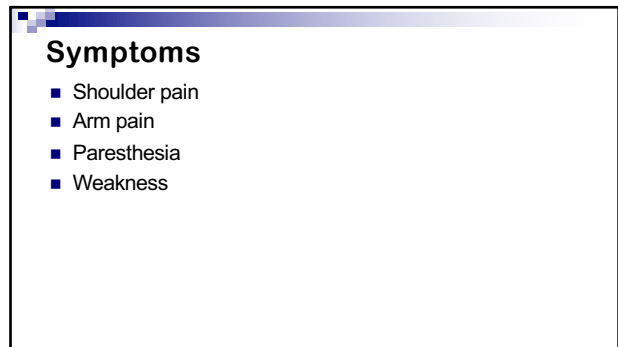
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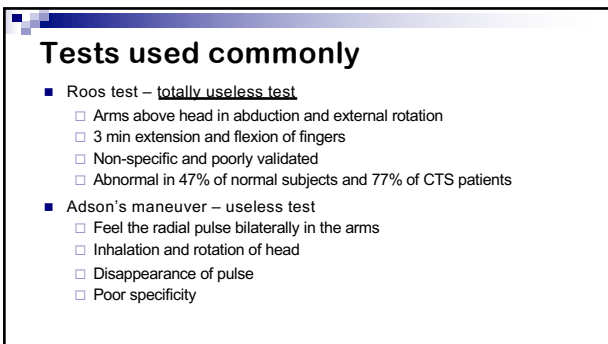
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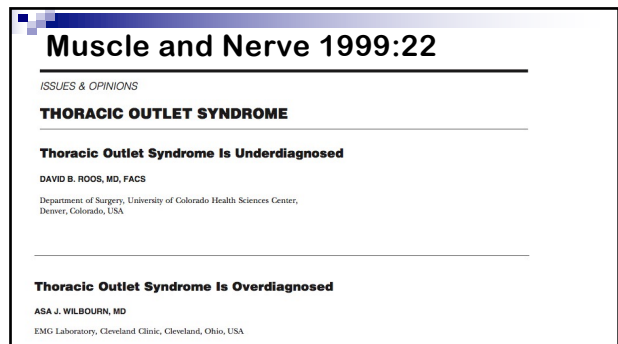
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ISSUES & OPINIONS

THORACIC OUTLET SYNDROME

Thoracic Outlet Syndrome Is Underdiagnosed

DAVID B. ROOS, MD, FACS

Department of Surgery, University of Colorado Health Sciences Center, Denver, Colorado, USA

- Anomalies (cervical ribs and bands) are common
- Unusual activity may trigger anatomical alterations that cause neurovascular compression
- Roos test
- EMG has limited value in conformation of TOS
 - EMG sees only axonal damage
 - Thin fibers not tested

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Thoracic Outlet Syndrome Is Overdiagnosed

ASA J. WILBOURN, MD

EMG Laboratory, Cleveland Clinic, Cleveland, Ohio, USA

- Poorly defined entity
 - Neurogenic, vascular (arterial, venous)
- Symptomatology widespread
- How can a neurogenic process evade EDX?
- What does the Roos' test really test for?
- Problem could be settled only with controlled studies
 - Roos has refused to do this, considers it unethical

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Cochrane Database of Systematic Reviews

Treatment for thoracic outlet syndrome (Review)

Povlsen B, Hansson T, Povlsen SD

2015

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Cochrane - background

- TOS is one of the most controversial diagnoses in medicine.
- The term TOS represents three related syndromes
 - Brachial plexus is compressed
 - Major blood vessels of the upper chest are compressed
 - Painful non-specific or disputed TOS

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Cochrane - background

- There is a lack of widely accepted standards for making the diagnosis of TOS, arm pain, weakness, loss of feeling, or all three, have been ruled out.
- Most people diagnosed with TOS have the disputed form.

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Cochrane - conclusions

- This review was complicated by a lack of generally accepted diagnostic criteria for the diagnosis of TOS.
- Low-quality evidence that transaxillary first rib resection decreased pain more than supraclavicular neuroplasty,
 - No randomized evidence that either is better than no treatment
- No evidence from RCTs for the use of other currently used treatments.

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Conclusions on TOS

- There is a need for an agreed definition
 - Diagnosis of TOS, especially the disputed form,
 - Outcome measures
 - Randomized trials that compare the outcome of interventions with no treatment and with each other.

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Neurological Sciences 2017;38:383-388

Neurol Sci (2017) 38:383–388
DOI 10.1007/s10072-016-2794-4



REVIEW ARTICLE

Thoracic outlet syndrome: wide literature for few cases. Status of the art

Pietro Emiliano Doneddu¹ · Daniele Coraci^{2,3} · Paola De Franco² · Ilaria Paolasso² · Pietro Caliendo¹ · Luca Padua^{1,2}

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Conclusions

- TOS subject to extensive literature debate
 - Out of proportion to its actual incidence
- Neurophysiologists and neurologists
 - Sceptical, many deny its existence
- Surgeons
 - Claim its common and responsive to surgery
- True neurogenic TOS
 - Very rare 1/1000000/year
 - Must be based on objective findings

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Own experience

- TOS over diagnosed in surgical specialities
- I have seen more complications following surgery for TOS than true neurogenic TOS patients
- Chronic compression of plexus brachialis is rare
- Occurs
 - Following deformed clavicular fracture
 - Very rarely in association with cervical rib

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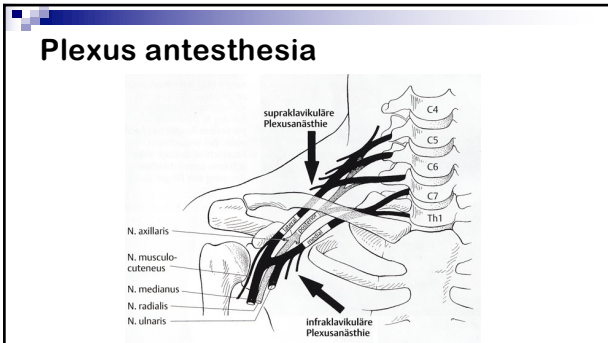
Iatrogenic plexus lesions

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Iatrogenic

- Complication of plexus anesthesia
- Radiation therapy
- Hematoma from trans axillary percutaneous angiograms
- Perioperative
 - Surgery in the neck region
 - Thoracotomy
 - **Complications of surgery for thoracic outlet syndrome**

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Plexus antesthesia

- Localization of plexus
 - Ultrasound
 - Electrical stimulation
 - Mechanical paresthesia caused by needle
- 0,5% incidence of neuropathies

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Pathophysiology

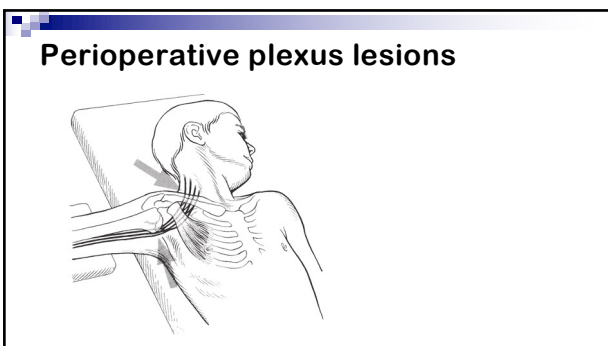
- Direct laceration or minor trauma by the needle
- Toxic effect of the anesthetic
 - Type of drug, adrenaline, preservatives
- Intraneural injection of drugs
 - Intrafascicular - epineural injections

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Arteriography

- Direct trauma by catheter
- Hematoma

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Sternotomy

- Occurs in 1-5% in carotid bypass surgery
- Inferior trunk
- Usually, good outcome

Retractor
Pericardium
Heart

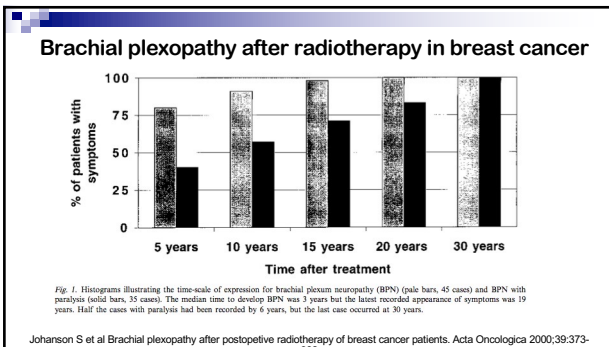
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Cancer

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- ## Cancer
- Tumours
 - Lung cancer, Pancoast tumour
 - Metastasis of the lymph nodes
 - Radiotherapy for cancer

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- ### Brachial plexopathy after radiation therapy for breast cancer
- Dose related
 - TD₅ 57-61 Gy
 - TD₅₀ 68-73 Gy
 - Onset 2,5 years to 20 years after radiation
 - 4% at 5 years
 - 25 % at 10 years
 - 30 % at 15 years
 - 55 % at 20 years
 - Chemotherapy does not increase rate
- Bajrovic A et al. Is there a life long risk of brachial plexopathy after radiotherapy of supraclavicular lymph nodes in breast cancer patients. Radiology and oncology. 2004;71:297-301

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- ## Benign tumors
- Schwannnomas
 - Neurofibromas

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Diagnosis of brachial plexopathies

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Diagnosis

- History
- Clinical findings
- EMG and ENG
- Imaging
 - MRI
 - Ultrasound
 - CT myelography

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Practical issues

- Brachial plexus lesions are rarely focal
 - Traction injuries extend diffusely along the nerves
 - Gunshot wound are diffuse
- Parsonage – Turner syndrome often affects individual nerves
 - May be multifocal
- Plexus anatomy varies
- EMG does not give etiology
 - History
 - Clinical findings
 - Imaging findings

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History

- Time course
 - When did it start?
 - Acute onset?
 - Progression?
- Sensory symptoms
 - Paresthesias
 - Pain
- Weakness
- Predisposing factors
 - Diabetes, rheumatoid arthritis, cancer
 - Clavicular fractures
 - Trauma

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Clinical examination

- Testing muscle strength
- Tendon reflexes
- Horner's sign (severe lesions of C8-Th1 spinal nerves)
 - Miosis, ptosis and anhidrosis

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Goal of EMG and neurography

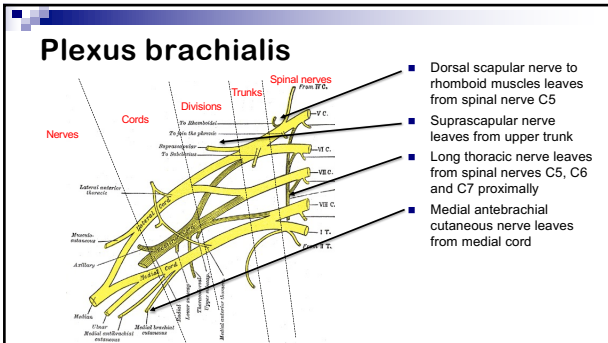
- Is there a peripheral neuropathy?
- Localize the neuropathy
- Assess severity
- Pathophysiology
 - Axonal
 - Conduction block
 - Demyelination
- Time course
 - Acute, subacute, chronic, inactive

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Demonstrate

- Neurogenic EMG findings in affected muscles
- Abnormal neurography
 - Reduced M wave amplitude
 - F wave latency and number
 - Reduced sensory nerve responses
 - Demonstrate local nerve conduction abnormality
- Differentiate from radiculopathy
 - Differential diagnosis is not always simple

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EMG

- M. rhomboideus (spinal nerve C5)
- M. infraspinatus/m. supraspinatus (upper trunk)
- M. deltoideus (upper trunk - posterior cord)
- M. biceps brachii (upper trunk - lateral cord)
- M. triceps (middle trunk - posterior cord)
- M. flexor carpi radialis (middle trunk - lateral cord)
- M. extensor indicis (lower trunk - posterior cord)
- M. interosseus dorsalis (lower trunk - medial cord)
- M. opponens pollicis (lower trunk - lateral+medial cord)
- M. serratus anterior (spinal nerves C5-C7)
- Paravertebral muscles C5-Th1

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Neurography

- Sensory
 - Median nerve digits 1-4
 - Ulnar nerve digits 4-5
 - Radial nerve
 - Lateral cutaneous of the forearm
 - Medial cutaneous of the forearm
- Motor (F-waves included)
 - Median
 - Ulnar

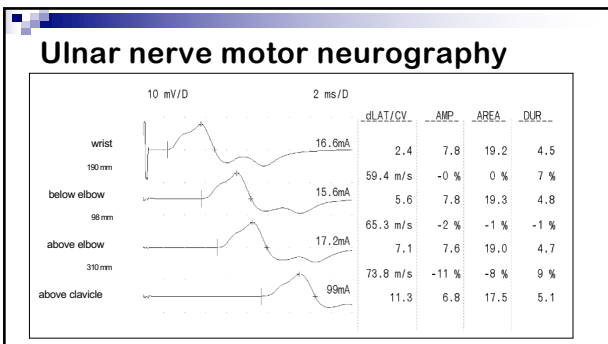
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Ulnar motor neurography

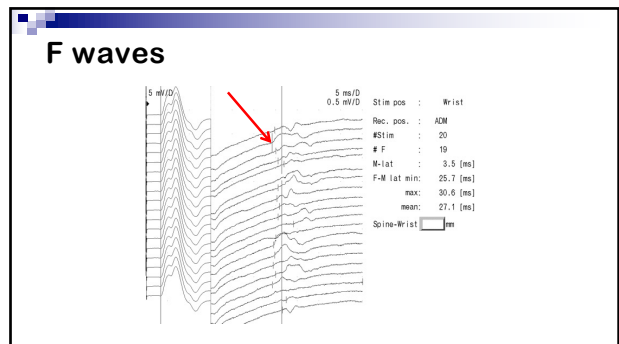
High stimulus intensity 80-100 mA, 0.2 ms duration

Stöhr & Blüthart
"Atlas der klinischen Elektromyographie und Neurographie"
Kohlhammer 1983

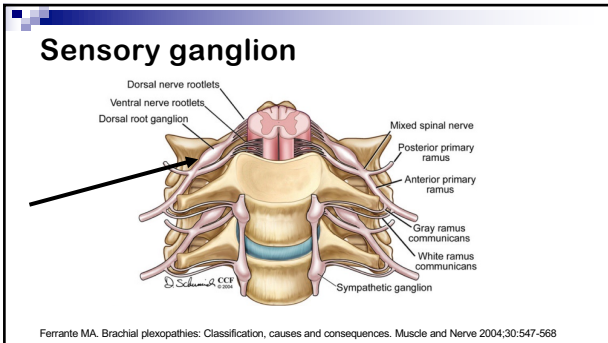
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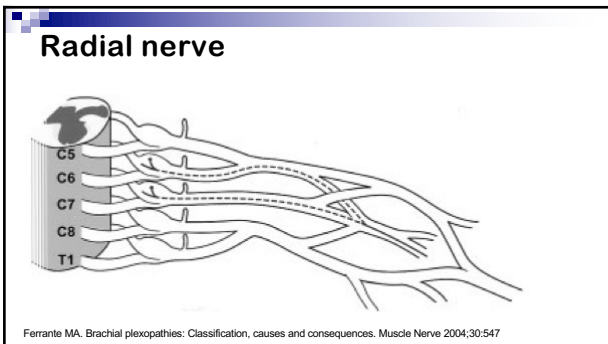
Sensory nerve action potential

- Low amplitude in plexopathies and peripheral neuropathies
- Normal/slightly reduced amplitude in radiculopathies

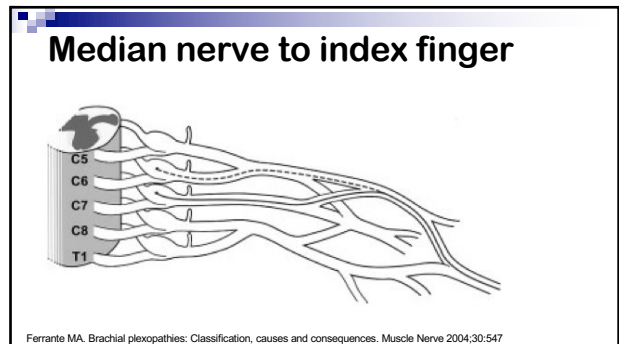
Forearm (D 1)
Elbow (Forearm)

Trace	AMP	DIST	LAT	CV	AMP
Forearm (D 1)	340				
Elbow (Forearm)	100	1.42			

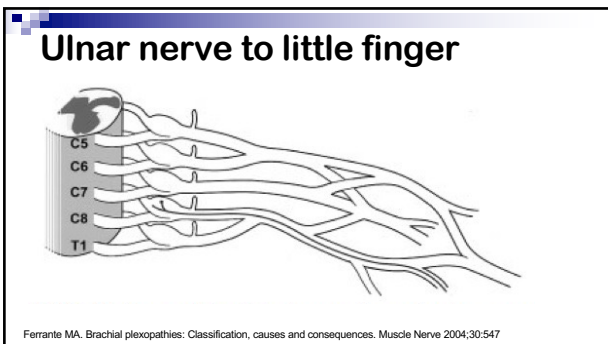
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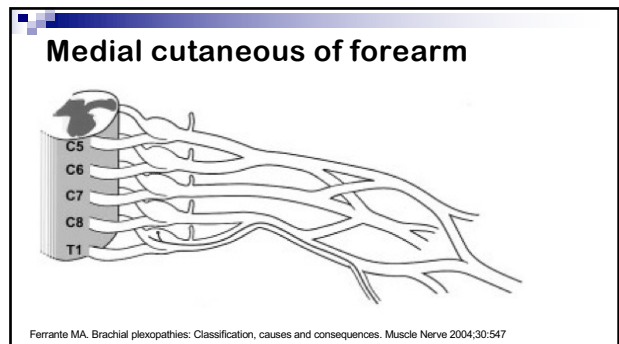
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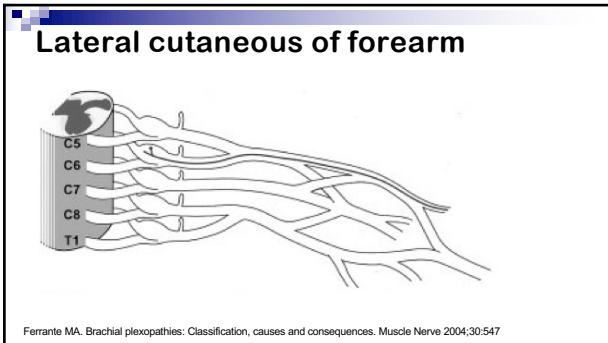
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ELECTRODIAGNOSTIC FEATURES OF TRUE NEUROGENIC THORACIC OUTLET SYNDROME

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²University of Tennessee Health Science Center, Department of Neurology, Memphis, Tennessee, USA
³Neuromuscular Center, Cleveland Clinic, Cleveland, Ohio, USA

Accepted 19 August 2013

ABSTRACT: Introduction: We report the electrodiagnostic (EDX) features of 32 patients with surgically verified true neurogenic thoracic outlet syndrome (TN-TOS). Methods: Retrospective record review. Results: We found uniform EDX evidence of a chronic axon loss process that affected the lower portion of the brachial plexus and disproportionately involved the T1 more than the C8 sensory and motor fibers. Because of this relationship, the medial antebrachial cutaneous sensory nerve (T1) and median motor (T1 > C8) study combination was abnormal in 89%, whereas response combinations that primarily assessed the C8 fibers were less frequently affected. Conclusions: The characteristic EDX features of TN-TOS are T1 > C8 nerve fiber involvement. A comprehensive EDX examination of the lower plexus with contralateral comparison studies is imperative to diagnose this disorder accurately.

Muscle Nerve 49: 724-727, 2014

- Inferior trunk
- C8 and Th1 muscles
 - Interosseus dorsalis
 - Thenar muscles
 - Hypothenar muscles
 - Extensor indicis
- Sensory neurography
 - Ulnar
 - Medial antebrachial

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Table 1. Sensory nerve conduction study results.

Sensory nerve (n)	Abnormal amplitude by side-to-side criteria (%)	Abnormal amplitude by age (%)	NR(%)
MABC (19)	18 (95)	16 (84)	13 (68)
Ulnar ring (7)	6 (86)	0	0
Ulnar little (32)	25 (78)	2 (6.3)	2 (6.3)
DUC (14)	10 (71)	1 (57.1)	5 (36)
Median ring (10)	3 (30)	0*	0
Median middle (29)	4 (14)	0*	0
Median thumb (21)	0	0	0
Median index (32)	0	0	0
LABC (17)	0	0	0

*No normal values available.
 NR, no response; DUC, dorsal ulnar cutaneous; MABC, medial antebrachial cutaneous; LABC, lateral antebrachial cutaneous.

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- ### SNAP domains
- Upper trunk
 - Lateral cutaneous of the forearm
 - Radial
 - Median nerve thumb
 - Middle trunk
 - Median nerve index finger and middle finger
 - Lower trunk
 - Ulnar nerve little finger
 - Medial cutaneous of the forearm

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- ### SNAP domains
- Lateral cord
 - Lateral cutaneous of the forearm
 - Median nerve digits 1-3
 - Posterior cord
 - Radial nerve
 - Medial cord
 - Ulnar nerve little finger
 - Medial cutaneous of the forearm

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- ### Root avulsion
- Proximal to sensory ganglion
 - Loss of sensation
 - Preserved sensory nerve action potential
 - Severe denervation of muscles
 - Paraspinal muscles denervated
 - No recovery expected

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Twenty patients with thoracic outlet syndrome (TOS) seen at the Mayo Clinic between October 1984 and November 1985 were studied prospectively with routine nerve conduction studies, concentric needle examination, and bilateral median and ulnar somatosensory evoked potentials (SEPs). Results of nerve conduction studies and needle examination were abnormal in 30% of the patients, one patient having a reduced ulnar sensory nerve action potential amplitude and five others having neurogenic motor unit potential changes in the hand muscles. Ulnar SEPs were abnormal in three patients (15%), and median SEPs were abnormal in one patient, who also had abnormalities in ulnar SEPs. In patients with TOS, routine nerve conduction studies and needle examination were the most helpful electrophysiologic studies in excluding more common conditions. The routine use of ulnar SEPs in the evaluation of patients with TOS is probably not worthwhile.

MUSCLE & NERVE 11:571-575 1988

SOMATOSENSORY EVOKED POTENTIALS: LACK OF VALUE FOR DIAGNOSIS OF THORACIC OUTLET SYNDROME

MARTIN VELLEUX, MD, J. CLARKE STEVENS, MD, and J. KEITH CAMPBELL, MD

SEPs are not helpful in the diagnosis of plexopathies

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Erb's palsy - EMG

- Rhomboideus
- Deltoidaeus
- Supraspinatus
- Biceps
- Triceps
- Extensor digitorum communis
- Intersseseus dorsalis I
- Flexor carpi radialis
- Paravertebral muscles C5-6

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Erb's palsy - neurography

- Ulnar motor
- Median sensory
- Ulnar sensory
- Radial sensory

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Timing of EMG in Erb's palsy

- 2-3 weeks, evaluation of severity
- 3 months evaluation of reinnervation

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MRI and US in the study of plexus brachialis

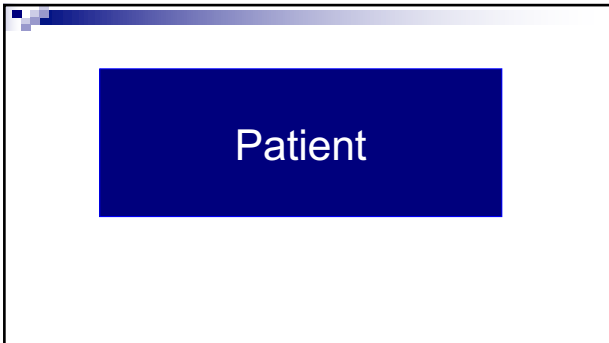
- Differential diagnosis with radiculopathies
- Root avulsions in traumatic plexopathies
- Tumors of brachial plexus
- Pancoast tumor
- Often focal changes in Parsonage-Turner syndrome

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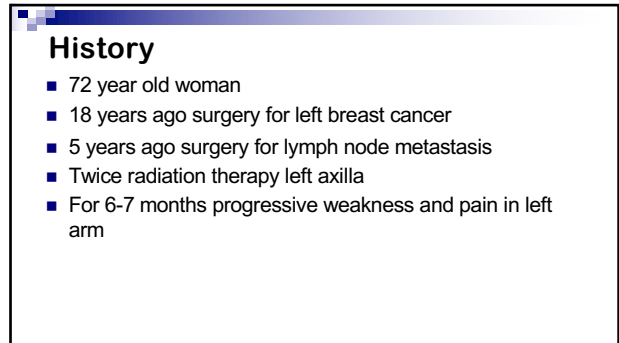
Differential diagnosis

- Acute cervical radiculopathy due to disc herniation
- Borreliosis related polyradiculopathy
 - Often combined with facial palsy
- Mononeuritis multiplex
- Immune mediated neuropathies
 - Lewis-Sumner
 - Multifocal motor neuropathy with conduction blocks
- Infectious neuro(no)pathies
 - Herpes zoster
 - Tick borne encephalitis

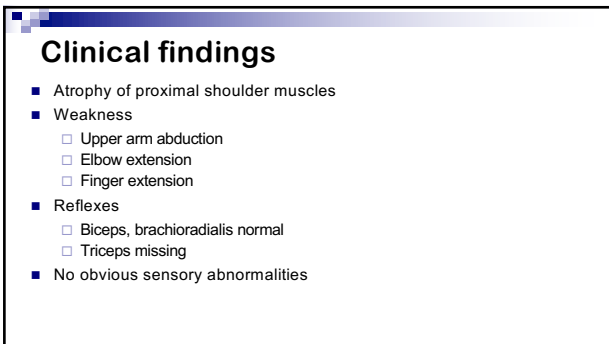
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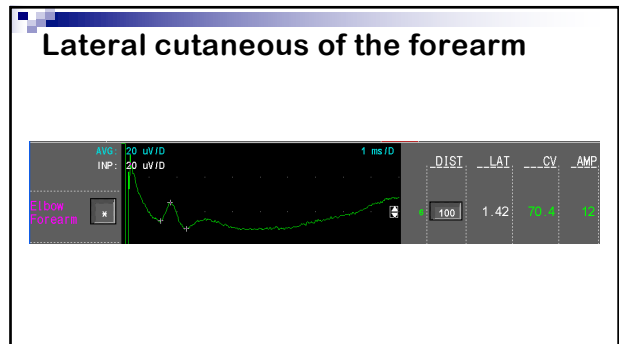
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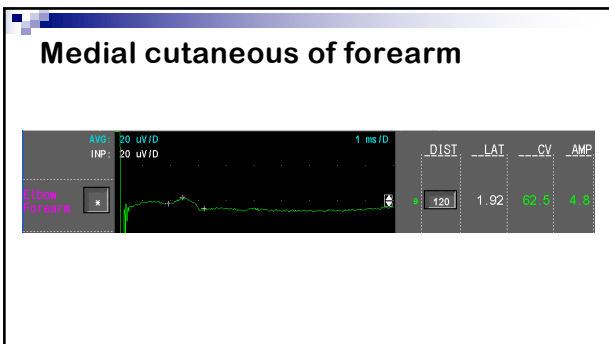
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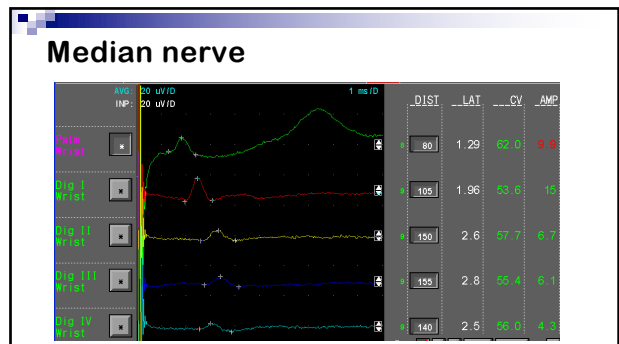
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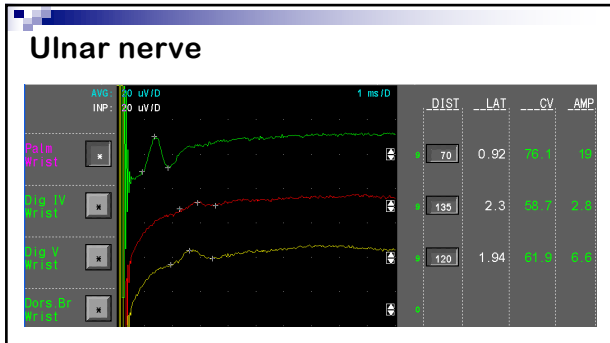
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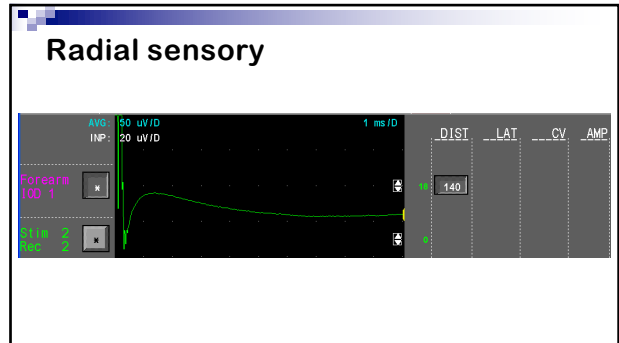
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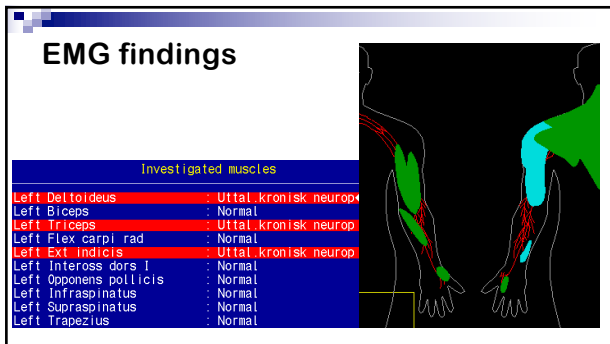
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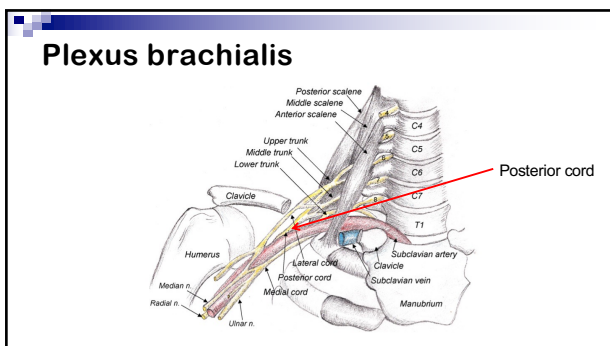
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Where is the problem?

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Conclusion

- Focal, severe, chronic lesion in the posterior cord
- Etiology
 - Metastasis likely
 - Parsonage-Turner syndrome unlikely, chronic progression
 - Radiation complication unlikely because the lesion is focal

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Follow-up

- MRI of the brachial plexus showed tumor below the clavicle

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Game over

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