Decoding the shoulder problem with diagnostic tools: neural vs non-neural pathology

Mark Brooks, PT, DSc
Richard McKibben, PT, DSc
Mohini Rawat, PT, DPT
Disclosure

The speakers have no financial interest in any company or product that is related to the content of this presentation.
Outline

1. Introduction and Purpose
2. Overview of electrodiagnosis in patients with shoulder dysfunction, pain and weakness
3. Ultrasound Imaging of the shoulder for neural and non-neural pathology
4. Case studies to integrate clinical exam findings and diagnostic tests results to determine prognosis and treatment
5. Summary
6. Questions and answers
Decoding the shoulder problem with diagnostic tools: neural vs non-neural pathology

Mohini Rawat DPT, MS, ECS, OCS, RMSK
Shoulder dysfunction is one of the most common reason for patient’s visit to primary care physician and physical therapist. Prevalence of one month of shoulder and arm pain was reported to be about 30% [1].

Clinical tests and physical examination may not be enough to differentiate wide range of pathology related to shoulder-neck area which often can be confusing because of their similar presentation [2].


Shoulder Examination

• Majority of special test in shoulder, when used in isolation, lack diagnostic accuracy
• This diagnostic accuracy improves when special tests are evaluated in combination

Shoulder Pain or impingement

- The Hawkins-Kennedy test- sensitivity 80%, specificity 56%. LR+ of 1.84 and LR- of 0.35*
- The Neer test- LR+ of 1.79 and LR- of 0.47*

SLAP Lesion-
active compression, speeds, anterior slide, crank, Yergason’s, relocation, biceps palpation, and compression relocation not clinically significant*

- Modified dynamic labral shear test, strongly supports the diagnosis of a SLAP lesion (LR+, 31.57) when positive. Negative test result provides a small decrease in the likelihood of a SLAP lesion (LR-, 0.29)**
- Passive distraction test described by Schlechter et al. A positive test result moderately increases the likelihood of a SLAP lesion (LR+, 8.83), but a negative test result offers only a minimal decrease in the likelihood of a lesion (LR-, 0.5).***

*Hegedus EJ, Goode AP, Cook CE, et al. Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tests. Br. J. Sports Med. 2012; 46:964Y78


Anterior Instability

• The apprehension test has an LR+ of 17.21 and LR- is 0.39,

• negative test result represents a small decrease in the likelihood of instability.

• Negative predictive value can be improved by the addition of the relocation test

Hegedus EJ, Goode AP, Cook CE, et al. Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tests. Br. J. Sports Med. 2012; 46:964Y78

Rotator Cuff Pathology

- Isometric rotator cuff strength testing is the most common assessment
- There are other considerations like age-
  - As men age, their abduction and external rotation strength decreases. As women age, their abduction strength decreases but external rotation strength is preserved.

Important to understand 1) the typical age progression of rotator cuff tears and 2) the incidence of asymptomatic rotator cuff tears with advancing age in the interpretation of isometric rotator cuff strength testing.

• The belly off test strongly supports the diagnosis of a subscapularis tendon tear when it is positive (LR+, 9.67), while a negative test result moderately decreases the likelihood of a tear (LR-, 0.14)*
• External rotation lag sign evaluates for the presence of a full-thickness supraspinatus or infraspinatus tear.
• Partial-thickness supraspinatus tears could not be identified reliably, and full-thickness partial-width anterior supraspinatus tears could not be ruled out with a negative test result (LR-, 0.73), while a positive test result only increased the likelihood of a tear a small amount (LR+, 4.6).
• The likelihood of a full-width supraspinatus tear was increased strongly with a positive test result (LR+, 28.00) but small decrease in likelihood with a negative test result (LR-, 0.45).
• A combined full-thickness tear of the supraspinatus and infraspinatus could be ruled in effectively by a positive test result (LR+, 13.86) and also ruled out by a negative test result (LRj, 0.03).1,2

The clinical diagnosis of rotator cuff pathology becomes more accurate when the physical examinations are evaluated in the context of patient history. Three positive findings that would predict supraspinatus pathology,:

1. age >39;
2. self-reported popping and clicking; and
3. a painful arc of motion.

The likelihood of supraspinatus tendinopathy in the setting of these findings increased dramatically, with an LR+ of 32.20.*

Imaging for Rotator Cuff

- For partial-thickness tears, MRI and ultrasound are equally good.
- For both partial and full thickness rotator cuff tears, there were no significant differences in the performance of MRI, MR arthrography, and ultrasound as imaging modalities.
- Ultrasound is lower cost and non-invasive as compared to MR arthrography.

Imaging SLAP lesion

- For the diagnosis of SLAP lesions, the imaging results are less accurate.
- MRI for SLAP lesion (LR+, 0.98; LRj, 1.1).
- MR arthrography was useful only in the setting of a negative result. Comparing combined physical examinations with imaging, concordant findings with the active compression and passive distraction tests perform better than MR arthrography to confirm or rule out a SLAP lesion.


Combining history and physical examination improves accuracy over isolated physical examination or special test. Combination is better than imaging tests.

There is value in imaging studies, however clinician must understand the limitations and identify the need for additional information to support or refute the suspected diagnoses derived from the history and physical examinations.
not intended for patients presenting with shoulder pain in the setting of systemic illness or other risk factors.

Ultrasound imaging is rapidly growing and popular point-of-care assessment tool which has its application in not only PT practice but other disciplines of health care.

Appropriate and effective use can eliminate unnecessary costly imaging tests and can provides insight into the pathophysiology of the shoulder.
Musculoskeletal Ultrasound Imaging

- Readily available
- Real time evaluation
- Time saving
- Cost saving
- Greater patient satisfaction with the care*
- Can be safely used when other imaging modalities contraindicated
- Comparison of contralateral structures

Ultrasound as an important complementary or alternative technique to MRI

1. Every Patient Can Undergo Sonography
2. Sonography Can Resolve Finer Details than MRI
3. Sonography Allows Real-Time Dynamic Examination of the Patient
4. The Ultrasound Probe Can Be Placed Exactly Where It Hurts
5. Sonography Can Effectively Image Patients with Surgical Hardware
6. Doppler Sonography Gives Important Physiologic Information
7. Sonography Is Better for Differentiating Fluid from Solid Material
8. Sonography Is Better for Guiding Therapeutic Interventions
9. Sonography Facilitates Bilateral Comparison
10. Sonography Has a More Flexible Field of View

Ultrasound Terminology

**Echogenicity** - amount of energy reflected back from the tissue interface

- **Hyperechoic** - Greatest intensity - WHITE
- **Hypoechoic** - Intermediate - GREY
- **Anechoic** - No signal - BLACK

![Short Axis view of wrist]
Shoulder

- Need systematic and comprehensive assessment of individual tendons.
- We examine tendons in stretched position so that the bony structure does not limit US access.
Four-step ultrasound protocol

<table>
<thead>
<tr>
<th>Step no.</th>
<th>Static examination</th>
<th>Dynamic examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Long head of biceps brachii tendon</td>
<td>Biceps tendon dislocation/subluxation</td>
</tr>
<tr>
<td></td>
<td>Subscapularis tendon</td>
<td>Subcoracoid impingement</td>
</tr>
<tr>
<td>2</td>
<td>Supraspinatus tendon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rotator interval</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Infraspinatus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teres minor</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Acromioclavicular joint</td>
<td>Acromioclavicular joint</td>
</tr>
<tr>
<td></td>
<td>Subacromial-subdeltoid bursa</td>
<td>Subacromial impingement</td>
</tr>
</tbody>
</table>

Long Head of Biceps
Subscapularis tendon
Supraspinatus

https://orthoinfo.aaos.org
The rotator interval is the anterosuperior aspect of the glenohumeral joint capsule that is reinforced externally by the coracohumeral ligament, internally by the superior glenohumeral ligament and capsular fibers which blend together and insert medially and laterally to the bicipital groove.

Infraspinatus
AC joint
Case Examples
Supraspinatus Tendon
Supraspinatus Partial Tear

Articular side tear

Bursal side tear
Intrasubstance tear
Full Thickness tear
Tendinosis Vs Tendon tear

**Tendinosis**
- Hypoechoic,
- Heterogenous, ill defined
- Swelling in the tendon
- Degenerative process with fibrillar and mucoid degeneration.

**Tendon Tear**
- Anechoic,
- Well defined (not all the time)
- Thinning of the tendon
- Associated with cortical irregularity
Calcific deposit in Supraspinatus
Suprascapular Nerve Entrapment

https://www.rocmd.com
Nerve Injury and Repair
Intro to EDX
Classification of Nerve Injury

<table>
<thead>
<tr>
<th>Seddon</th>
<th>Sunderland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurapraxia</td>
<td>I</td>
</tr>
<tr>
<td>Axonotmesis</td>
<td>II</td>
</tr>
<tr>
<td>–</td>
<td>III</td>
</tr>
<tr>
<td>–</td>
<td>IV</td>
</tr>
<tr>
<td>Neurotmesis</td>
<td>V</td>
</tr>
</tbody>
</table>

Wallerian degeneration = 

Conduction block
- Endoneurium
- Perineurium
- Epineurium

Axonal discontinuity

Axonal + endoneurial disruption

Perineural rupture fascicle disruption

Nerve trunk discontinuity

Seddon *Brain* 1943;66:237-288
Wallerian Degeneration

Kandel et al, 1991
• Remyelination
  • Compression vs Inflammation

• Axonal Sprouting
  • 6-8 weeks
  • Type II quickest
  • >75% loss, poor outcome

• Axonal Regeneration
  • 1 inch per month

• Dependent Factors
  • Age relation
  • Length to target organ
  • Intact endoneurium
  • Concomitant processes

Fredericks & Saladin, 1996
EDX is an Extension of the Physical Examination…Why Consider?

• Abnormal Neuromotor Screening
  – *Weakness*
  – Paresthesias
  – Altered MSRs
  – Pain/Myalgia/Fatigue
  – Gait/Balance Disorders
  – Cramps/Fasciculations
Why EDX?

- Problems in the nerves or muscle physiology can be objectively measured electrically
- Peripheral nerve injury can be localized or generalized
- Estimate the extent of injury
- Detect injury progression or regression
- Aide in establishing an injury baseline
- Identify other causes or factors
EDX Can Assist in the Diagnosis of:

- Neuropathy
  - Focal Mononeuropathy (e.g. CTS, TTS)
  - Radiculopathy (Cervical, Lumbar, Thoracic)
  - Plexopathy
  - Polyneuropathy (e.g. Diabetic, Alcoholic, GBS)
  - Polyradiculopathy (e.g. Diabetic, Central Stenosis)
- Myopathy/Muscular Dystrophy
- Motor Neuron Disease (e.g. ALS, SMA, PPS)
- Neuromuscular Junction Disorder (e.g. MG, LES)
EDX is an Extension of PE
Where’s this lesion?
Motor Nerve Conduction

Mild focal slowing 44m/s (demyelination) across the elbow

Mild UNE
Sensory Nerve Conduction

Low Amplitude (9 μV)
Slow Transcarpal NCV (16 m/s)
Slow Wrist-Digit Latency (6.7 ms)

Moderate Median Neuropathy at the Wrist
Focal neuropathy of peroneal nerve at the left knee with 75% Conduction Block. Possibly Low Amplitude Distally could implicate Axon Loss....DO EMG!
Electromyography (EMG)

- Electrical representation of muscle activity
  
  Insertional
  - 50-200 ms duration
  - Increased vs. decreased

  Resting
  - Normal is quiet, MEPPs, EPPs
  - Abnormal is Fibs/PSWs, CRDs, Fasc, etc.

- Volitional
  - Morphology, Recruitment

Normal Insertion without Resting Activity
Fibrillations and PSW’s
Recruitment

• Looking for transition from type I to type II motor units
  – Normal vs. Early

• Firing-Frequency
  – Approx 10-12 Hz before another motor unit recruited
  – Normal vs. Fast

• Interference Pattern
  – Normal vs. Reduced
Normal Recruitment
Long-Duration Polyphasia
Larger than Normal – Rapid-Fire
Early Recruitment - Myopathic
Motor NCS of the Shoulder

- Upper Trunk
  - Suprascapular
  - Axillary
  - Musculocutaneous
- Lateral Cord
  - Musculocutaneous
- Posterior Cord
  - Axillary
- Spinal Accessory CN XI
- Long Thoracic

Modified from Skurja. *RMUOH. 2001*
Sensory NCS

- Upper Trunk
  - LABC
  - Median DI, II, III
  - Superficial Radial

- Lateral Cord
  - LABC
  - Median DI, II, III

- Posterior Cord
  - Superficial Radial
Conduction Block vs. Axonopathy
Potential Pitfall

Conduction Block requires stim distal to the lesion
Needle EMG

- **Conduction Block**
  - Reduced/Rapid-fire Recruitment

- **Axonopathy**
  - Fibs/PSWs
  - Long Duration Polyphasia
  - Larger than Normal Amplitude MUAPs
  - Reduced/Rapid-fire Recruitment

- **But what about mixed lesions??**
  - Partial Conduction Block
  - Partial Axonopathy
## Severity and Prognosis

### Alternative Classification of Nerve Injury and Prognosis

<table>
<thead>
<tr>
<th>Severity</th>
<th>Type of Injury</th>
<th>Recovery</th>
<th>Time to Recover</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Mild</td>
<td>Mild Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mild</td>
<td>Advanced Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Moderate</td>
<td>Advanced Demyelination/Mild axon loss</td>
<td>Remyelination/Collateral Sprouts</td>
<td>2-6 months</td>
<td>Excellent</td>
</tr>
<tr>
<td>Severe</td>
<td>Moderate Axon Loss</td>
<td>Collateral Sprouts</td>
<td>2-6 months</td>
<td>Good</td>
</tr>
<tr>
<td>Profound</td>
<td>Severe Axon Loss</td>
<td>Collateral Spouts/Axon Regen</td>
<td>up to 18 months</td>
<td>Guarded/Fair</td>
</tr>
<tr>
<td>Complete</td>
<td>Severed Nerve</td>
<td>Surgery required</td>
<td>Protracted</td>
<td>Guarded at Best</td>
</tr>
</tbody>
</table>

© 2019 American Physical Therapy Association. All rights reserved.
Case 1 - Presentation

- 24yo male
- Fell off dirt bike 1 mos ago
- Referred for shoulder pain, weakness, radial palsy
- Deltoid/TM/Lats > radial weakness
- Paresthesias in axillary/radial distributions, D5
- Diminished MSRs Br/Tri
<table>
<thead>
<tr>
<th>Site</th>
<th>NR</th>
<th>Peak (ms)</th>
<th>Norm Peak (ms)</th>
<th>O-P* Amp (µV)</th>
<th>Norm O-P Amp</th>
<th>Site1</th>
<th>Site2</th>
<th>Delta-P (ms)</th>
<th>Dist (cm)</th>
<th>Vel (m/s)</th>
<th>Norm Vel (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Median Anti Sensory (3rd Digit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm</td>
<td></td>
<td>1.7</td>
<td>&lt;2.2</td>
<td>47.9</td>
<td>&gt;10</td>
<td>Palm</td>
<td>3rd Digit</td>
<td>1.7</td>
<td>7.0</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td></td>
<td>3.2</td>
<td>&lt;3.6</td>
<td>43.2</td>
<td></td>
<td>Wrist</td>
<td>Palm</td>
<td>1.5</td>
<td>7.0</td>
<td>47</td>
<td>&gt;39</td>
</tr>
<tr>
<td>Right Radial Anti Sensory (Base 1st Digit)</td>
<td></td>
<td>2.7</td>
<td>&lt;2.5</td>
<td>5.5</td>
<td></td>
<td>Wrist</td>
<td>Base 1st Digit</td>
<td>2.7</td>
<td>10.0</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Radial Anti Sensory (Base 1st Digit)</td>
<td></td>
<td>2.4</td>
<td>&lt;2.5</td>
<td>23.7</td>
<td></td>
<td>Wrist</td>
<td>Base 1st Digit</td>
<td>2.4</td>
<td>10.0</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Right Ulnar Anti Sensory (5th Digit)</td>
<td></td>
<td>3.1</td>
<td>&lt;3.4</td>
<td>19.7</td>
<td>&gt;10</td>
<td>Wrist</td>
<td>5th Digit</td>
<td>3.1</td>
<td>12.0</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Left Ulnar Anti Sensory (5th Digit)</td>
<td></td>
<td>2.8</td>
<td>&lt;3.4</td>
<td>23.8</td>
<td>&gt;10</td>
<td>Wrist</td>
<td>5th Digit</td>
<td>2.8</td>
<td>12.0</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Right Median/Radial Comparison (Digit 1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median 10 cm</td>
<td></td>
<td>2.5</td>
<td>31.9</td>
<td>&gt;7uV</td>
<td></td>
<td>Median 10 cm</td>
<td>Radial 10 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>NR</th>
<th>Peak (ms)</th>
<th>O-P* Amp (µV)</th>
<th>Norm O-P Amp</th>
<th>Site1</th>
<th>Site2</th>
<th>Delta-P (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Median/Radial Comparison (Digit 1)</td>
<td></td>
<td>2.5</td>
<td>31.9</td>
<td>&gt;7uV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median 10 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial 10 cm</td>
<td>NR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NR</th>
<th>F-Lat (ms)</th>
<th>Lat Norm (ms)</th>
<th>L-R F-Lat (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Median (Mrkrs) (Abd Poll Brev)</td>
<td>27.35</td>
<td>&lt;33</td>
<td></td>
</tr>
<tr>
<td>Site</td>
<td>NR</td>
<td>Onset (ms)</td>
<td>Norm Onset (ms)</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----</td>
<td>------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Right Axillary Motor (Deltoid)</strong> 99% decrement L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deltoid R</td>
<td></td>
<td>4.1</td>
<td>&lt;4.9</td>
</tr>
<tr>
<td>Deltoid L</td>
<td></td>
<td>3.9</td>
<td>&lt;4.9</td>
</tr>
<tr>
<td><strong>Right Median Motor (Abd Poll Brev)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td></td>
<td>3.6</td>
<td>&lt;4.2</td>
</tr>
<tr>
<td>Elbow</td>
<td></td>
<td>8.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Axilla</td>
<td></td>
<td>9.7</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Right Radial Motor (Ext Ind Prop) 75% decrement L</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forearm 8cm</td>
<td>3.3</td>
<td>&lt;3.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Brachium</td>
<td></td>
<td>7.2</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Left Radial Motor (Ext Ind Prop)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forearm 8cm</td>
<td>2.7</td>
<td>&lt;3.0</td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Right Supra Scap Motor (Infraspinatus)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus L</td>
<td>3.6</td>
<td>&lt;4.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Infraspinatus R</td>
<td>3.6</td>
<td>&lt;4.3</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Right Ulnar Motor (Abd Dig Minimi)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist 8cm</td>
<td>3.6</td>
<td>&lt;3.6</td>
<td>8.6</td>
</tr>
<tr>
<td>B Elbow</td>
<td></td>
<td>7.2</td>
<td>8.4</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>9.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Elbow</td>
<td></td>
<td>11.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Erb's</td>
<td></td>
<td>15.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Side</td>
<td>Muscle</td>
<td>Nerve</td>
<td>Root</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------</td>
<td>--------------</td>
<td>--------</td>
</tr>
<tr>
<td>Right</td>
<td>Infraspinatus</td>
<td>Suprascap</td>
<td>C5-6</td>
</tr>
<tr>
<td>Right</td>
<td>Deltoide</td>
<td>AxillaryRad</td>
<td>C5-6</td>
</tr>
<tr>
<td>Right</td>
<td>Brachioradialis</td>
<td>Radial</td>
<td>C5-6</td>
</tr>
<tr>
<td>Right</td>
<td>FlexorRadialis</td>
<td>Median</td>
<td>C6-7</td>
</tr>
<tr>
<td>Right</td>
<td>Triceps</td>
<td>Radial</td>
<td>C6-7-8</td>
</tr>
<tr>
<td>Right</td>
<td>LatisDorsi</td>
<td>Thoracodors</td>
<td>C6-8</td>
</tr>
<tr>
<td>Right</td>
<td>ExtDigCom</td>
<td>Radial( Post Int)</td>
<td>C7-8</td>
</tr>
<tr>
<td>Right</td>
<td>AbdPollBrev</td>
<td>Median</td>
<td>C8-T1</td>
</tr>
<tr>
<td>Right</td>
<td>1stDorInt</td>
<td>Ulnar</td>
<td>C8-T1</td>
</tr>
<tr>
<td>Right</td>
<td>Trapezius</td>
<td>SpinalAcc</td>
<td>CN XI, C3-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Side</th>
<th>Muscle</th>
<th>Nerve</th>
<th>Root</th>
<th>Ins Act</th>
<th>Fibs</th>
<th>Psw</th>
<th>Other</th>
<th>Amp</th>
<th>Dur</th>
<th>Poly</th>
<th>Recrt</th>
<th>Int Pat</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>C5-6</td>
<td>DPR</td>
<td>C5-6</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>C6-7</td>
<td>DPR</td>
<td>C6-7</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>C7-T1</td>
<td>DPR</td>
<td>C7,C8</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td>NT'd</td>
<td></td>
</tr>
</tbody>
</table>
Case 1 – Summary EDX

- Profound axillary CMAP decrement 99%
- 75% radial motor and superficial radial sensory decrement.
- Superficial radial response not elicited D1
- Slowed ulnar NCV across elbow
- Profoundly reduced and rapid-fire recruitment with fibs/PSWs deltoid, less severe remaining radial innervated mm’s and lats
- Remaining EMG/NCS WNL
Case 1 – Impression (Abnormal Study)

• Evidence suggests severe right posterior cord brachial plexopathy.
  – This involves the axillary component (very severe) > radial and thoracodorsal components.
  – Given the severity, expected prognosis for radial return is good, but slow with less encouraging recovery of the axillary components.
  – Recommend repeat EMG/NCS is 3 months to assess recovery.

• There is also evidence of mild ulnar focal neuropathy at the right elbow.
• There are no findings of primary lateral/medial cord involvement and no findings of cervical radiculopathy.
• Recommend ongoing PT for joint protection, modified functional mobility and activity with gradual return to duty as tolerated.
Case 1 - Follow up 3 months

- 100% radial motor improvement
  - 4.8mV vs. 2.1mV prior study. 52% s-s decrement persists
- 32% superficial radial SNAP improvement
  - 67% deficit persists
- 640% axillary motor improvement
  - 42% deficit persists
- R ulnar motor NCV WNL.
- Significant improvement in recruitment, evidence of motor unit remodeling due to collateral sprouting (long duration, polyphasia, continued fibs/PSWs)
Case 1 – Impression  3 months

- There continues to be evidence of ongoing R posterior cord brachial plexopathy, but with significant improvements from prior study in February 2014. There is evidence of motor unit remodeling due to collateral axon sprouting, but the significant rapid recovery is indication that a significant portion of injury was likely result of conduction block with only partial axonopathy.

- Given the rapid significant improvement, the opportunity for continued function recovery is excellent with anticipation of nearly complete to complete resolution of symptoms within the next year.

*Pt interviewed by phone 6 months later.*

*Indicated return to duty, reported feeling of fatigue with overhead activities, but about 90% improved overall.*
Case 2 Presentation

• 51 yom, 75 in, 245 lbs
• Insidious severe pain posterolateral shoulder
• MRI with Dx GH cysts. Unclear involvement of SSN
• EDX 2 weeks post MRI by other tester
• Alleged probable Cx radiculopathy and CTS
• Did not stick the spinatii or the Cx paraspinals
• Tester suggested that further electrophysiological evaluation may be warranted to confirm his suspicions
Review of Complaints

- “Knife Stabbing”
- No neck or distal arm pain or any UE dysesthesia
- 0-10 Pain Rating
  - Best = 0
  - Worst = 10
  - Avg = 5
- Irritability (Maitland)
  - T1 - reach back/immediate
  - T2 - immediate
  - T3 - elevate arm and ice/2hr

- Hx of throwing injury
- No other PMH
- Patient Specific Functional Scale (PSFS)
  - 3.7, throwing, working, driving, close door, brush hair
- Shoulder Disability Questionnaire
  - 16 item questionnaire
  - 15/16 (93.8%)
Physical Examination

• Unable to actively forward elevate, abduct, or externally rotate against gravity without increased pain.

• Full PROM without pain.

• TTP infraspinous fossa and coracoid

• MSR’s 2+ and symmetric to uppers

• CxSp cleared

• + Speed’s, + Obrien’s, - Hawkin’s, Neer’s
PT Assessment

- Severe weakness without pain in abduction and external rotation raises suspicion to a neuropathic deficit of the suprascapular nerve. It is also rationale to suspect some involvement of the axillary nerve.

- Normal but painful MMT in the biceps are thought to implicate the muscle-tendon unit. This coupled with a positive Obrien’s and Speed’s strongly suggest involvement of the labral-bicepital complex.

- Lack of provocation in the neck, normal muscle stretch reflexes, normal sensation and no other detected weakness in muscles with common C5-C6 nerve root innervation lend minimal evidence to support suspicion of cervical radiculopathic or plexopathic lesions of the upper trunk, lateral or posterior cords.
EDX

- Severe CMAP deficit R SSN recording from IS (90%) with slowed latency, SS NCS Nml

- Profuse fibs/psws infraspinatus

- Rapid-recruitment severely reduced

- All other C5-6 muscles and SS Nml

- Slight slowing with preserved SNAPs in R median sensory at the wrist with Nml motor studies

- MCN, AxN, SupRad, L Median Nml
Electrophysiological Impression

- Severe partial acute axonal > demyelinating neuropathic process of the SSN on the right that is distal to the innervation of the supraspinatus (estimate at or near the spinoglenoid notch).

- Mild delay in the median transcarpal latency (digit III) may suggest a mild right focal median sensory neuropathic process at the wrist.

- No evidence to suggest right radiculopathic or plexopathic processes.
Intervention

- Arthroscopic repair of Type II SLAP Lesion
- Open Debridement of Ganglion Cyst
- Physical Therapy
  - 2 visits
  - Non-compliant with home program

Outcomes

• Limited A/PROM FE, Abd, ER, Hor Abd 10-15%

• Speed’s and O’brien’s tests were negative.

• Slight comparative weakness w/o pain ER only.

• Nml elbow flexion & Abd of the shoulder.

• 3.9 DML to IS, No fibs/psws, polyphasic MUAPs 12 wks post-op

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Initial</th>
<th>8 weeks</th>
<th>12 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective Pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Worst</td>
<td>10</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Irritability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>immediate</td>
<td>immediate</td>
<td>---</td>
</tr>
<tr>
<td>T2</td>
<td>immediate</td>
<td>immediate</td>
<td>---</td>
</tr>
<tr>
<td>T3</td>
<td>15min-1hr</td>
<td>0-2 minutes</td>
<td>---</td>
</tr>
<tr>
<td>PSFS</td>
<td>3.7</td>
<td>6.8</td>
<td>8.0</td>
</tr>
<tr>
<td>SDQ</td>
<td>93.8%</td>
<td>25%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Is Clinical Examination Sufficient?
Case 1 History & Subjective Complaints

- Patient seen in clinic 12/18/18
- 71 year old female with complaints of right shoulder and arm pain and paraesthesias, limited motion, weakness and functional loss
- She reports symptom onset in September 2018 after a fall and proximal humerus fracture requiring ORIF
  - Has had extensive physical therapy for shoulder and arm with minimal improvements in ROM, strength, function
  - Reports that her neural symptoms are worse following surgery
- PMH:
  - Hypertension
  - Thyroid disease
  - Osteoporosis
- Referred for electrodiagnostic testing by orthopedic surgeon to rule out plexus or proximal nerve pathology
Case 1 Clarifying Examination

- Observation
  - 4’11”, 200#
  - Atrophy of right shoulder girdle muscles, with marked atrophy of right deltoid
  - Healed surgical incision right anterior shoulder
  - Edema/hematoma?? distal right arm
  - Skin intact
Case 1 Clarifying Examination

• Range of motion
  • Limited throughout right shoulder actively:
    • Flx 100, abd 75, ER 10, ext 45
    • Markedly limited passively all directions
    • Essentially normal for age otherwise

• Strength
  • Normal for age throughout except:
    • Right shoulder flx 3+/5, abd 3/5, ER 3/5, IR 4-/5, ext 4/5
    • Right elbow and wrist flx, ext 4/5

• Neurological
  • MSRs 1+ and symmetrical
  • Altered light touch digits 2, 3 and 5 on right
  • No clonus or spasticity

• Provocative tests
  • Positive: R. Phalen’s, Tinel’s at wrist and elbow
  • Negative: Spurling’s

Discuss Clinical Findings and Differential Diagnosis
**Case 1 EDX Examination**

**Sensory NCS**

<table>
<thead>
<tr>
<th>Nerve / Sites</th>
<th>Latency ms</th>
<th>Amp μV</th>
<th>Distance cm</th>
<th>NCV m/s</th>
<th>Temp ºC</th>
</tr>
</thead>
<tbody>
<tr>
<td>R MEDIAN - Dig III Ortho</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dig III</td>
<td>4.75</td>
<td>7.1</td>
<td>14</td>
<td>29.5</td>
<td>31</td>
</tr>
<tr>
<td>R MEDIAN - Palmar Ortho</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm</td>
<td>3.25</td>
<td>9.5</td>
<td>8</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>R ULNAR - Dig V Ortho</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dig V</td>
<td>3.50</td>
<td>6.5</td>
<td>14</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>R ULNAR - Palmar Ortho</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm</td>
<td>1.95</td>
<td>10.3</td>
<td>8</td>
<td>41.0</td>
<td></td>
</tr>
<tr>
<td>R RADIAL - Thumb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forearm</td>
<td>2.55</td>
<td>26.0</td>
<td>10</td>
<td>39.2</td>
<td></td>
</tr>
</tbody>
</table>

**Motor NCS**

<table>
<thead>
<tr>
<th>Nerve / Sites</th>
<th>Latency ms</th>
<th>Amp mV</th>
<th>Amp %</th>
<th>Distance cm</th>
<th>NCV m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>R MEDIAN - APB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td>4.90</td>
<td>7.1</td>
<td>100</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td>8.70</td>
<td>6.7</td>
<td>94.2</td>
<td>22</td>
<td>57.9</td>
</tr>
<tr>
<td>R ULNAR - ADM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td>3.50</td>
<td>5.8</td>
<td>100</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>B. Elbow</td>
<td>7.50</td>
<td>5.2</td>
<td>89.2</td>
<td>20</td>
<td>50.0</td>
</tr>
<tr>
<td>A. Elbow</td>
<td>10.20</td>
<td>4.7</td>
<td>81</td>
<td>8</td>
<td>29.6</td>
</tr>
<tr>
<td>R AXILLARY - Deltoid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erbs</td>
<td>2.85</td>
<td>3.4</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L AXILLARY - Deltoid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erbs</td>
<td>2.55</td>
<td>4.1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NCS Summary:**

- R median sensory: prolonged latencies & slowed NCVs with preserved SNAP amplitudes
- R median motor: prolonged distal latency with preserved CMAP amplitudes
- R ulnar motor: markedly slowed across elbow NCV, with normal latency, forearm NCV & CMAP amplitudes
- R ulnar & radial sensory: normal latencies, SNAP amplitudes & NCVs
- B axillary motor: normal latencies & CMAP amplitudes
Case 1 EDX Examination

EMG Summary:

- R FDI: Increased numbers of highly polyphasic motor units
- R APB: Increased numbers of highly polyphasic, fast firing motor units
- R Deltoid, Supraspinatus, Infraspinatus, Teres minor: Normal
- R Biceps, Triceps, FCR, FDP ulnar, Cervical paraspinals: Normal
Case 1 Electrophysiologic Impression

- Moderate sensorimotor axonal & demyelinating neuropathy affecting the right median nerve at or about the wrist (carpal tunnel),
- Moderate primarily motor axonal & demyelinating neuropathy affecting the right ulnar nerve at or about the elbow,
- No electrophysiologic evidence of proximal nerve, plexus or nerve root pathology,
- No electrophysiologic evidence of underlying polyneuropathic or myopathic processes
**Case 2 History & Subjective Complaints**

- Patient seen in clinic 10/8/18
- 19 year old male with complaints of left shoulder and arm pain and paraesthesias, limited motion, weakness and functional loss
- He reports symptom onset in September 2018 after an MVA and distal radius & ulna fracture requiring ORIF
  - Has had some physical therapy for shoulder, arm and wrist dysfunction with improvements in ROM, strength, function of the wrist and hand, but..
  - Reports that he is having progressive loss of function, ROM & weakness in the left shoulder
- PMH:
  - Unremarkable
- Referred for electrodiagnostic testing by orthopedic surgeon to rule out plexus, proximal nerve pathology or cervical radiculopathy
Case 2 Clarifying Examination

• Observation
  • 5’10”, 155#, BMI 22.2
  • Atrophy of left shoulder girdle muscles, with marked atrophy of left deltoid
  • Mild atrophy of left arm & forearm
  • Healed surgical incision left forearm
  • Skin intact
Case 2 Clarifying Examination

- Range of motion
  - Limited throughout left shoulder actively:
    - Flx 160, abd 125, ER 60, ext 90
    - Normal passively all directions
    - Essentially normal for age otherwise

- Strength
  - Normal for age throughout except:
    - Left shoulder flx 2/5, abd 2/5, ER 3/5, IR 3+/5, ext 4-/5
    - Left elbow and wrist flx, ext 4/5, forearm pronation & supination 4/5, intransics 4/5
    - Right UE 5/5

- Neurological
  - MSRs 2+ and symmetrical
  - Altered light touch digits 2, 3 and 5 on left and on left middle deltoid
  - No clonus or spasticity

- Provocative tests
  - Positive: L. Phalen’s, Tinel’s at wrist and elbow
  - Negative: Spurling’s

Discuss Clinical Findings and Differential Diagnosis
Case 2 EDX Examination

NCS Summary:

- L median sensory: slowed transcarpal NCV with preserved SNAP amplitudes
- L median motor: prolonged distal latency with preserved CMAP amplitudes
- L ulnar sensory: prolonged latency, slowed NCV with preserved SNAP amplitude
- L ulnar motor: slowed across elbow NCV, prolonged latency, normal forearm NCV & CMAP amplitudes
- L axillary motor: 90% diminished CMAP amplitude relative to uninvolved side
- L radial & med/lateral antebrachial cutaneous sensory nerves are normal
### Case 2 EDX Examination

**EMG Summary:**

- L deltoid & teres minor: increased insertional activity, increased numbers of fibrillations & positive sharp waves, increased numbers of long duration highly polyphasic motor units & significantly reduced numbers of volitional motor units that were fast firing

- All other left shoulder girdle, upper extremity & cervical paraspinal muscles: Normal

<table>
<thead>
<tr>
<th>EMG Summary Table</th>
<th>Spontaneous Activity</th>
<th>Motor Unit Analysis</th>
<th>Recruitment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insert Act</td>
<td>Fib</td>
<td>PSW</td>
</tr>
<tr>
<td>L. DELTOID (M)</td>
<td>Normal</td>
<td>2+</td>
<td>4+</td>
</tr>
<tr>
<td>L. DELTOID (A)</td>
<td>Increased</td>
<td>1+</td>
<td>3+</td>
</tr>
<tr>
<td>L. TERES MINOR</td>
<td>Increased</td>
<td>1+</td>
<td>3+</td>
</tr>
<tr>
<td>L. BICEPS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. TRICEPS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. PRON TERES</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. FLEX DIG PROF IV</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. EXT DIG COMM</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. FIRST D INTEROSS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. ABD POLL BREVIS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. CERV PSP (M)</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. CERV PSP (L)</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. INFRASPINATUS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. SUPRASPINATUS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. SERR ANT</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. TRAPEZIUS (U)</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
**Case 2 Electrophysiologic Impression**

- Severe motor axonopathy affecting the left axillary nerve,
  - Suggest follow up examination in 4-6 months to assess neural reinnervation
- Moderate sensorimotor primarily demyelinating neuropathy affecting the left median nerve at or about the wrist (carpal tunnel),
- Mild primarily motor demyelinating neuropathy affecting the left ulnar nerve at or about the elbow,
- Mild sensorimotor primarily demyelinating neuropathy affecting the left ulnar nerve at or about the wrist,
- No electrophysiologic evidence of plexus or nerve root pathology,
- No electrophysiologic evidence of underlying polyneuropathic or myopathic processes.
### Case 2 Prognosis

#### Alternative Classification of Nerve Injury and Prognosis

<table>
<thead>
<tr>
<th>Severity</th>
<th>Type of Injury</th>
<th>Recovery</th>
<th>Time to Recover</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Mild</td>
<td>Mild Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mild</td>
<td>Advanced Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Moderate</td>
<td>Advanced Demyelination/Mild axon loss</td>
<td>Remyelination/Collateral Sprouts</td>
<td>2-6 months</td>
<td>Excellent</td>
</tr>
<tr>
<td>Severe</td>
<td>Moderate Axon Loss</td>
<td>Collateral Sprouts</td>
<td>2-6 months</td>
<td>Good</td>
</tr>
<tr>
<td>Profound</td>
<td>Severe Axon Loss</td>
<td>Collateral Sprouts/Axon Regen</td>
<td>up to 18 months</td>
<td>Guarded/Fair</td>
</tr>
<tr>
<td>Complete</td>
<td>Severed Nerve</td>
<td>Surgery required</td>
<td>Protracted</td>
<td>Guarded at Best</td>
</tr>
</tbody>
</table>

- Based on this patient's EDX findings, can we assess prognosis?
  - 90% CMAP amplitude decrement side to side at face value is guarded/fair indicator
  - But we are unsure what component of the STS amp difference may be due to conduction block vs. axon loss
  - Proximity of target muscles to site of injury suggests better possibility of reinnervation & improvement
  - Retesting in 4-6 month timeframe to assess reinnervation critical to establishing a long term prognosis
Case 3 History & Subjective Complaints

- Patient seen in clinic 11/30/17
- 43 year old male with complaints of left shoulder & anterior arm & hand pain and paraesthesias, limited motion, weakness and functional loss
- He reports symptom onset in June 2017 following posterior approach C5-6, C6-7 laminectomy & fusion with hardware placement
  - No physical therapy to this point
  - Plain films indicate proper hardware placement
- PMH:
  - Osteoarthritis
  - DDD lumbar & cervical with multilevel cervical laminectomy & fusion June 2017
  - COPD
  - HTN
  - CAD

Referred for electrodiagnostic testing by his family practitioner to assess potential causes of atrophy & functional decline
Case 3 Clarifying Examination

- Observation
  - 5’10”, 210#
  - Atrophy of left shoulder girdle muscles, deltoid, supra/infraspinatus
  - Left scapular winging
  - Healed surgical incision posterior cervical region
  - Skin intact
Case 3 Clarifying Examination

• Range of motion
  • Essentially normal left shoulder actively:
    • Excessive protraction/elevation, but painful in all directions
    • Normal passively all directions
    • Cervical ROM limited
    • Essentially normal for age otherwise

• Strength
  • Normal for age throughout except:
    • Left shoulder flx 3-/5, abd 3-/5, ER 3/5, IR 3+/5, ext 4-/5
    • Left elbow flx 4-/5, forearm supination 4-/5
    • Left otherwise 4+/5 to 5/5 in wrist/hand
    • Right UE 5/5

• Neurological
  • MSRs 1+ and symmetrical except absent left biceps/brachioradialis
  • Altered light touch digits left median distribution
  • No clonus or spasticity

• Provocative tests
  • Positive: L. Phalen’s, Tinel’s at wrist and elbow

Discuss Clinical Findings and Differential Diagnosis
Case 3 EDX Examination

Sensory NCS

<table>
<thead>
<tr>
<th>Nerve / Sites</th>
<th>Latency ms</th>
<th>Amp μV</th>
<th>Distance cm</th>
<th>NCV m/s</th>
<th>Temp °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>L MEDIAN - Dig III Ortho</td>
<td>3.65</td>
<td>6.2</td>
<td>14</td>
<td>38.4</td>
<td>31.8</td>
</tr>
<tr>
<td>L MEDIAN - Palmar Ortho</td>
<td>2.50</td>
<td>11.0</td>
<td>8</td>
<td>32.0</td>
<td></td>
</tr>
<tr>
<td>L ULNAR - Dig V Ortho</td>
<td>2.90</td>
<td>3.8</td>
<td>14</td>
<td>48.3</td>
<td></td>
</tr>
<tr>
<td>L ULNAR - Palmar Ortho</td>
<td>1.90</td>
<td>6.8</td>
<td>8</td>
<td>42.1</td>
<td></td>
</tr>
<tr>
<td>L RADIUS - Thumb Antidr</td>
<td>2.20</td>
<td>29.8</td>
<td>10</td>
<td>45.5</td>
<td></td>
</tr>
<tr>
<td>L ABRACH C N FORE - Lateral Antidr</td>
<td>2.90</td>
<td>8.8</td>
<td>12</td>
<td>41.4</td>
<td></td>
</tr>
</tbody>
</table>

Motor NCS

<table>
<thead>
<tr>
<th>Nerve / Sites</th>
<th>Latency ms</th>
<th>Amp mV</th>
<th>Amp %</th>
<th>Distance cm</th>
<th>NCV m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>L MEDIAN - APB</td>
<td>4.20</td>
<td>9.5</td>
<td>100</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td>9.15</td>
<td>8.7</td>
<td>91.6</td>
<td>26</td>
<td>52.5</td>
</tr>
<tr>
<td>L ULNAR - ADM</td>
<td>2.90</td>
<td>8.1</td>
<td>100</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td>6.90</td>
<td>7.6</td>
<td>94.8</td>
<td>23</td>
<td>57.5</td>
</tr>
<tr>
<td>A. Elbow</td>
<td>8.75</td>
<td>7.5</td>
<td>92.5</td>
<td>8</td>
<td>42.2</td>
</tr>
<tr>
<td>L AXILLARY - Deltoid</td>
<td>3.95</td>
<td>2.1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erbs</td>
<td>3.20</td>
<td>8.6</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R AXILLARY - Deltoid</td>
<td>8.6</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L SUPRASCAP - Infrasp</td>
<td>4.1</td>
<td>2.4</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erbs</td>
<td>3.6</td>
<td>9.1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NCS Summary:

- L median sensory: prolonged latencies & slowed NCVs with preserved SNAP amplitudes
- L median motor: prolonged distal latency relative to ulnar latency with preserved CMAP amplitudes
- L ulnar motor: slowed across elbow NCV, normal latency, forearm NCV & CMAP amplitudes
- L axillary motor: 76% diminished CMAP amplitude relative to uninvolved side
- L suprascap motor: 74% diminished CMAP amplitude relative to contralateral side
- L ulnar, radial & lateral antebrachial cutaneous sensory nerves are normal
### EMG Summary:

- **L deltoid, infra/supraspinatus, rhomboids:** increased insertional activity, increased numbers of fibrillations & positive sharp waves, increased numbers of highly polyphasic motor units & reduced numbers of volitional motor units
- **L serratus anterior:** mildly increased insertional activity & numbers of positive sharp waves, mildly reduced numbers of motor units
- **All other left shoulder girdle, upper extremity muscles:** Normal
- **Cervical paraspinals not assessed due to surgery**

#### EMG Summary Table

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Spontaneous Activity</th>
<th>Motor Unit Analysis</th>
<th>Recruitment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insert Act</td>
<td>Fib</td>
<td>PSW</td>
</tr>
<tr>
<td>L. DELTOID</td>
<td>Increased</td>
<td>Few</td>
<td>2+</td>
</tr>
<tr>
<td>L. BICEPS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. TRICEPS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. FLEX CARPI RAD</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. EXT DIG COMM</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. EXT INDICIS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. FIRST D INTEROSS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. ABD POLL BREVIS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. INFRASPINATUS</td>
<td>Normal</td>
<td>Few</td>
<td>1+</td>
</tr>
<tr>
<td>L. SUPRASPINATUS</td>
<td>Increased</td>
<td>Few</td>
<td>2+</td>
</tr>
<tr>
<td>L. RHOMB MAJOR</td>
<td>Increased</td>
<td>None</td>
<td>1+</td>
</tr>
<tr>
<td>L. SERRATUS ANT</td>
<td>Increased</td>
<td>None</td>
<td>Few</td>
</tr>
<tr>
<td>L. TRAPEZIUS (Upper)</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
Case 3 Electrophysiologic Impression

- Axonal pathology affecting the left C5 > C6 nerve roots,
- Mild sensorimotor primarily demyelinating neuropathy affecting the left median nerve at or about the wrist (carpal tunnel),
- Mild primarily motor demyelinating neuropathy affecting the left ulnar nerve at or about the elbow,
- No electrophysiologic evidence of plexus pathology, although proximal nerve (axillary/suprascapular) pathology cannot be entirely ruled out
- No electrophysiologic evidence of underlying polyneuropathic or myopathic processes.
Case 3 Imaging

- CT
- Multilevel disc degeneration from C5-T1
  - No alteration of hardware placement
- Large disc protrusion at C4-5
  - Disc calcification
  - Central canal stenosis
  - High grade/severe left neuroforaminal stenosis with severe compromise of C5 nerve root
- Effacement of dural sac
- Increased signal intensity of spinal cord
Radiculopathy:

• Greek
  “radix” root
  “pathos” suffering or disease

• Any pathological condition of the nerve roots
• Epidemiology
  • Cervical 85 cases / 100,000 population Rare!
  • Lumbosacral 3000-5000 cases / 100,000 population
• Etiology
  • Mechanical compression
    • Disc prolapse
    • Bone spur
    • Other space occupying lesion i.e.. tumor, cyst, etc.
  • Other irritation
    • Vascular impairment i.e.. diabetes
    • Trauma i.e.. Stretch
    • Viral i.e.. shingles, etc.
Radiculopathy:

- Pathophysiology
- Dorsal root

- Generally compression occurs intraforaminal proximal to DRG
- Consequently preganglionic fibers are injured & postganglionic fibers are spared
- Normal SNAPs despite clinical sensation impairment
- Pain
- Proprioceptive & temperature changes

Sensory fiber compromise is the most common clinical presentation of radiculopathy (motor fiber compromise is the least common presentation)
Case 3 Pathophysiology

Radiculopathy:
• Pathophysiology
  • Ventral root
    • Compression of the ventral root can result in demyelination and/or axon loss
      • With axon loss Wallerian degeneration occurs resulting in abnormalities of insertional & spontaneous activity, MUAP morphology & recruitment
      • With demyelination there may be focal slowing and/or conduction block

• Needle EMG is the most sensitive electrodiagnostic test for radiculopathy
  • In LS radiculopathy needle EMG determines the involved root level, not the site of compression
  • Near nerve stimulation may show nerve root conduction slowing but is technically difficult
  • H reflex testing is sensitive for S1 (and C7??) nerve root compression
Case 3 Pathophysiology

- Pathophysiology
  - Radiculopathy breakdown:
    - C5: 2%
    - C5-6: 14%
    - C6: 11%
    - C6-7: 13%
    - C7: 23%
    - C7-8: 13%
    - C8: 7%
    - C8-T1: 10%
    - >2 Levels: 5%

Data adapted from Yoss RE et al. Significance of symptoms and signs in localization of involved root in cervical disc protrusion. Neurology 1957;7:673–683, with permission
Case 3 Pathophysiology

<table>
<thead>
<tr>
<th>Disk Herniation</th>
<th>Affected Root</th>
<th>Motor Test/Muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4-5</td>
<td>C5</td>
<td>Shoulder abduction/deltoid</td>
</tr>
<tr>
<td>C5-6</td>
<td>C6</td>
<td>Elbow flexion/biceps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radial wrist extension/extensor carpi radialis longus</td>
</tr>
<tr>
<td>C6-7</td>
<td>C7</td>
<td>Elbow extension/triceps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finger extension/extensor digitorum communis</td>
</tr>
<tr>
<td>C7-T1</td>
<td>C8</td>
<td>Finger flexion/flexor digitorum superficialis and profundus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hand intrinsics/interossei (&lt;T1)</td>
</tr>
<tr>
<td>T1-2</td>
<td>T1</td>
<td>Hand intrinsics/interossei</td>
</tr>
</tbody>
</table>

Diagnostic Concern | Diagnostic Clues
--- | ---
C5 versus rotator cuff tear | Intrinsic shoulder problems often are associated with shoulder motion that causes pain and decreased range of motion |
C6 or C7 versus carpal tunnel syndrome | Carpal tunnel syndrome is associated with nocturnal dysesthesias in the palmar aspect of the index through ring fingers, and may produce a positive Phalen test result and Tinel sign at the wrist |
C7 versus posterior interosseous nerve compression | The posterior interosseous nerve does not have a sensory component, C7 radiculopathy can cause a diminished or absent triceps reflex or weakness |
C8 versus anterior interosseous nerve compression | Anterior interosseous nerve entrapment does not cause sensory changes and may produce a positive pinch test in which the terminal phalanges of the thumb and index finger are hyperextended. |
C8 versus ulnar entrapment | Ulnar entrapment may produce a positive Phalen test result or Tinel sign at the elbow |
Case 3 Prognosis

Alternative Classification of Nerve Injury and Prognosis

<table>
<thead>
<tr>
<th>Severity</th>
<th>Type of Injury</th>
<th>Recovery</th>
<th>Time to Recover</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Mild</td>
<td>Mild Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mild</td>
<td>Advanced Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Moderate</td>
<td>Advanced Demyelination/Mild axon loss</td>
<td>Remyelination/Collateral Sprouts</td>
<td>2-6 months</td>
<td>Excellent</td>
</tr>
<tr>
<td>Severe</td>
<td>Moderate Axon Loss</td>
<td>Collateral Sprouts</td>
<td>2-6 months</td>
<td>Good</td>
</tr>
<tr>
<td>Profound</td>
<td>Severe Axon Loss</td>
<td>Collateral Sprouts/Axon Regen</td>
<td>up to 18 months</td>
<td>Guarded/Fair</td>
</tr>
<tr>
<td>Complete</td>
<td>Severed Nerve</td>
<td>Surgery required</td>
<td>Protracted</td>
<td>Guarded at Best</td>
</tr>
</tbody>
</table>

Based on this patient's EDX findings, can we assess prognosis?

- 74-76% CMAP amplitude decrement side to side is guarded/good indicator
  - But is condition still ongoing??

- But we are unsure what component of the STS amp difference may be due to conduction block vs. axon loss
- Proximity of target muscles to site of injury suggests better possibility of reinnervation & improvement
- Retesting in 4-6 month timeframe to assess reinnervation critical to establishing a long term prognosis
Case 4 History & Subjective Complaints

- Patient seen in clinic 7/26/17
- 68 year old male with complaints of left shoulder, arm & hand pain and paraesthesias, limited motion, weakness and functional loss
- He reports symptom onset in June 2017 (approx. 5 weeks):
  - Acute onset of severe shoulder/neck pain with no history of injury
    - Pain 80% subsided in 2-3 week timeframe after onset
  - Shoulder & arm weakness onset 1 week after pain onset
    - Atrophy noticeable over the last 1-2 weeks
- PMH:
  - Osteoarthritis
  - HTN
  - Hyperlipidemia
  - Low back & neck pain
  - Currently disabled
  - Recreational user of alcohol & “other drugs”, smokes > 1 pack/day

Referred for electrodiagnostic testing by orthopedic surgery PA to assess potential causes of atrophy
Case 4 Clarifying Examination

• Observation
  • 5’8”, 175#
  • Atrophy of left shoulder girdle muscles, deltoid, supra/infraspinatus, biceps, pectorals, forearm mm
  • Left scapular winging
  • Altered posture
  • Uses waistband/belt of trousers to support arm
  • Skin intact
Case 4 Clarifying Examination

- Range of motion
  - Severely restricted/painful left shoulder actively:
    - Restricted passively all directions, guarded/painful
    - Cervical ROM limited
    - Essentially normal for age otherwise
- Strength
  - Normal for age throughout except:
    - Unable to assess left shoulder due to patient guarding/pain
    - Left elbow flx 4-/5, forearm supination 4-/5
    - Left otherwise 4+/5 in wrist/hand
    - Right UE 5/5
- No imaging or other diagnostic studies to the point
- Neurological
  - MSRs 1+ and symmetrical except absent left biceps/brachioradialis
  - Intact light touch sensation
  - No clonus or spasticity
- Provocative tests
  - Negative: L. Phalen’s, Tinel’s at wrist and elbow

Discuss Clinical Findings and Differential Diagnosis
### Case 4 EDX Examination

**NCS Summary:**

- **L sup radial sensory:** diminished amplitude with normal latency/NCV
- **L LABC sensory:** diminished amplitude with normal latency/NCV
- **L axillary motor:** 74% diminished CMAP amplitude relative to uninvolved side
- **L suprascap motor:** 58% diminished CMAP amplitude relative to contralateral side
- **L ulnar, median sensory nerves are normal**
- **L ulnar, median motor nerves are normal**

#### Table: Nerve Conduction Studies (NCS)

<table>
<thead>
<tr>
<th>Nerve / Sites</th>
<th>Latency (ms)</th>
<th>Amp (μV)</th>
<th>Distance (cm)</th>
<th>NCV (m/s)</th>
<th>Temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L MEDIAN - Dig III Ortho</strong></td>
<td>3.45</td>
<td>8.3</td>
<td>14</td>
<td>40.6</td>
<td>32.2</td>
</tr>
<tr>
<td>Dig III</td>
<td>2.05</td>
<td>11.0</td>
<td>8</td>
<td>39.0</td>
<td></td>
</tr>
<tr>
<td><strong>L MEDIAN - Palmar Ortho</strong></td>
<td>3.60</td>
<td>7.1</td>
<td>14</td>
<td>38.9</td>
<td></td>
</tr>
<tr>
<td><strong>L ULNAR - Dig V Ortho</strong></td>
<td>2.35</td>
<td>8.6</td>
<td>10</td>
<td>42.6</td>
<td></td>
</tr>
<tr>
<td><strong>L RADIAL - Thumb</strong></td>
<td>2.20</td>
<td>22.4</td>
<td>10</td>
<td>45.5</td>
<td></td>
</tr>
<tr>
<td><strong>R RADIAL - Thumb</strong></td>
<td>2.95</td>
<td>1.1</td>
<td>14</td>
<td>47.5</td>
<td></td>
</tr>
<tr>
<td><strong>L vs R ABRACH C N FORE - Lateral</strong></td>
<td>2.90</td>
<td>1.0</td>
<td>14</td>
<td>45.9</td>
<td></td>
</tr>
</tbody>
</table>

#### Table: Motor Conduction Studies (MCS)

<table>
<thead>
<tr>
<th>Nerve / Sites</th>
<th>Latency (ms)</th>
<th>Amp (mV)</th>
<th>Amp (%)</th>
<th>Distance (cm)</th>
<th>NCV (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L MEDIAN - APB</strong></td>
<td>3.80</td>
<td>6.5</td>
<td>100</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td>9.25</td>
<td>6.1</td>
<td>94.5</td>
<td>30</td>
<td>55.0</td>
</tr>
<tr>
<td><strong>L ULNAR - ADM</strong></td>
<td>3.05</td>
<td>7.4</td>
<td>100</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td>7.60</td>
<td>6.7</td>
<td>90.3</td>
<td>24</td>
<td>52.7</td>
</tr>
<tr>
<td>B. Elbow</td>
<td>9.15</td>
<td>6.6</td>
<td>90.2</td>
<td>8</td>
<td>51.6</td>
</tr>
<tr>
<td>A. Elbow</td>
<td>2.50</td>
<td>1.5</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R AXILLARY - Deltoid</strong></td>
<td>3.10</td>
<td>5.7</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erbs</td>
<td>3.55</td>
<td>2.1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>L SUPRASCAP - Infra</strong></td>
<td>3.25</td>
<td>5.0</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erbs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R SUPRASCAP - Infra</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Case 4 EDX Examination

## EMG Summary:

- **L. DELTOID**: Increased insertional activity, increased numbers of fibrillations & positive sharp waves, and reduced numbers of volitional motor units.
- **L. SUPRASPINATUS**: Increased insertional activity, increased numbers of fibrillations & positive sharp waves, and reduced numbers of volitional motor units.
- **L. INFRASPINATUS**: Increased insertional activity, increased numbers of fibrillations & positive sharp waves, and reduced numbers of volitional motor units.
- **L. TRICEPS**: Normal.
- **L. BICEPS**: Increased insertional activity, increased numbers of fibrillations & positive sharp waves, and reduced numbers of volitional motor units.
- **L. FLEX CARPI RAD**: Normal.
- **L. EXT INDICIS**: Increased insertional activity, normal numbers of fibrillations & positive sharp waves, and normal numbers of volitional motor units.
- **L. FIRST D INTEROSS**: Normal.
- **L. FLEX POLL LONG**: Increased insertional activity, normal numbers of fibrillations & positive sharp waves, and normal numbers of volitional motor units.
- **L. ABD POLL BREVIS**: Normal.
- **L. CERV PSPINAL (M)**: Increased insertional activity, normal numbers of fibrillations & positive sharp waves, and normal numbers of volitional motor units.
- **L. CERV PSPINAL (L)**: Normal.

### EMG Summary Table

<table>
<thead>
<tr>
<th>EMG Summary Table</th>
<th>Insert Act</th>
<th>Spontaneous Activity</th>
<th>Motor Unit Analysis</th>
<th>Recruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insert Act</td>
<td>Fib</td>
<td>PSW</td>
<td>Fasc</td>
</tr>
<tr>
<td>L. DELTOID</td>
<td>Increased</td>
<td>1+</td>
<td>2+</td>
<td>None</td>
</tr>
<tr>
<td>L. SUPRASPINATUS</td>
<td>Increased</td>
<td>1+</td>
<td>2+</td>
<td>None</td>
</tr>
<tr>
<td>L. INFRASPINATUS</td>
<td>Increased</td>
<td>1+</td>
<td>3+</td>
<td>None</td>
</tr>
<tr>
<td>L. TRICEPS</td>
<td>Increased</td>
<td>None</td>
<td>Few</td>
<td>None</td>
</tr>
<tr>
<td>L. BICEPS</td>
<td>Increased</td>
<td>1+</td>
<td>2+</td>
<td>None</td>
</tr>
<tr>
<td>L. FLEX CARPI RAD</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. EXT INDICIS</td>
<td>Increased</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. FIRST D INTEROSS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. FLEX POLL LONG</td>
<td>Increased</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. ABD POLL BREVIS</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>L. CERV PSPINAL (M)</td>
<td>Increased</td>
<td>None</td>
<td>1+</td>
<td>None</td>
</tr>
<tr>
<td>L. CERV PSPINAL (L)</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
Case 4 Electrophysiologic Impression

- Today’s findings are complex. There is evidence of multiple nerve root involvement (pre ganglionic) on the left involving the C5-C8 nerve root levels including mid cervical paraspinals. Additionally there is evidence of plexus/more peripheral involvement (post ganglionic) involving the left upper & middle trunks. When evaluated within the context of this patient's rapid symptom onset of severe pain followed by muscle weakness & atrophy, the findings may be suggestive of an acute brachial neuritis with involvement of the nerve roots on the left. Suggest follow up examination in 4-6 months to evaluate neural reinnervation.
- No electrophysiologic evidence of underlying polyneuropathic or myopathic processes.
Case 4 Pathophysiology

- Brachial amyotrophy
- Brachial neuritis
- Neuralgic amyotrophy
- Cervical radiculoplexus neuropathy
- Diabetic amyotrophy
- Shoulder Girdle Syndrome
  aka Parsonage Turner Syndrome

- **Epidemiology:**
  - 1.6-4 cases per 100,000
  - Male:Female 3:2
  - Peak incidence 3-4 decade
  - 30% of cases are bilateral with subclinical involvement on 1 side
**Case 4 Pathophysiology**

- **Etiology**
  - Idiopathic, but generally accepted as an immune mediated process
    - Mononuclear inflammatory infiltrate & complement fixing antibodies to myelin on biopsy/histopathology
  - Hereditary (rare)
    - Septin 9 gene on chromosome 17q25
  - Precipitating factors
    - Viral infection
    - Immunization
    - Strenuous exercise
    - Surgery
Case 4 Differential Diagnosis

- Cervical radiculopathy
- Brachial plexopathy
- Other mononeuritis

- Rotator cuff tear

- Differentiation:
  - Clinical exam
  - Electrodiagnosis
  - Imaging
  - Neuromuscular ultrasound
  - Surgical pathology
### Electrodiagnostic Utility / Treatment

**Sensory NCS**
- MABC 17%
- LABC 15%
- Sup Rad 12%
- All others <10%

**Motor NCS**
- Diminished CMAP amp
- Must assess atrophic or clinical weak muscles

**Needle EMG**
- Suprascapular 31%
- Axillary 26%
- Musculocutaneous 14%
- Long thoracic 9%
- Paraspinal 0/40 cases

van Alfen et al. (2009)

**Treatment**
- Steroids
- NSAIDS
- IVIg
- Anti ganglioside antibodies
- Physical therapy

van Alfen et al, Moriguchi et al, Johnson et al, all report anecdotal evidence that early (<1 month from onset of symptoms) steroid/prednisone treatment & IVIg significantly improve outcomes

**Cruz-Martínex et al. (2002)**

van Alfen et al. (2006)

- PIN 24%
- AIN 18%
- Axillary 13%
- Radial 11%
- Pan plexus 11%
- Ulnar 8%
- Median 5%
- Suprascapular 5%
- Musculocutaneous 5%

Milner et al. (2016)
**Case 3 Prognosis**

Alternative Classification of Nerve Injury and Prognosis

<table>
<thead>
<tr>
<th>Severity</th>
<th>Type of Injury</th>
<th>Recovery</th>
<th>Time to Recover</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Mild</td>
<td>Mild Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mild</td>
<td>Advanced Demyelination</td>
<td>Remyelination</td>
<td>2-12 weeks</td>
<td>Excellent</td>
</tr>
<tr>
<td>Moderate</td>
<td>Advanced Demyelination/Mild axon loss</td>
<td>Remyelination/Collateral Sprouts</td>
<td>2-6 months</td>
<td>Excellent</td>
</tr>
<tr>
<td>Severe</td>
<td>Moderate Axon Loss</td>
<td>Collateral Sprouts</td>
<td>2-6 months</td>
<td>Good</td>
</tr>
<tr>
<td>Profound</td>
<td>Severe Axon Loss</td>
<td>Collateral Spouts/Axon Regen</td>
<td>up to 18 months</td>
<td>Guarded/Fair</td>
</tr>
<tr>
<td>Complete</td>
<td>Severed Nerve</td>
<td>Surgery required</td>
<td>Protracted</td>
<td>Guarded at Best</td>
</tr>
</tbody>
</table>

- Based on this patient's EDX findings, can we assess prognosis?
  - 58-74% CMAP amplitude decrement side to side is guarded/good indicator
  - Proximity of target muscles to site of injury suggests better possibility of reinnervation & improvement for more proximal muscles
  - Retesting in 4-6 month timeframe to assess reinnervation critical to establishing a long term prognosis
Questions?

Thank You!