

# Nerve Conduction Study[NCS] -n- Needle Electromyography [EMG]

## ENTRAPMENT NEUROPATHY UE

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- ## Objectives
- General Knowledge
    - Components to the Electrophysiological Report
    - Purpose of NCS and needle EMG
    - Test Procedures
  - Synthesis
    - Understand typical findings
    - Pathology for common upper limb presentations
  - Case Reviews

# EDX Report COMPONENTS

## EDX Report

**Chief Complaint (s)** Patient is a 35-year-old RHD male who reports on 5/15/2013 was injured at work after his left elbow got stuck in a machine pulling his arm away from his body. Since this time, he reports ongoing left shoulder and elbow discomfort as well as numbness and tingling into the distal fingertips D4-5+D3 aggravated when he attempts to lift objects. He is now 3 months following this reported event. He underwent a prior EMG/NCV a few weeks after the accident which demonstrated normal findings.

**Medical History** Past Medical History: None. Past Surgical History: None. Allergies: NKDA. Medications: Baclofen, hydrocodone, Zolpidem, Meloxicam, and Cymbalta. Family History: He has no family history disease. Social History: He is a truck driver. He is married, with 2 children. He does not drink. Non-smoker.

**Evaluation** Observation: no atypical pain posturing noted within the upper limbs without guarding of the limb. Pain: reports mild left shoulder discomfort at "2 out of 10" mainly within the shoulder joint itself. Reports mild medial elbow discomfort on the left at "7 out of 10." Motor: good strength in bilateral C5-T1 myotomes; no visible wasting/atrophy within the arm and shoulder girdle musculature. Sensation: reduced light touch sensibility into D4-5 on the left; otherwise, intact C5-T1 dermatomes. No abnormalities within the MAC distribution and DUC distribution. Reflexes: 2+ and symmetric C5 (biceps), C6 (BR), and C7 (triceps) bilaterally. Special Tests: Cervical Spine: - Quadrant test Rt/L, - Spurling's Rt/L, - Adson Rt/L, - Phalen's Rt/L, Tinel's: + Ulnar Tinel's Lt elbow, mild Lt supraclavicular fossa.

**Reason for Referral** LUE NCV/EMG for Ulnar Tunnel Lt elbow vs Brachial Plexopathy.

### Nerve Conduction Velocity [NCV] Findings

Sensory Nerves		Site	NR	Peak (mV)	Norm Peak (mV)	P-T Amp (µV)	Norm Amp (µV)	Segment Name	Delta-P (ms)	Dist (cm)	Vel (m/s)	Norm Vel (m/s)	
Palm		1.04		17.21				Wrist-3rd Digit	4.50	14	31.11	>38	
Wrist		4.50	<-3.6	26.05		>18.0		Wrist-Palm	2.56	23	58.82	>48	
Elbow		8.61		22.76				Elbow-Wrist	3.91	14	45.31	>38	
Palm		1.01		45.30				Wrist-5th Digit	2.09	19	75.10	>50	
Wrist		3.09	<-3.7	37.15		>15.0		Wrist-Palm	1.19	19	63.38	>50	
BE		5.03		23.83				BE-Wrist	2.53	13.5			
AE		7.75		16.50				AE-BE	2.13	11.5			
Motor Nerves		Site	NR	Onset (ms)	Norm Onset (ms)	O-P Amp (mV)	Norm Amp (mV)	Seg Dur (ms)	Segment Name	Delta-O (ms)	Dist (cm)	Vel (m/s)	Norm Vel (m/s)
Palm		1.40		8.55				7.03	Wrist-Palm	3.28	20.5	51.51	
Wrist		4.77	>4.2	8.12		>5.0		6.48	Elbow-Wrist	3.08	20.5	51.51	
Elbow		8.75		7.53				6.72					
Wrist		3.52	<-3.7	12.93		>3.0		5.39	BE-Wrist	2.89	19	65.74	
R Elbow		6.41		11.78				5.78	AE-BE	2.03	15.5	76.35	
A Elbow		8.44		11.36				5.86	Wrist FDI-Wrist	1.25			
F Wave/HisReflex		NR	Lat1 (ms)	Lat2 (ms)	Delta (ms)	Amp (µV)							
Right Ulnar-F (ADM)			3.18	26.04	22.86								

### Electromyographic [EMG] Findings

Side	Muscle	Nerve	Root	Ins Act	Fibs	Paw	Amp	Dur	Poly	Recrt	Int Pat	Comment
Right	Abd Psoil Brv	Median	C6-T1	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	ABD Digt/Main	Ulnar	C6-T1	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	FlexDig/Prof	Ulnar	C6-T1	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	FlexCar/Rad	Median	C6-T7	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	ExtInd/Mdn	Radial (Post Int)	C7-8	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	BrachioRad	Radial	C5-6	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	Triceps	Radial	C6-7-8	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	Deltoid	Axillary	C5-6	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	
Right	Parasp	Rami	C5-6	Nil	Nil	Nil	Nil	0	Nil	Nil	Nil	

## Summary of Findings

**Summary of EMG & NCV Findings:** Evaluation of the Left Ulnar Motor nerve showed decreased conduction velocity (AE-BE, 43 m/s), decreased conduction velocity (ME-BE, 37 m/s), and decreased conduction velocity (AE FDI-BE FDI, 43 m/s). The Left Ulnar Anti Sensory nerve showed prolonged distal peak latency (Palm, 2.6 ms, Wrist, 4.2 ms), reduced amplitude (Wrist, 4.3 µV, Palm 4.6 µV). All remaining nerves (as indicated in the following tables) were within normal limits. All F Wave latencies were within normal limits. Needle evaluation of the Left 1stDorInt muscle showed increased motor unit duration, moderately increased polyphasic potentials, and 75% IP. All remaining muscles (as indicated in the following table) showed no evidence of electrical instability.

## Electrophysiological Conclusion(s)

**Electrophysiological Conclusion(s):** (Limited study as per reason for referral). Electrophysiological findings reveal

- Low moderate left ulnar motor and sensory changes across the elbow with features c/w focal demyelinating process and axonometric changes. There is evidence of reinnervation within the FDI.
- No evidence of left-sided C5-T1 radiculopathic or plexopathic changes.
- Normal left median motor and sensory findings across the wrist.
- Clinical correlation is suggested.

# CLINICAL ASSESSMENT

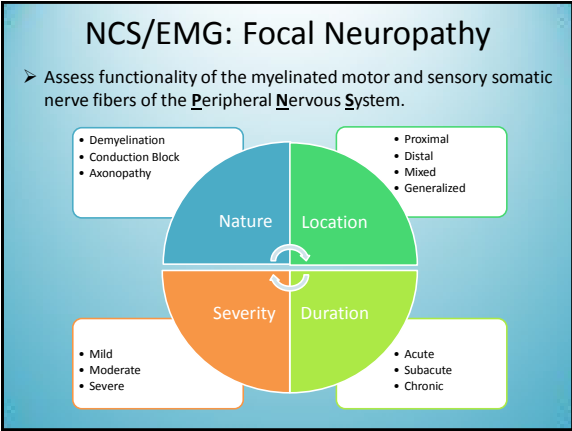
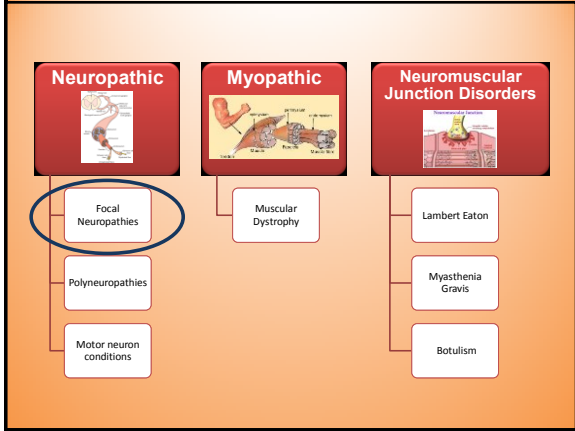
## History and Clinical Evaluation

- History
- Clinical Evaluation and Neurologic Evaluation
  - Motor (myotome vs peripheral nerve pattern)
  - Sensory (dermatome vs peripheral nerve pattern)
  - Reflexes

**Sensory Exam**

Kosin S, Kothari M. Evaluating the patient with peripheral nervous system complaints. JGIM 105(2);2008.71-83

# EDX TESTING PURPOSE

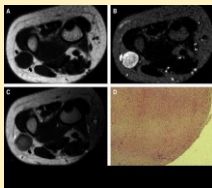


➤ Prognostic Aide

➤ *Complements* clinical assessment and other test findings (e.g. MRI)

Consider within your differential

1. Pre-existing or co-existing etiologies
2. Non-neural factors
3. Atypical presentations
4. Intrinsic vs Extrinsic Mediators



**NCS/EMG FINDINGS**

≠

**“CAUSATION”**

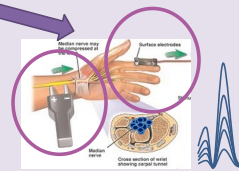
ULNAR	LMN
Paralysis: movement alterations	Paralysis: weakness muscle(s)
Atrophy: none or slight except if severe chronic lesion	Atrophy: evidenced
Tone: hypertonicity, spasticity	Tone: hypotonic, flaccid
MSR's: ↑, clonus	MSR's ↓ or absent
Superficial Reflexes diminished or modified	Superficial reflexes often unaltered
Abdominal reflex absent	
Babinski sign positive; inc jaw jerk	

**Nerve Conduction Study [NCS] Technique**

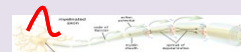
Typical Findings and Pathology

**NCS Technique**

- A supramaximal electrical stimulus is applied to the nerve at key sites (Palm, Wrist, Elbow, Axilla, etc.)



- A wave of depolarization (ionic discharge) travels along the nerve activating the sensory & motor fibers supplied by that nerve



- The desired response is recorded with special electrodes.

– As shown, the bar electrode D2

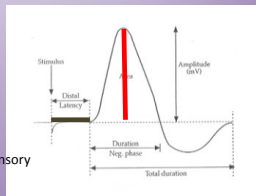
**NCS Measures**

- Tabular Data are organized by nerve, site of stimulation, distance between segments, and normative values

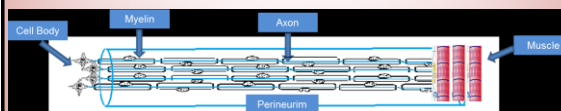
Site	NR	Peak (ms)	Norm Peak (ms)	O-P Amp (µV)	Norm O-P Amp	Neg Dur (ms)	Neg Area (µV.ms)	Site1	Site2	Delta-P (ms)	Dist (cm)	Vel (m/s)	Norm Vel (m/s)
Left Median Anti Sensory (3rd D)								Wrist	3rd Digt	3.5	14.0	40	>38
Wrist		3.5	<3.6	27.0	>10	1.75	24.29	Wrist	Palm	1.7	7.0	41	
Elbow		8.1		13.1		1.69	12.59	Elbow	Wrist	4.6	25.5	55	>48

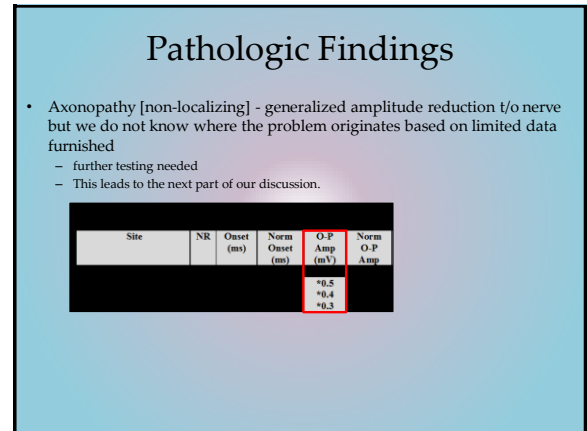
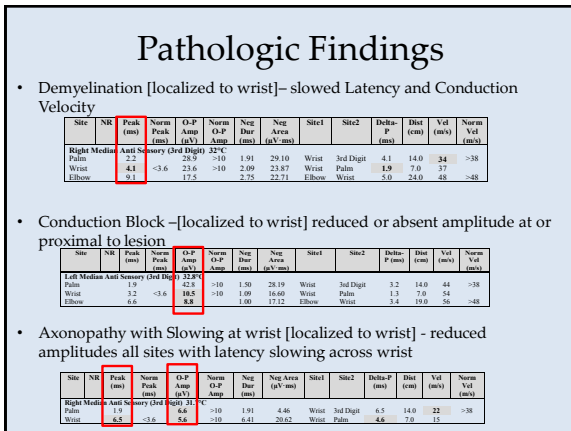
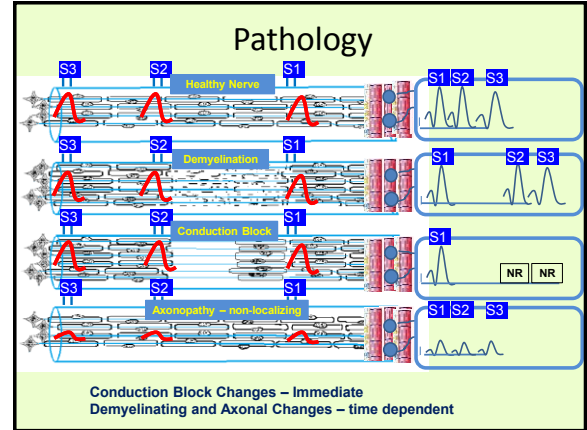
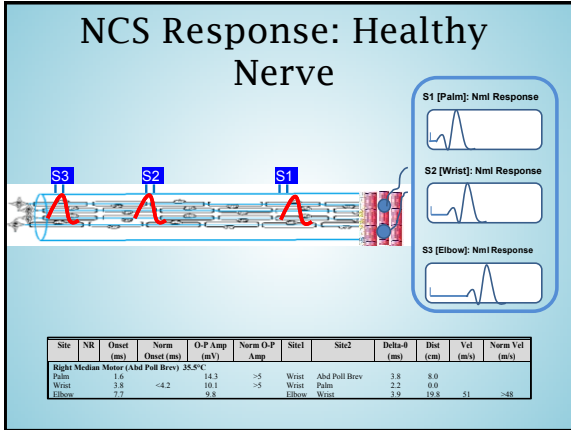
- Waveform parameters include:

- Latency (ms) – time from stimulus to wave onset or peak (x-axis)
- Conduction Velocity (m/sec) – the latency factored by distance between segments
- Amplitude (mV or microV) – strength of sensory or motor response to the supramaximal stimulus (y-axis)



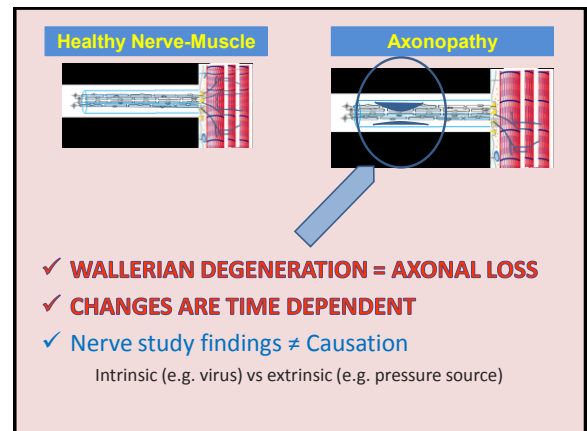
**Focal Neuropathy: Value of NCS Findings**





## Electromyography Technique

### Normal vs Pathologic Findings



### EMG Changes Correlate to Axonal Timeline

3-4 Weeks Muscle Membrane Instability

3-4 Months Collateral Sprouts

9-12 Months Maturation

1 inch/month Axonal Regrowth

### EMG: TYPICAL TABLE OF FINDINGS

Side	Muscle	Nerve	Root	Ins Act	Fibs	Paw	Amp	Dur	Poly	Reprt	Int Pat	Comment
Right	Abd Flex Brv	Median	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	ABD DigMinimi	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	FlexDigProf	Ulnar	C8, T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	FlexCarRad	Median	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	ExtIndicis	Radial (Post lat)	C7-8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	BrachioRad	Radial	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Triceps	Radial	C6-T8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Debroid	Axillary	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Parasp	Rami	C5	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	

### EMG Assessment: Abnormal Findings

**NORMAL STATE**

Rest

Voluntary Contraction

Side	Muscle	Nerve	Root	Ins Act	Fibs	Paw	Amp	Dur	Poly	Reprt	Int Pat	Comment
Right	Abd Flex Brv	Median	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	ABD DigMinimi	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	FlexDigProf	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	FlexCarRad	Median	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	ExtIndicis	Radial (Post lat)	C7-8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	BrachioRad	Radial	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Triceps	Radial	C6-T8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Debroid	Axillary	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Parasp	Rami	C5	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	

### EMG Approach

- So far we discussed
  - EMG to define Severity and Duration of axonal pathology
  - NCS
    - Localizing: demyelination and conduction block
    - Non-localizing: axonopathy
- How do we determine the lesion site when there are axonal loss changes?
  - By performing needle EMG into muscles distal to the lesion and then proximal. Then assure non-affected nerves follow a normal pattern
  - Remember muscles innervated *downstream* [distal] from site of nerve injury show abnormalities
- Lets look at an example

### EMG Localization

Particularly useful for AIN and PIN palsies

**Pronator Teres Entrapment: AIN**

- Map potential abnormalities at/distal to compression site?
  - Assess PQ, FPL, FDP (median)
- Define normal muscles?
  - PT, FCR
  - Check Ulnar FDI, radial EIP
  - C8 multifidus
  - Check rostral/caudal areas

Source: Netter

### Brachial Plexopathy vs Cervical Radiculopathy

Pathology and Localization of the Problem

### NCS Technique

- A supramaximal electrical stimulus is applied to the nerve at key sites
- A wave of depolarization (ionic discharge) travels along the nerve activating the sensory & motor fibers supplied by that nerve
- The desired response is recorded with special electrodes
  - As shown, deltoid recording

### Pre and post-ganglionic lesions

- Recall: Wallerian degeneration, the axon dies back towards lesion
  - Lesion proximal to cell body = preserved stimulated response
  - Lesion distal to cell body = abnormal response
- Avulsion: proximal to sensory cell body (Preserved SNAP), distal to the motor cell body (Abnormal MAP)
- Rupture: distal both sensory and motor cell bodies (Abnormal SNAP and MAP)

	Preganglionic	Postganglionic
Location	Proximal to DRG	Distal to DRG
Preservation	SNAPs	
Abnormalities	MAPs	SNAPs & MAPs

### Peripheral Nerve: Basics

**Motor Nerve**

**Motor Study**  
Robust signals (mV)  
Assess Responses to the arm

**Sensory Nerve**

**Sensory Study**  
Small signals (microV)  
Assess Distal responses

### Preganglionic Axonopathy

**Partial Axonopathy**

**Complete Axonopathy**

### Postganglionic Axonopathy

**Partial Axonopathy**

**Complete Axonopathy**

### NCS Delineation of Pre vs Postganglionic Lesion

*Key: recording sites delineate which file*

**C5 Root vs Upper Plexus**

- Motor Study: Axillary Nn, Musculocutaneous, Suprascapular
- Sensory Study: LAC

**C6 Root vs Upper Plexus**

- Motor Study: as above
- Sensory Study: LAC, Median D1

**C7 Root vs Mid Plexus**

- Motor Study: Radial
- Sensory Study: Radial, Median D3
- Median H-reflex off FCR

**C8, T1 Root vs Lower Plexus**

- Motor Study: Median APE, Ulnar
- Sensory: Ulnar D5, MAC

## Electromyography Technique Normal vs Pathologic Findings

## EMG TABLE OF FINDINGS

Look over the table and lets review key findings

1. Significant EMG change seen in all muscles at rest but less in the neck
2. No evidence of volitional motor unit activity in the C5-T1 ventral motor fibers from hand to root
3. Severe postganglionic > preganglionic changes C5-C7 and pre/post-ganglionic changes C8-T1

## Brachial Plexopathies

- NCS testing
  - We perform motor and sensory testing C5-T1 to
    - Evaluate sensory and motor amplitude changes for pre and post ganglionic changes
    - Evaluate focal changes along nerve (demyelination and conduction block)
- Needle evaluation: sensitive measure for detecting axonopathy and further evaluates extent of pathology
  - Recall: Axonopathic changes occur within muscle supplied by a nerve just distal to the site of the lesion
  - Needle Sampling Approach
    - Sample distal and proximal along nerve to delineate normal vs abnormal findings
    - Sample other nerves in distal and proximal

## NCS: Considerations

- Temperature: cool hand = decreased latency, increased amplitude
- Age: <5 and >65-70 = decreased latency, decreased amplitude
- Anomalies: Martin Gruber, Riche Cannei', Pre vs post fixed plexus
- Time from reported onset
- Height – adjust with certain parts of test
- Concurrent Issues – consider multiple overlapping issues (CTS vs C6-7 radiculopathy/plexopathy, CTS with underlying poly)

## Case Reviews

## Publications on Testing Methodology

- Carpal Tunnel Syndrome<sup>1, 6-9</sup>
  - Median sensory and motor NCSs are valid and reproducible clinical laboratory studies.
  - Confirm a clinical diagnosis of CTS with a high degree of sensitivity (>85%) and specificity (>95%).
- Cubital Tunnel Syndrome<sup>2, 6-9</sup>
  - Guidelines for testing proposed. Optimal elbow position (70-90 deg) and stimulus site recommendations
  - Sensitivity and specificity studies needed
  - Operator rigor and experience critical.
- Radial Sensory, Ulnar Tunnel, Anterior and Posterior Interosseous Neuropathies<sup>6-9</sup>
  - Guidelines for testing proposed
  - Sensitivity and specificity studies needed
  - Operator rigor and experience critical

## Publications on Testing Methodology

- Brachial Plexopathies<sup>5</sup>
  - Overview of testing methodologies and sensitivities for detection
- Cervical Radiculopathies<sup>2</sup>
  - Minimal needle sampling 5-6 muscles + Para spinals for localization
- Mononeuropathies
  - Testing techniques published with normal values and recommendations for standardization. Sensitivity and specificity studies lacking<sup>6-9</sup>

## Normal Values: Sensory NCS

Nerve	Recdg	Site	Dist (cm)	Peak Lat (msec)	O-P Amp	Normal CV	Other
Median	Digit 2 or D3	Wrist	W	<3.8		>38	1. W-P transcarpal lat <17 ms @ 7-cm distance
		Elbow	n/a			>48	2. W-P no >50% reduction
		BE					3. Side-to-side no >50% difference for all test sites
		AE					4. <3.0 ms if using onset
Med-Ulnar	D4	wrist	W	<3.6			1. No >0.5 msec diff difference
Med-Radial	D1	wrist/forearm	W	<3.6			1. No >0.5 msec diff difference
Ulnar	D5	Wrist	W	<3.7		>38	1. Med SCL to Uln SCL no >5
		BE				>48	2. W-P transcarpal lat <17 ms @ 7-cm distance
	AE					>50	3. W to P no >50% reduction
DULC	4th web	EUC	W	CS 2 (peak)	SmedV (p to p)	~46	4. <3.0 ms if using onset
							5. Side to side amp no >50% difference
LAC	4th web	EUC	W	CS 2 (peak)	SmedV (p to p)	~46	1. Amp no >50% reduction side to side
LAC	Lat Fm	A/m	W	CS 2 (peak)	SmedV (p to p)	~46	1. A SNAP amp >50% is significant
MAC	Mid Fm	Scm up from Cubital Crease	W		10microV	~45	1. A SNAP amp >50% is significant
Sap-Nadial	D1	Lat Forearm	W			>38	1. Amp are greater with recording using no-over EPL vs Thumb
		EPL	Dorsal radius	W		~40	

## Normal Values: Motor NCS

Nerve	Recording	Site	Dist	Onset Lat (msec)	Amp (mV)	Normal CV	Other	
Median	APB	Wrist	Scm	<4.0 to 4.5 ms	5.00	n/a	1. MDL (p to l) or central ulnar no >10 msec New Wrist to palm <2.2 msec	
		Elbow				>45 (spike use 50)		
		Forearm				>50		
		End				>50		
	2nd web space	Wrist	Scm				1. Actixs upper and lower trunks <12 or 13 msec for rim latency 2. Wrist to interosseus comparison. Diff <0.5 s insignificant	
Ulnar	ADM (ADD)	Wrist	Scm	3.00	<3.8	3.00	1. MDL to ADM no >10msec than MDL to APB 2. MDL to ADM no >20msec than MDL to FDI 3. Anterior tibial no	
		BE				50	1. Greater 20% amp reduction with BE and AE is significant	
		AE					2. Change in morphology may be significant	
		AE					3. A >5m/sec reduction compared to forearm segment is abnormal. Some use <6m/sec side to side or compared to region	
	ADBB					>55		
FDI	Wrist				>50	1. Actixs upper and lower trunks <12 or 13 msec for rim latency 2. No >6ms compared to ADM value		
Axillary	Delta 0	Elb's			<4.9		>20% side to side	
Suprascapular	Suprascapular (axillary)	Elb's				<3.7	1. Actixs upper and lower trunks <12 or 13 msec for rim latency	
			Elb's (axillary)				<4.3	
Radial	EP	Fm	4.5cm			<2.5		
		AE					>50	
		AE					>50	
		ED's					>50	

## References

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5. Ferrante MA. Electrodiagnostic assessment of the brachial plexus. Neurol Clin 2012(30):551-580<sup>6-9</sup>

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6. Dumitru D, Amato A, Zwarts M. Electrodiagnostic Medicine 2<sup>nd</sup> Ed. Hanley and Belfus, Philadelphia 2002
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