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ELECTROMYOGRAPHY (EMG), ELECTROENCEPHALOGRAPHY (EEG), AND NEUROPHYSIOLOGY IN CLINICAL PRACTICE

February 19-25, 2023
Ritz-Carlton Amelia Island
Amelia Island, FL

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ULNAR NEUROPATHY

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OBJECTIVES

- Review ulnar nerve anatomy in order to recognize common sites of compression
- Learn an electrodiagnostic approach for suspected ulnar neuropathy
- Understand the role of NM ultrasound as an adjunctive tool in ulnar neuropathy
- Increase awareness regarding management options for ulnar neuropathy at the elbow

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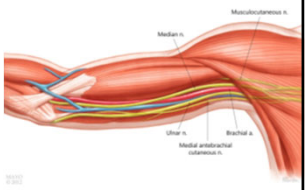
ULNAR NEUROPATHY

- Panas first described 1878
  - Called "tardy" ulnar palsy as it occurred long after an elbow injury and subsequent arthritic changes
- Ulnar neuropathy at the elbow (UNE) is the *second most common* entrapment neuropathy
  - Less commonly, compressed at wrist, upper arm, or forearm (rare)
  - Incidence 25 cases per 100,000 for UNE
- Must review and comprehend ulnar anatomy
  - To understand why (and how) UN occurs
  - To appropriately apply nerve conduction studies (NCS) and needle examination (EMG)

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ULNAR NERVE ANATOMY: ROOTS AND PLEXUS

- Originates from the C8, T1 roots
- Travels in brachial plexus
  - Lower trunk
  - Medial cord
  - (Some C7, middle trunk, lateral cord)
- Nerve itself branches off medial cord in axilla
  - *Essentially, a continuation of the medial cord*



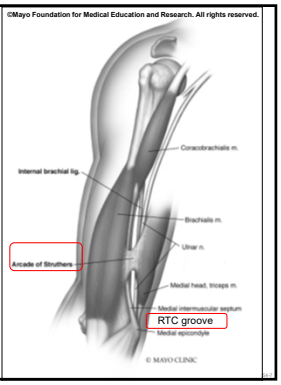
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ULNAR NERVE ANATOMY: ARM

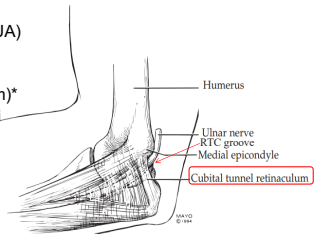
- Travels with neurovascular bundle (median nerve and brachial artery) in medial arm
- Midway in arm, pierces intermuscular septum to lie on medial head of triceps (Arcade of Struthers)
  - Arcade present in 15-70% cadavers
  - 7-8 cm prox to medial epicondyle (ME)
- *No muscular branches in arm*
- Passes around posterior ME into retroepicondylar (RTC) groove
  - Formed by ME and olecranon

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ULNAR NERVE ANATOMY: FOREARM

- Ulnar nerve emerges from groove, passes under humeroulnar aponeurotic arcade (HUA) aka cubital retinaculum
  - "Cubital tunnel"
  - 3-35 mm distal to ME (usually 10-15 mm)*
  - Dives between two heads of flexor carpi ulnaris (FCU)
- Ulnar nerve largest here

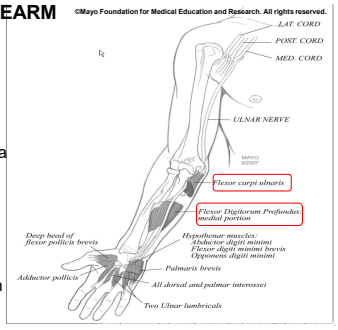


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ULNAR NERVE ANATOMY: FOREARM

- Gives branch to FCU at or *proximal* to HUA
  - Branch to flexor digitorum profundus (FDP) more distal
  - Nerve continues *within* FCU
  - Exits 4-6 cm distal to the ME through a deep flexor-pronator aponeurosis
- Gives off dorsal ulnar cutaneous 5-8 cm **proximal** to wrist
  - Sensory innervation for dorsal 4th and 5th digits to level of wrist
- At ulnar styloid, palmar cutaneous branch

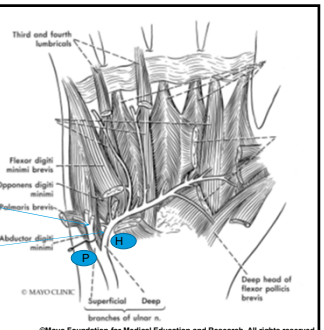
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ULNAR NERVE ANATOMY: WRIST

- With ulnar artery, travels through Guyon's Canal at wrist
  - Formed by pisiform and hamate
  - Divides into 2 branches

1. Superficial branch
   - Sensory to 5th digit & ulnar aspect 4th digit
   - Palmaris brevis
2. Deep branch
   - All other ulnar muscles in hand



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ULNAR NEUROPATHY: CAUSES AND FINDINGS

ULNAR NERVE MECHANICS

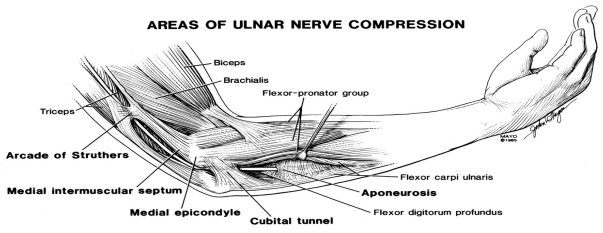
- With elbow flexion,
  - HUA tightens, narrows interspace
  - Extraneural pressure rises, especially with FCU contraction (9→20 mmHg)
  - Pressure also increases with pronation
- If HUA absent or shallow groove →ulnar nerve subluxation



Ulnar nerve injury

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AREAS OF ULNAR NERVE COMPRESSION



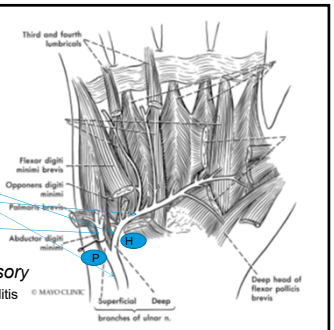
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ULNAR NEUROPATHY: SITES OF COMPRESSION

- Elbow
  - May occur at medial epicondyle or cubital tunnel
  - Causes: Trauma, old injury (tardy ulnar palsy), arthritis, HNPP, DM, prolapse of nerve, fibrosis of FCU aponeurosis
- Forearm
  - **UNCOMMON**
    - Causes: FCU muscle hypertrophy/injury
  - Must evaluate for median to ulnar (Martin-Gruber) crossover if forearm compression suspected due to NCS findings

ULNAR NEUROPATHY: SITES OF COMPRESSION- WRIST

- Can occur at any of 4 sites:
  1. Guyon's Canal
     - Deep and Superficial
  2. Proximal Deep Branch
     - ADM,FDI
  3. Distal Deep Branch
     - FDI
  4. Superficial Branch
     - Sensory and palmaris brevis
- **2 and 3** most common (75%)- *no sensory*
  - Common causes: trauma, ganglion, RA, vasculitis



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ULNAR NEUROPATHY CAUSES: WORK-RELATED DIFFERENCES

- Prospective studied evaluated 117 patients with definite (EDX and US) UNE
- Ulnar neuropathy at the HUA (27%)
  - Hard manual labor, dominant arm and age predictive
  - Defined as localization distal to ME
- UNE in the RTC groove (73%)
  - Non-dominant arm of younger office workers (*extrinsic compression*)
  - Defined as localization at or proximal to ME

0mejec,Clinical Neurophysiology, 2015

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ULNAR NEUROPATHY: EXPANDED CAUSES

- Direct pressure
  - Surgery
  - Coma
  - Positioning
  - Casting
- Mechanical Causes
  - Recurrent elbow dislocation
  - Trauma
  - Fracture
- Systemic causes
  - Diabetes
  - Alcoholism
  - Malnutrition
  - Leprosy
  - Hereditary neuropathies
- Tumor /Mass
  - Fibrolipomatous hamartoma
  - Ganglia
  - Lipoma
  - Intraneural hemangioma
- Muscle anomalies
  - Anconeus epitrochlearis/snapping triceps
- Bone and joint deformities
  - Heterotopic ossification
  - Cubitus valgus
  - Sesamoid bone
- Inflammatory arthritis/synovitis
- Vascular

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ULNAR NEUROPATHY: CLINICAL FEATURES

- Motor symptoms *can predominate*, in contrast to CTS
  - Insidious intrinsic hand weakness
    - Spares thumb abduction→ median and radial nn
  - Typically, wrist flexion not clinically significant
    - Flexor carpi radialis (median innervated) intact
- If sensory complaints, follows ulnar distribution, often at night
  - Numbness, but also prickling, tingling

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ULNAR NEUROPATHY: CLINICAL FEATURES

- Due to anatomic variations, sensory abnormalities may not always fit expected distributions
- Splitting ring finger sensation *highly specific* for UN
- Sensory abnormalities in forearm should raise concern for brachial plexopathy or C8 radiculopathy

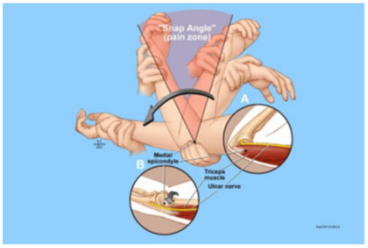
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ULNAR NEUROPATHY: CLINICAL FEATURES

- Pertinent occupational/ behavioral history
  - Repetitive motion?
    - Carpentry →"hammer hand"
    - Cycling
- Previous trauma
  - Chronic, minor trauma can also be causative
- Elbow flexing/resting
- Pain, exacerbating factors

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ULNAR NEUROPATHY: CLINICAL FEATURES



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ULNAR NEUROPATHY: PHYSICAL EXAMINATION

- Tinel's sign not specific
- Elbow flexion/pressure
- Joint deformities
- Nerve enlargement/subluxation
- Clawing
  - Weak lumbricals, unopposed flexors

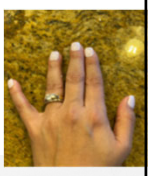


Claw Hand
(Ulnar Nerve Injury)

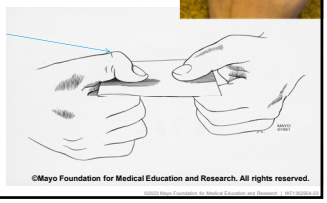
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ULNAR NEUROPATHY: PHYSICAL EXAMINATION

- Wartenberg's sign (finger abducted)
  - Inadequate adduction of little finger due to weakness of lumbrical
  - Unopposed extensor digiti minimi



- Froment's Sign (weak pinch)
  - Collapse of distal interphalangeal joint
  - Weak adductor pollicis and first dorsal interosseous
  - FPL and FDP (ii) used



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ULNAR NEUROPATHY: DIFFERENTIAL DIAGNOSIS

- Myelopathy/syrinx
  - Bilateral, hyperreflexia
- C8/T1 radiculopathy
  - APB, EIP, FPL, cervical paraspinals
- Plexopathy (Pancoast, NTOS)
  - Sensory loss in arm (*medial antebrachial*)
  - Horner's
  - APB, EIP, FPL

Clinical differentiating factors in suspected ulnar neuropathy

	UNW	UNE	Medial cord	Lower trunk	C8 to T1
Weakness of the interossei	x	x	x	x	x
Weakness of the hypothenar muscles	x	x	x	x	x
Weakness of the third and fourth lumbricals	x	x	x	x	x
Weakness of distal finger flexion of the little and ring fingers		x	x	x	x
Weakness of thumb abduction			x	x	x
Weakness of thumb flexion			x	x	x
Weakness of index finger extension				x	x
Sensory loss of the volar medial hand, little finger, and medial ring finger	x	x	x	x	x
Sensory loss of the dorsal medial hand, dorsal little finger, and ring finger		x	x	x	x
Sensory loss of the medial forearm			x	x	x
Tinel sign at the elbow		x			
Neck pain					x

Adapted from Preston DC, Shapiro BE. Ulnar neuropathy. In: Electromyography and neuromuscular disorders. 1st ed. Burlington (MA): Butterworth Heinemann; 1998. p. 270-1.

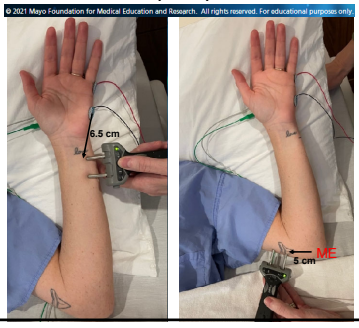
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Ulnar Neuropathy: NCS and EMG tools

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ULNAR NEUROPATHY: NCS TOOLS
ULNAR MOTOR (ADM)

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Note positioning:
- **Arm abducted 90°**
- **Elbow flexed 70-90°**

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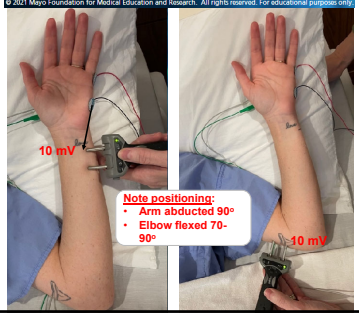
ULNAR NEUROPATHY: MOTOR NCS ALGORITHM

- Ipsilateral ulnar motor NCS with F-waves recording over ADM
  - Assess: CMAP amplitude, distal latency, CV
  - Perform below elbow (BE) stimulation if CMAP drop >20% between AE-wrist
- Perform Inching (short segmental) stimulation if
  - >20% CMAP drop between BE-AE sites or
  - CV slowing > 8m/s between BE-Wr and AE- Wr sites
- Perform crossover check (MGA) if
  - >20% CMAP amplitude drop between BE-Wrist stimulation sites

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ULNAR NEUROPATHY: NCS TOOLS
ULNAR MOTOR (ADM)

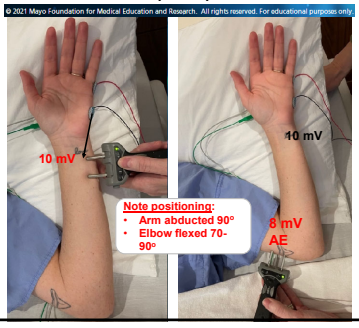
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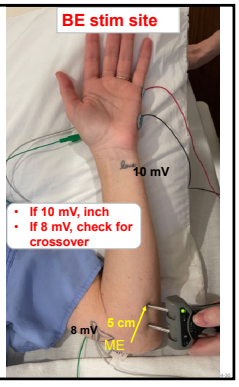


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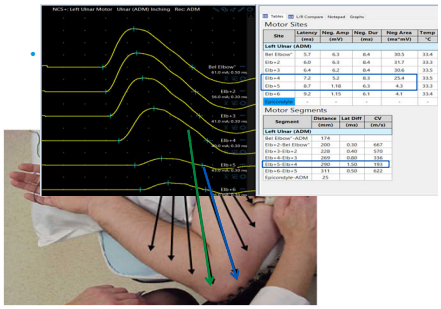
ULNAR NEUROPATHY: NCS TOOLS
ULNAR MOTOR (ADM)

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INCHING (SHORT SEGMENTAL STIMULATION)



Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Bel Elbow*	5.7	6.3	8.4	30.5	33.4
Elb+2	6.0	6.3	8.4	31.7	33.3
Elb+3	6.4	6.2	8.4	30.6	33.5
Elb+4	7.2	5.2	8.3	25.4	33.5
Elb+5	8.7	1.18	6.3	4.3	33.3
Elb+6	9.2	1.15	6.1	4.1	33.4
Epicondyle	-	-	-	-	-

Motor Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Bel Elbow* -ADM	174		
Elb+2-Bel Elbow*	200	0.30	667
Elb+3-Elb+2	228	0.40	570
Elb+4-Elb+3	260	0.80	325
Elb+5-Elb+4	260	1.50	173
Elb+6-Elb+5	311	0.50	622
Epicondyle-ADM	73		

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ULNAR NEUROPATHY: MOTOR NCS- CAVEATS

- Consider FDI recording site (instead or in addition to ADM) if
  - Atrophy of FDI with normal ulnar motor (ADM) recording
  - Suspicion of ulnar neuropathy in hand

  NOTE: FDI recording is more technically limited
- *Consider* inching studies if *high clinical suspicion* not meeting criteria AND
  - >10% drop in CMAP amplitude between BE-AE
  - AE-Wr CV is <52 m/s
- Abnormal inching criteria (~2 cm increments)
  - Amplitude decrease >10% between 2 sites
  - And/or latency increase of >0.8 ms between 2 sites

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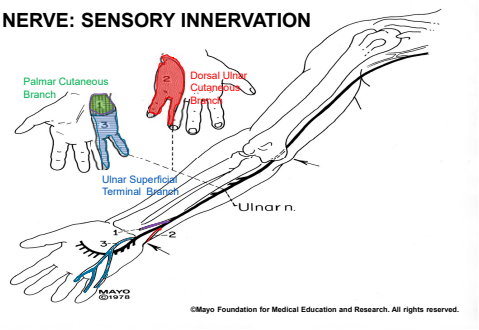
A PATIENT HAS SENSORY LOSS IN THE DORSUM OF THE HAND. YOU SUSPECT ULNAR NEUROPATHY.

The neuropathy would least likely localize to which of the following sites?

A. Ulnar nerve at or distal to the wrist
B. Ulnar nerve in distal forearm
C. Ulnar nerve near or at elbow
D. Ulnar nerve/medial cord plexus lesion

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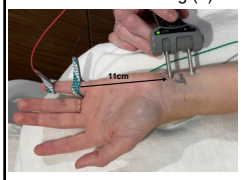
ULNAR NERVE: SENSORY INNERVATION



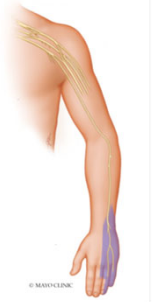
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ULNAR NEUROPATHY: ANTIDROMIC SENSORY FROM FIFTH DIGIT

- Findings in UN
  - Low amplitude or absent SNAP
  - Asymmetry→ if high concern, do both sides
    - 50% side-to side difference
  - Focal slowing (?)





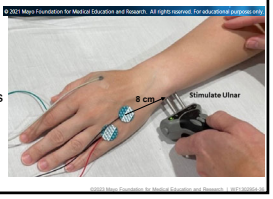


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ULNAR NEUROPATHY: DORSAL ULNAR CUTANEOUS SENSORY



- Consider dorsal ulnar cutaneous sensory study (DUC) if:
  - Low or absent ulnar antidromic with high index of suspicion for UN at wrist
    - Since DUC exists in forearm, should be **normal** if the site of compression is at or distal to wrist
    - Side to side comparison
- Reverse is NOT the case
  - ***DUC normal in up to 50% of UNE***
  - Fascicular sparing of DUC branches



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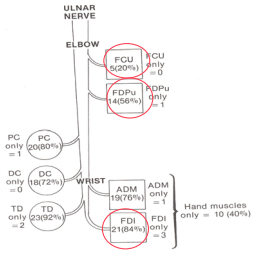
ULNAR NEUROPATHY: NEEDLE TOOLS

- Chronicity, axonal, reinnervation
- Include:
  - First dorsal interosseous (FDI):
    - Most likely to be affected (both in proximal and distal deep palmar)
  - Abductor digiti minimi (ADM) (+/- if FDI shows involvement)
  - Flexor digitorum profundus IV/V (FDP)
  - Flexor carpi ulnaris (FCU)
    - Occasionally, branches proximal to elbow (10%)
    - Can be NORMAL in UNE
- **Other C8/T1 non-ulnar muscles**
  - APB (median), EIP (radial), FPL (median), cervical paraspinals

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ULNAR NEUROPATHY: NEEDLE EXAMINATION

- Studied clinical and EDX findings of 25 UNE cases
  - FCU/FDP can be clinically and electrophysiologically normal
- FDI most frequently affected and should be tested



Stewart, J Neurol Neurosurg Psych 1987.

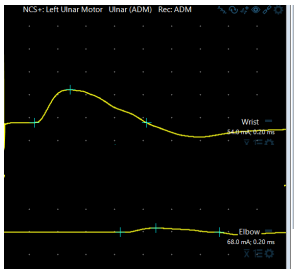
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HOW GOOD IS EMG IN DIAGNOSING UNE?

- 80-90% sensitive if motor and sensory symptoms
- Less so if only sensory symptoms

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ULNAR NEUROPATHY: CASE #1



Tables | L/R Compare | Notepad | Graphs

Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C	Comment
Left Ulnar (ADM)						
Wrist	2.4	7.3	7.9	33.4	33.1	
Elbow	8.4	1.03	6.9	3.9	33.1	

Motor Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Wrist-ADM	61		
Bel Elbow-Wrist	175	3.1	56
Elbow-Wrist	285	6.0	48

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WHAT IS THE NEXT APPROPRIATE STEP?

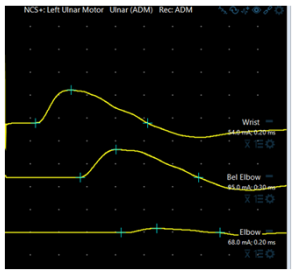
A. Nothing, criteria for abnormality is >50% drop
B. Inching studies
C. Below Elbow (BE) stimulation
D. Check for crossover

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ULNAR NEUROPATHY: MOTOR NCS

- Ipsilateral ulnar motor NCS with F-waves recording over ADM
  - Parameters assessed: CMAP amplitude, area, CV
  - Perform below elbow (BE) stimulation if CMAP drop >20% between AE-wrist
- Perform Inching (short segmental) stimulation if
  - >20% CMAP drop between BE-AE sites
  - CV slowing > 8m/s between BE-Wr and AE- Wr sites
- Perform crossover check (MGA) if
  - >20% CMAP amplitude drop between BE-Wrist stimulation sites

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Tables | L/R Compare | Notepad | Graphs

Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C	Comment
Left Ulnar (ADM)						
Wrist	2.4	7.1	7.9	33.4	33.1	
Bel Elbow	5.5	6.2	8.3	30.3	33.2	
Elbow	8.4	1.03	6.9	3.9	33.1	

Motor Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Wrist-ADM	61		
Bel Elbow-Wrist	175	3.1	56
Elbow-Wrist	285	6.0	48

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WITH THESE FINDINGS, WHICH IS THE NEXT BEST STEP?

A. Short-segmental stimulation (Inching) studies
B. No further ulnar NCS are needed
C. Check for a crossover
D. Calculate the AE-BE conduction velocity

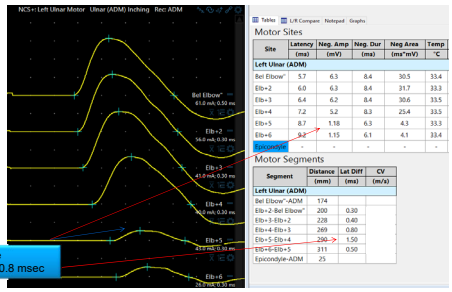
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ULNAR NEUROPATHY: MOTOR NCS

- Ipsilateral ulnar motor NCS with F-waves recording over ADM
  - Parameters assessed: CMAP amplitude, area, CV
  - Perform below elbow (BE) stimulation if CMAP drop >20% between AE-wrist
- Perform Inching (short segmental) stimulation if
  - >20% CMAP drop between BE-AE sites
  - CV slowing > 8m/s between BE-Wr and AE- Wr sites
- Perform crossover check (MGA) if
  - >20% CMAP amplitude drop between BE-Wrist stimulation sites

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CASE #1 SHORT SEGMENTAL STIMULATION OR "INCHING"



Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Bel Elbow"	5.7	6.3	8.4	30.5	33.4
Elb+2	6.0	6.3	8.4	31.7	33.3
Elb+3	6.4	6.2	8.4	30.6	33.5
Elb+4	7.2	5.2	8.3	25.4	33.5
Elb+5	8.7	1.18	6.3	4.3	33.3
Elb+6	9.2	1.15	6.1	4.1	33.4
Epicondyle	-	-	-	-	-

Motor Segments

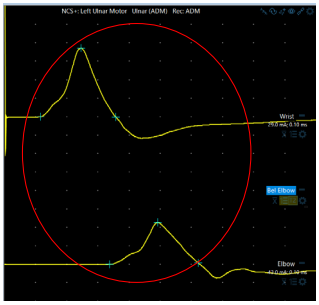
Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Bel Elbow"-ADM	174		
Elb+2-Bel Elbow"	200	0.30	
Elb+3-Elb+2	228	0.40	
Elb+4-Elb+3	269	0.80	
Elb+5-Elb+4	290	1.50	
Elb+6-Elb+5	311	0.50	
Epicondyle-ADM	25		

- Drop in amplitude
- Shift in latency > 0.8 msec

Abnormal inching criteria (2 cm increments)
Amplitude decrease >10% between 2 sites
And/or latency increase of >0.8 ms between 2 sites

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ULNAR NEUROPATHY: CASE 2



Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Wrist	3.5	7.5	7.3	23.1	32.5
Elbow	10.1	4.6	8.5	17.0	32.5

Motor Segments

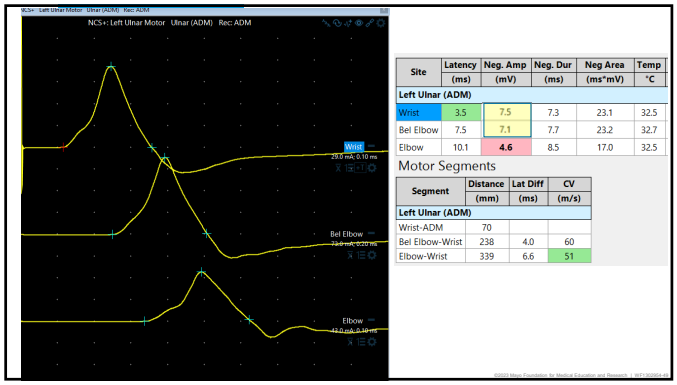
Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Wrist-ADM	70		
Bel Elbow-Wrist	238	-	-
Elbow-Wrist	339	6.6	51

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WHAT IS THE NEXT BEST STEP?

A. Below elbow stimulation as there is a >20% drop
B. No further studies as there is not a relevant CMAP amplitude change
C. Inching studies
D. Check for crossover

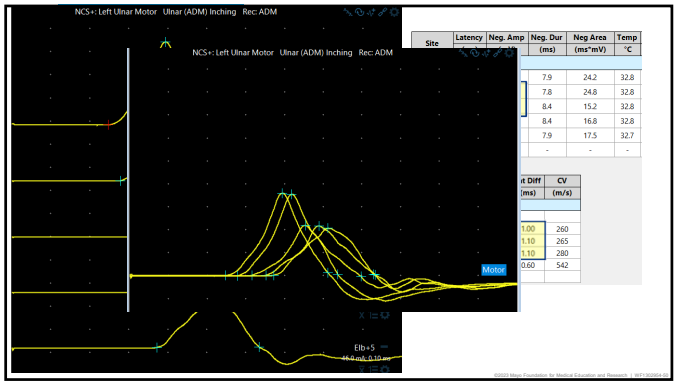
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Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Wrist	3.5	7.5	7.3	23.1	32.5
Bel Elbow	7.5	7.1	7.7	23.2	32.7
Elbow	10.1	**4.6**	8.5	17.0	32.5

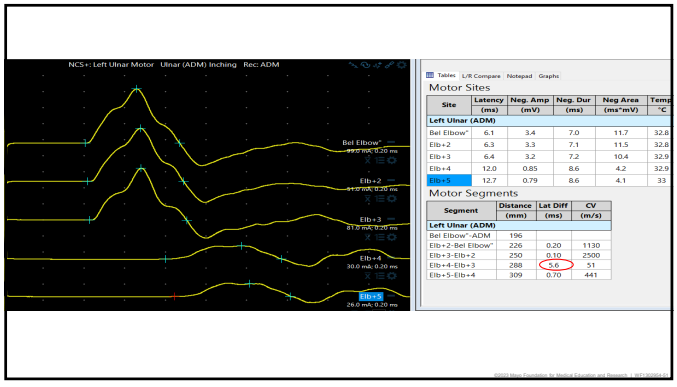
Motor Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Wrist-ADM	70		
Bel Elbow-Wrist	238	4.0	60
Elbow-Wrist	339	6.6	51



Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
			7.9	24.2	32.8
			7.8	24.8	32.8
			8.4	15.2	32.8
			8.4	16.8	32.8
			7.9	17.5	32.7
			-	-	-

t Diff (ms)	CV (m/s)
1.00	260
1.10	265
1.10	280
0.60	542



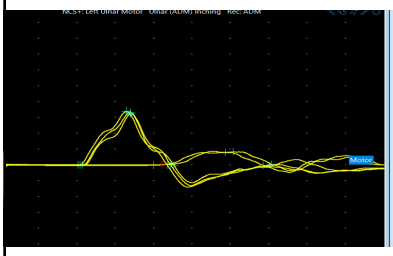
Tables L/R Compare Notepad Graphs

Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Bel Elbow*	6.1	3.4	7.0	11.7	32.8
Elb+2	6.3	3.3	7.1	11.5	32.8
Elb+3	6.4	3.2	7.2	10.4	32.9
Elb+4	12.0	0.85	8.6	4.2	32.9
Elb+5	12.7	0.79	8.6	4.1	33

Motor Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Bel Elbow*-ADM	196		
Elb+2-Bel Elbow*	226	0.20	1130
Elb+3-Elb+2	250	0.10	2500
Elb+4-Elb+3	288	5.6	51
Elb+5-Elb+4	309	0.70	441



Tables L/R Compare Notepad Graphs

Motor Sites

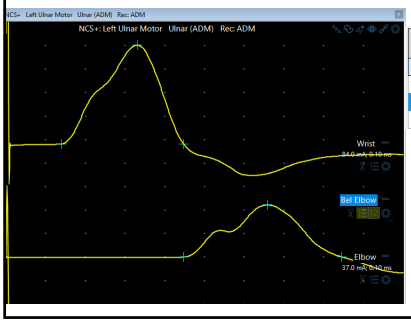
Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Bel Elbow*	6.1	3.4	7.0	11.7	32.8
Elb+2	6.3	3.3	7.1	11.5	32.8
Elb+3	6.4	3.2	7.2	10.4	32.9
Elb+4	12.0	0.85	8.6	4.2	32.9
Elb+5	12.7	0.79	8.6	4.1	33

Motor Segments

Segment	Distance (mm)	Lat Diff (ms)
Left Ulnar (ADM)		
Bel Elbow*-ADM	196	
Elb+2-Bel Elbow*	226	0.20
Elb+3-Elb+2	250	0.10
Elb+4-Elb+3	288	5.6
Elb+5-Elb+4	309	0.70

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ULNAR NEUROPATHY: CASE #3



Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Wrist	2.8	8.4	6.2	27.6	32.8
Bel Elbow	-	-	-	-	32.8
Elbow	9.0	**4.4**	7.9	17.6	32.7

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THE NEXT STEP SHOULD BE:

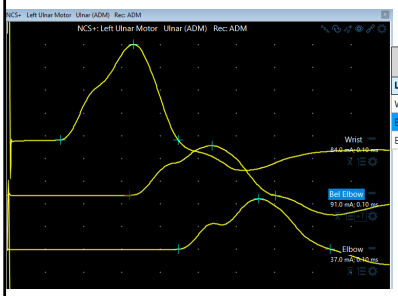
A. Below elbow stimulation as there is a >20% drop
B. No further studies as there is not a relevant CMAP amplitude change
C. Inching studies
D. Check for crossover

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ULNAR NEUROPATHY: MOTOR NCS

- Ipsilateral ulnar motor NCS with F-waves recording over ADM
  - Parameters assessed: CMAP amplitude, area, CV
  - Perform below elbow (BE) stimulation if CMAP drop >20% between AE-wrist
- Perform Inching (short segmental) stimulation if
  - >20% CMAP drop between BE-AE sites
  - CV slowing > 8m/s slower between BE-Wr and AE- Wr sites
- Perform crossover check (MGA) if
  - >20% CMAP amplitude drop between BE-Wrist stimulation sites

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Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Left Ulnar (ADM)					
Wrist	2.8	8.4	6.2	27.6	32.8
Bel Elbow	6.4	4.4	7.7	18.6	32.8
Elbow	9.0	4.4	7.9	17.6	32.7

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GIVEN THESE RESULTS, YOU SHOULD THEN CONSIDER:

A. Performing inching studies
B. Checking for a crossover
C. Comparing to the other side
D. No further studies

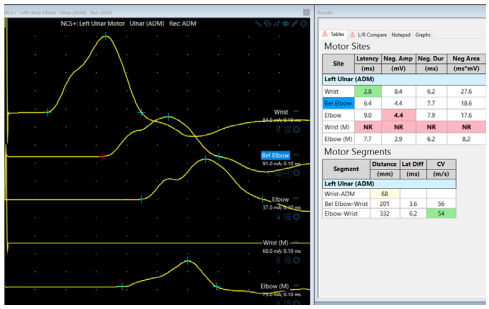
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ULNAR NEUROPATHY: MOTOR NCS

- Ipsilateral ulnar motor NCS with F-waves recording over ADM
  - Assess: CMAP amplitude, distal latency, CV
  - Perform below elbow (BE) stimulation if CMAP drop >20% between AE-wrist
- Perform Inching (short segmental) stimulation if
  - >20% CMAP drop between BE-AE sites or
  - CV slowing > 8m/s between BE-Wr and AE- Wr sites
- Perform crossover check (MGA) if
  - >20% CMAP amplitude drop between BE-Wrist stimulation sites

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ULNAR NEUROPATHY: CASE #3

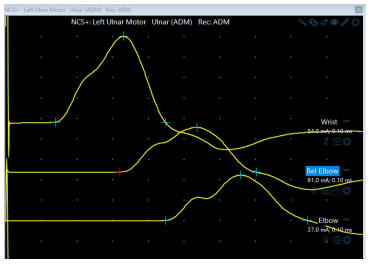


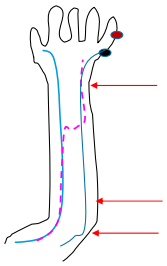
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MARTIN GRUBER CROSSOVER

- Described by Martin 1763 and Gruber in 1870
- 15-20% prevalence
  - Other reports to 34%
  - Up to 62% in those with a positive family history
  - Minority bilateral
- FDI more often affected
- Communication 3-10 cm distal to ME
  - Distal to BE stim site

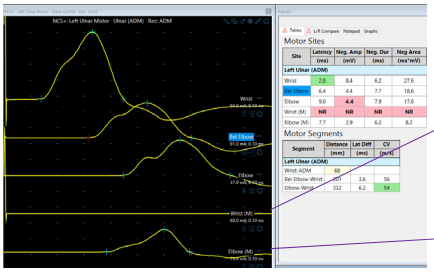
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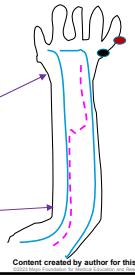


Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)
Left Ulnar (ADM)				
Wrist	2.8	8.4	6.2	27.6
Bel Elbow	6.4	4.4	7.7	18.6
Elbow	9.0	**4.4**	7.9	17.6
Wrist (M)	NR	NR	NR	NR
Elbow (M)	7.7	2.9	6.2	8.2

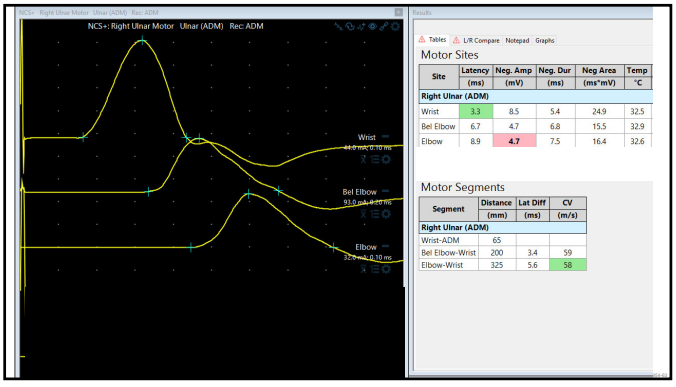
Motor Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Left Ulnar (ADM)			
Wrist-ADM	68		
Bel Elbow-Wrist	257	3.6	56
Elbow-Wrist	232	6.2	54



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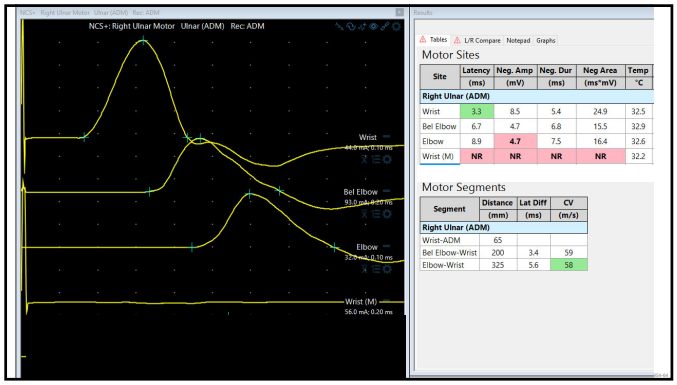


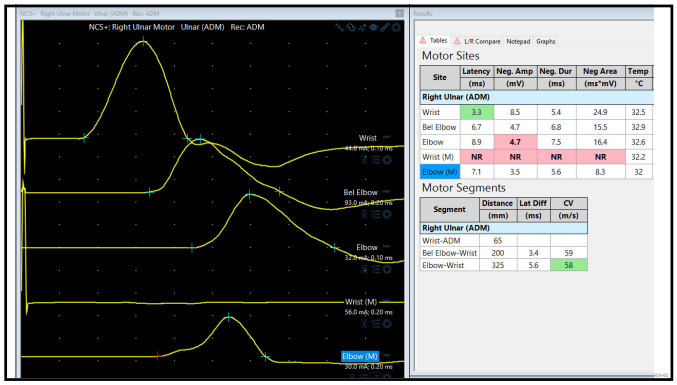
Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)	Neg Area (ms*mV)	Temp °C
Right Ulnar (ADM)					
Wrist	3.3	8.5	5.4	24.9	32.5
Bel Elbow	6.7	4.7	6.8	15.5	32.9
Elbow	8.9	**4.7**	7.5	16.4	32.6

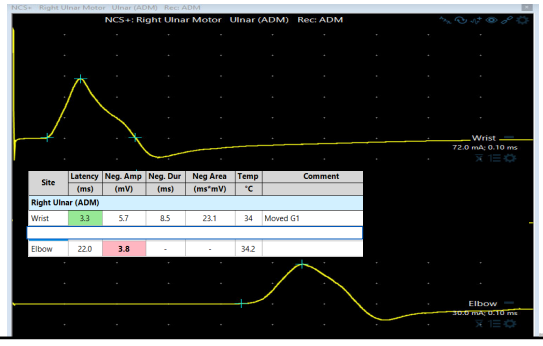
Motor Segments

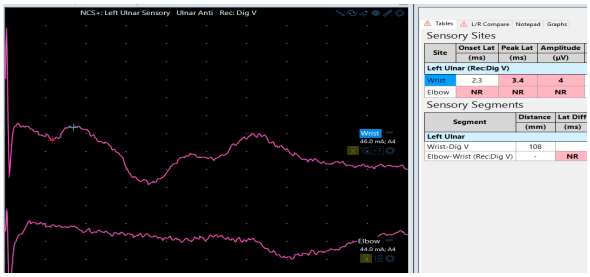
Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Right Ulnar (ADM)			
Wrist-ADM	65		
Bel Elbow-Wrist	200	3.4	59
Elbow-Wrist	325	5.6	58

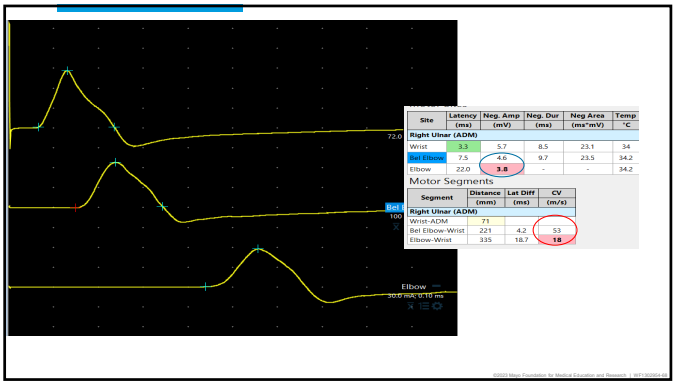




ULNAR NEUROPATHY: CASE #4

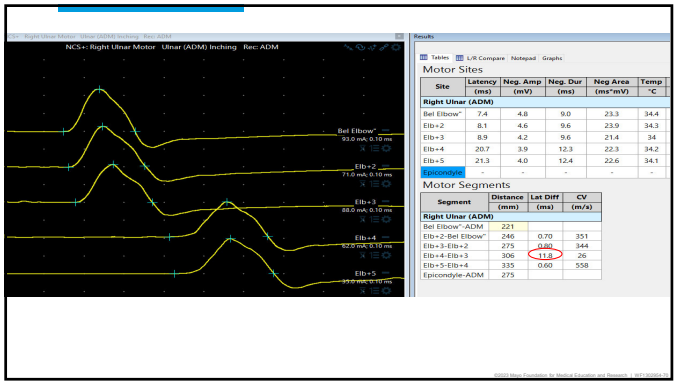


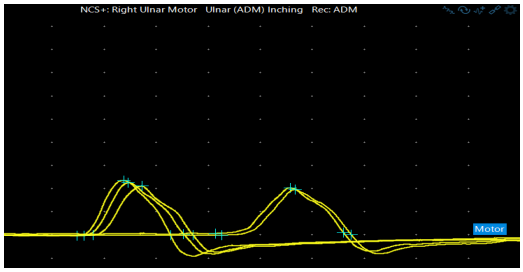




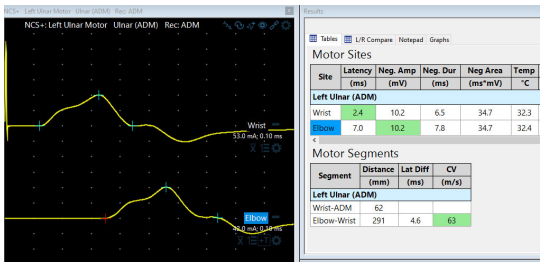
ULNAR NEUROPATHY: MOTOR NCS

- Ipsilateral ulnar motor NCS with F-waves recording over ADM
  - Parameters assessed: CMAP amplitude, area, CV
  - Perform below elbow (BE) stimulation if CMAP drop >20% between AE-wrist
- Perform Inching (short segmental) stimulation if
  - >20% CMAP drop between BE-AE sites
  - CV slowing > 8m/s slower between BE-Wr and AE- Wr sites
- Perform crossover check (MGA) if
  - >20% CMAP amplitude drop between BE-Wrist stimulation sites

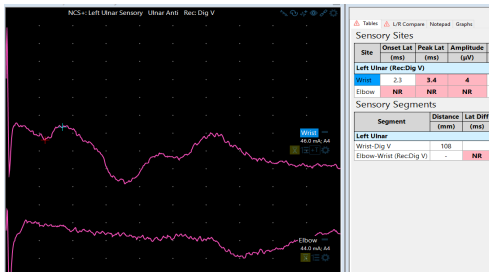

NCS+: Right Ulnar Motor Ulnar (ADM) Inching Rec: ADM
Bel Elbow*
Elb+2
Elb+3
Elb+4
Elb+5
Results
Tables
L/R Compare
Notepad
Graphs
Motor Sites
Site
Latency (ms)
Neg. Amp (mV)
Neg. Dur (ms)
Neg Area (ms*mV)
Temp °C
Right Ulnar (ADM)
Bel Elbow* 7.4 4.8 9.0 23.3 34.4
Elb+2 8.1 4.6 9.6 23.9 34.3
Elb+3 8.9 4.2 9.6 21.4 34
Elb+4 20.7 3.9 12.3 22.3 34.2
Elb+5 21.3 4.0 12.4 22.6 34.1
Epicondyle - - - - -
Motor Segments
Segment
Distance (mm)
Lat Diff (ms)
CV (m/s)
Right Ulnar (ADM)
Bel Elbow*-ADM 221
Elb+2-Bel Elbow* 246 0.70 351
Elb+3-Elb+2 275 0.80 344
Elb+4-Elb+3 306 11.8 26
Elb+5-Elb+4 335 0.60 558
Epicondyle-ADM 275


NCS+: Right Ulnar Motor Ulnar (ADM) Inching Rec: ADM
Motor

CASE #5


NCS+: Left Ulnar Motor Ulnar (ADM) Rec: ADM
Wrist
Elbow
Tables
L/R Compare
Notepad
Graphs
Motor Sites
Site
Latency (ms)
Neg. Amp (mV)
Neg. Dur (ms)
Neg Area (ms*mV)
Temp °C
Left Ulnar (ADM)
Wrist 2.4 10.2 6.5 34.7 32.3
Elbow 7.0 10.2 7.8 34.7 32.4
Motor Segments
Segment
Distance (mm)
Lat Diff (ms)
CV (m/s)
Left Ulnar (ADM)
Wrist-ADM 62
Elbow-Wrist 291 4.6 63

CASE #5



Tables L/R Compare Notepad Graphs

Sensory Sites

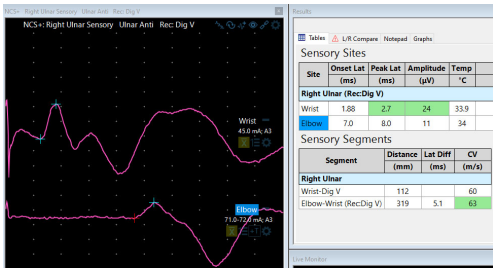
Site	Onset Lat (ms)	Peak Lat (ms)	Amplitude (µV)
Left Ulnar (Rec:Dig V)			
Wrist	2.3	3.4	4
Elbow	NR	NR	NR

Sensory Segments

Segment	Distance (mm)	Lat Diff (ms)
Left Ulnar		
Wrist-Dig V	108	
Elbow-Wrist (Rec:Dig V)	-	NR

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CASE #5



Results

Tables L/R Compare Notepad Graphs

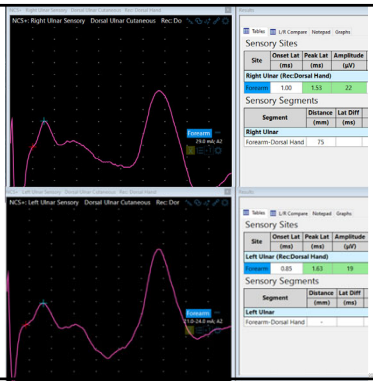
Sensory Sites

Site	Onset Lat (ms)	Peak Lat (ms)	Amplitude (µV)	Temp °C
Right Ulnar (Rec:Dig V)				
Wrist	1.88	2.7	24	33.9
Elbow	7.0	8.0	11	34

Sensory Segments

Segment	Distance (mm)	Lat Diff (ms)	CV (m/s)
Right Ulnar			
Wrist-Dig V	112		60
Elbow-Wrist (Rec:Dig V)	319	5.1	63

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Results

Tables L/R Compare Notepad Graphs

Sensory Sites

Site	Onset Lat (ms)	Peak Lat (ms)	Amplitude (µV)
Right Ulnar (Rec:Dorsal Hand)			
Forearm	1.00	1.53	22

Sensory Segments

Segment	Distance (mm)	Lat Diff (ms)
Right Ulnar		
Forearm-Dorsal Hand	75	

Results

Tables L/R Compare Notepad Graphs

Sensory Sites

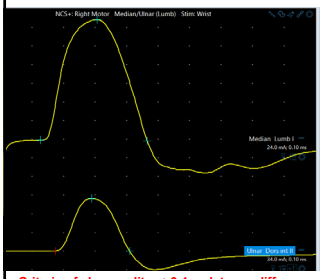
Site	Onset Lat (ms)	Peak Lat (ms)	Amplitude (µV)
Left Ulnar (Rec:Dorsal Hand)			
Forearm	0.85	1.63	19

Sensory Segments

Segment	Distance (mm)	Lat Diff (ms)
Left Ulnar		
Forearm-Dorsal Hand	-	

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CASE #5: CONSIDERATION

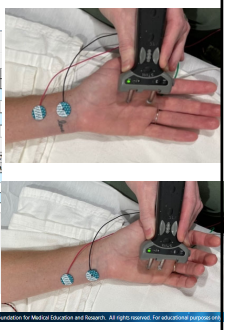


Motor Sites

Site	Latency (ms)	Neg. Amp (mV)	Neg. Dur (ms)
Right Median (Lumb I)			
Wrist	2.5	13.0	6.8
Right Ulnar (Dors int II)			
Wrist	3.5	5.6	4.7

Motor Segments

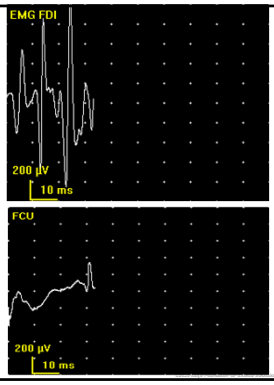
Segment	Distance (mm)	Lat Diff (ms)	C (m
Right Median (Lumb I)			
Wrist-Lumb I	91		
Right Ulnar (Dors int II)			
Wrist-Dors int II	91		



Criteria of abnormality= >0.4ms latency difference

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- FDI
- FCU



ULNAR NEUROPATHY: IMAGING EVALUATION

- Plain Xrays
  - Fracture, arthritis, deformity, bone spur
- MRI
  - Nerve enlargement and increased signal
  - Anconeus epitrochlearis
  - Evaluate Guyon's canal
- Ultrasound
  - Cross-sectional area (CSA) at various sites
  - Dynamic information
    - Subluxation
    - Snapping triceps

ULTRASONOGRAPHY IN UNE

- Multiple studies with differing results
- UN varies more with anthromorphic features (gender, weight, height) than median nerve
- Each lab should create its own normal values; recent metanalysis unable to create absolute CSA cutoff values
  - Class 1 evidence supports measure of ulnar nerve diameter or CSA
    - Within the hyperechoic epineurium
    - At level of the medial epicondyle and across the elbow segment
    - should span from at least 2 cm proximal to 2 cm distal to the medial epicondyle

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Diagnostic accuracy of ultrasonographic and nerve conduction studies in ulnar neuropathy at the elbow

Gregor Omejec, Tomaž Žgur, Simon Podnar *

- 109 patients (113 arms) with clinical symptoms of UNE compared to control (49 arms)
- Diagnostic accuracy of US (using CSA) in UNE was 80% compared to NCS
  - *CSA max being more sensitive of a marker than CSA ratio*
- US most helpful in cases with clinically suspected UNE and normal ulnar sensory studies
- Other relevant point
  - Concomitant UNE in 4 of 11 patients with C8→
  - Reinforces need to needle non-ulnar innervated muscles in those with suspected ulnar neuropathy

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Ulnar neuropathy with abnormal non-localizing electrophysiology: Clinical, electrophysiological and ultrasound findings

Luciana Pelosi [a,*], Dominic Ming Yin Tse [b], Eoin Mulroy [d], Andrew M. Chancellor [a], Michael R. Boland [c]

[a] Department of Neurology and Clinical Neurophysiology, Bay of Plenty District Health Board, Tauranga Hospital, Tauranga, New Zealand
[b] Calgary Stroke Program, Foothills Medical Centre, Alberta, Canada
[c] Hand Institute Bioengineering Institute, University of Auckland, Auckland, New Zealand
[d] Auckland District Health Board, Auckland Hospital, Auckland, New Zealand

- Study examined whether US could be useful in cases where EDX cannot localize the neuropathy
- 113 patients prospectively identified with clinical signs or symptoms of ulnar neuropathy underwent electrodiagnostic testing

Clinical Neurophysiology 126(2015) 1797-1804

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Demographic, side of neuropathy, clinical and electrophysiological severity classification, ultrasound findings and associated pathology in 16 patients with NL-UN.

Patient	Sex	Age	Side	SEVERITY SCORES		ULTRASOUND		
				CLINIC	EDX	CSA Max (mm^2)	Abnormal site	
1	M	50	L	MOD	MOD	16	Diffuse	Diabetes
2	F	41	R	MOD	SEV	13	Diffuse	Diabetes
3	F	71	L	SEV	SEV	16	Diffuse	Diabetes
4	M	52	L	SEV	SEV	20	Epicondyle	Dislocation and S Triceps
5	M	48	R	SEV	SEV	12	HUA	Cubital tunnel syndrome
6	M	88	L	SEV	SEV	17	Epicondyle	Osteoarthritis
7	M	82	R	SEV	SEV	20	Epicondyle	Osteoarthritis
8	M	72	L	SEV	SEV	14	Epicondyle	Osteoarthritis
9	M	31	L	SEV	SEV	13	Epicondyle	Dislocation and S Triceps
10	M	77	L	MOD	MOD	17	Epicondyle	
11	M	72	L	SEV	SEV	24	HUA	Osteoarthritis and Cubital tunnel syndrome
12	M	48	R	MOD	MOD	16	Epicondyle	Trauma elbow
13	M	60	L	MOD	MILD	12	Epicondyle	
14	M	52	R	MILD	MILD	11	Epicondyle	Dislocation
15	M	52	R	MILD	MILD	13	Epicondyle	Subluxation
16	M	42	L	MILD	MILD	10	Epicondyle	Subluxation

Clinic = Clinical scale; CSA Max = Maximal cross-sectional area; EDX = Electrophysiological scale; HUA = Humero-ulnar aponeurosis; MOD = Moderate; SEV = Severe; S Triceps = Snapping Triceps Syndrome.

- Compared to their own normals (8.7mm^2 at elbow)
- 13/16 had focal enlargement at elbow (range 10-24mm^2)
- Remaining 3 with diffuse enlargement- all with DM2

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NEUROMUSCULAR ULTRASOUND IN ELECTRICALLY NON-LOCALIZABLE ULNAR NEUROPATHY

MOHAMMAD ALRAJEH, MD, and DAVID C. PRESTON, MD

Neurological Institute, University Hospitals Cleveland Medical Center, Case Western Reserve University, 11100 Euclid Avenue, Cleveland, Ohio, 44106-5098, USA

Muscle Nerve **58**:655–659, 2018

- Similar prospective study of 56 patients
- 12 patients without localizing electrodiagnostic findings
  - US localized pathology in all 12 (CSA > 10mm^2)
    - 5 retrocondylar
    - 2 cubital tunnel
    - 3 both
    - 1 wrist
    - 1 tandem lesion

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Expert consensus on the combined investigation of ulnar neuropathy at the elbow using electrodiagnostic tests and nerve ultrasound



Luciana Pelosi [a,*], Zsuzsanna Arányi [b], Roy Beekman [c], Jeremy Bland [d], Daniele Coraci [e], Lisa D. Hobson-Webb [f], Luca Padua [g,s], Simon Podnar [h], Neil Simon [i], Nens van Alfen [j], Camiel Verhamme [k], Leo Visser [l], Francis O. Walker [m], Joon Shik Yoon [n], Michael S. Cartwright [o] Clinical Neurophysiology 132 (2021) 2274–2281

- Using Delphi method created a series of consensus statements by experts in NMUS and EDX
- Highest consensus:

Group consensus (≥80% ratings).

1. EDX and US together are more informative than either modality alone
2. Both modalities should be performed in all investigations of UNE
3. EDX testing should always include nerve conduction studies
4. US of the ulnar nerve should include CSA measurement
5. US of the ulnar nerve should include an assessment of nerve mobility
6. US of the ulnar nerve should include the entire length of the ulnar nerve

CSA = cross-sectional area; EDX = electrodiagnostic; UNE = ulnar neuropathy at the elbow; US = ultrasound.

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Received: 9 November 2021 | Accepted: 9 November 2021
DOI: 10.1002/mus.27460

AANEM MONOGRAPH

Answer questions and earn CME https://education.aanem.org/URL/MM72.

CME MUSCLE&NERVE WILEY

Recommendation: For patients with symptoms and signs suggestive of ulnar neuropathy, clinicians should offer ultrasonographic measurement of ulnar nerve CSA or diameter to confirm the diagnosis and localize the site of compression (Level B).

Ultrasound is a cost-effective,[5] noninvasive adjunctive test that adds diagnostic accuracy to the clinical and electrodiagnostic (EDx) evaluation for UNE. Ultrasound may also reveal specific pathology not identifiable by clinical or EDx examination alone, and may aid in localization. Based on the available Class I evidence, the accuracy of neuromuscular ultrasound is not sufficient to replace clinical examination or EDx.

ULNAR NEUROPATHY: MANAGEMENT

- Controversial
- Conservative:
  - Beneficial in ~90% of patients with mild and 38% of patients with moderate symptoms
    - Avoid direct pressure over elbow or repetitive triceps strenghtening
    - Elbow pad
    - Elbow splinting at night in 45 degree flexion
    - NSAIDs OK,
  - 3-6 month trial
  - Unlike CTS, corticosteroids have not been effective

ULNAR NEUROPATHY: MANAGEMENT STRATEGIES

- On study suggests patient phenotype should guide intervention (not severity)
  - Mechanism
  - Localization
- Entrapment at HUA→ decompress
- Retrocondylar groove compression
  - More common
  - No anatomical constriction; likely due to nerve compression against bone
  - Recommend conservative measures (no surgery)

Omejec, 2018

Received: 17 May 2019 | Revised: 25 April 2020 | Accepted: 29 April 2020
DOI: 10.1002/mus.26912

CLINICAL RESEARCH ARTICLE

MUSCLE&NERVE WILEY

In situ decompression vs conservative treatment for mild ulnar neuropathy at the elbow

Sander M. Pompe MD[1,2] | Tobien Schreuder MD[1,2] | Laurien L. Teunissen MD, PhD[3,4] | Leo H. Visser MD, PhD[5,6] | Roy Beekman MD, PhD[1,2]

- 117 patients with clinically mild UNE (mild or absent motor weakness) confirmed by EDX or sonographically as focal and localized to elbow
  - EDX or sonographic ***severity not considered***
- Randomized to in situ decompression (56) or conservative management (61)
  - Assessed at 3 month (short-term) and 6-12 months (long-term)
  - F/U data included 35 surgical and 50 conservatively tx patients
- Results:
  - Surgical patients more likely to improve at 3 months (odds ratio 5.6) → 12% with complications
  - NO DIFFERENCE at long-term follow-up

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ULNAR NEUROPATHY: OPERATIVE MANAGEMENT

- Overall, no consensus on when to operate
- Generally agreed criteria:
  - Fixed sensory loss, (progressive) weakness
  - Intractable pain
  - Denervation on EMG

Dellon AL,1989
Elhassan B, 2007

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ULNAR NEUROPATHY: SURGERY OPTIONS

- Simple decompression of HUA
- Medial epicondylectomy
- Anterior transposition
  - Subcutaneous-common
  - Submuscular-more dissection, all sites decompressed, often used as second surgery
  - Intramuscular-controversial
  - Transmuscular
- Risk of medial antebrachial cutaneous damage in all

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Comparison of In Situ Versus Subcutaneous Versus Submuscular Transpositions in the Management of McGowan Stage III Cubital Tunnel Syndrome

HAND
1–5
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DOI: 10.1177/1558944719831387
hand.sagepub.com

Ali Izadpanah[1], Christopher Gibbs[1], Robert J. Spinner[1], and Sanjeev Kakar[1]

- Retrospective, single institution (Mayo Clinic Rochester) review of patients with at least 12 month F/U
- 74 patients underwent 80 surgeries
  - 17 decompression (21%)→ 66% improved
  - 47 subcutaneous transposition (59%)→ 89% improved
  - 16 submuscular transposition (20%)→ 100% improved

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- Only about half (52%) with symptom resolution post-operatively
- 12.5% with complications
  - Cellulitis, Pain, CRP (1)
- 47% had persistent sx after surgery→
  - 24% (19) had revision surgery at median 30 months
    - Primary surgery decompression 35%; SubQ 23%, SubM 12%
      - 42% of these had improvement after revision
    - Patients< 50 years and 2 point discrimination >10mm more likely to require revision

Kakar, 2019

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ULNAR NEUROPATHY AT THE ELBOW: OUTCOME

- 80% don't need surgery
  - Disabling, progressive signs/sxs and +EMG
  - ?50-60% improve after surgery
- Good predictors
  - Sensory symptoms o
  - Short duration (< 1 ye
  - No atrophy, denervati
  - Conduction block or slowing at elbow
- Poor:
  - Large diameter UN on U/S
  - Motor symptoms
  - More elbow slowing

Pts can recover even with severe EMG changes

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FAILED ULNAR NEUROPATHY

- Repeat EDX after nerve transposition tricky
- Nerve often moved anterior to medial epicondyle
  - Often kinked
  - Below elbow site may now be deeper→ supramaximal stimulus difficult
  - Still measure distance around elbow (behind ME)
  - Stimulate upper arm to test if Arcade of Struthers is impingement site
- If not helpful may need salvage procedures:
  - Tendon transfer
  - Repair of claw hand

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REVIEW: ULNAR NEUROPATHY PROTOCOL

- **Ulnar ADM motor at wrist and above elbow (AE)**
  - Below elbow (BE) if amplitude drops >20% between wrist and AE site
  - Beware of crossover (if drop is between wrist and BE site)
  - Inch across elbow if >20% drop at AE compared to BE or if CV slowed
- **Always will do median motor (APB)**
- **Ulnar and median antidromics**
- Compare to other side
- Consider using FDI and DUC recordings

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QUESTIONS & DISCUSSION

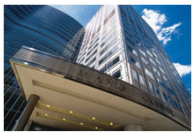


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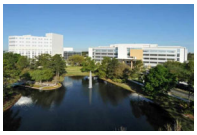
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