CTS
the Best EDX

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Definition of CTS*

• A syndrome 2d to *dysfunction of median nerve* in carpal tunnel resulting in:
  – Pain and numbness in the hand
  – Worse on finger activity
  – Aggravated by forceful griping
  – Symptoms more prominent at night

– *Dorland’s medical dictionary*
81 y/o lady being treated for ‘arthritis’ for 8 years
FIGURE 21

- Median Duo
- Median Nerve
- Palmaris Longus
- Radial Art.
- Flex. Carp. Rad.
- Flex. Poll. Long.
- Volar Carpal Lig. Turned Back
- Transverse Carpal Lig.
- Opponens Pollicis
- Adductor Pollicis
- Radial Trio
- Ulnar Artery
- Ulnar Nerve
- Ulnar Trio
- Superficial Palmar Arterial Arch
- Lumbrical Muscles
- Adductor Pollicis
- Flex. Poll. Long. in Radial Bursa
- Flex. Carp. Rad.
- Radial Art.

FIGURE 22

- Tendons of Flex. Digit. Sublimis and Profundus in Ulnar Bursa
- Ulnar Artery
- Ulnar Nerve
- Ulnar Trio
-pronator Quadratus

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SIMPLE METHOD OF DEMONSTRATING ARRANGEMENT OF SUBLIMIS TENDONS AT WRIST.
Sunderland dissection
EARLY Literature

- Phalen in 1966 reported “no need for EDX in dx of CTS”
- In middle ’50’s Gilliatt noted “EMG and sweating tests are too time consuming for a busy clinic”
- Marinacci (1st text on EMG) used only needle EMG in dx CTS
- *Now we know that motor and sensory nerve stimulation studies are most specific and sensitive!*
- *Ultra sound imaging is helpful in clarifying causes BUT not in diagnosing severity!*
Signs of CTS - PX

- a) Weakness of thenar muscles
- b) Phalen sign
- c) Tinel sign
- d) Wrist ratio (see later)
- e) 2-point discrimination

Kuhlman & Hennessey found best: d>a>e>b>c
PHALEN SIGN
How to test thenar muscles
IN CTS - 3 Things can occur

• Some axons die
• Some axons block
• Some axons conduct slowly
• Some are functioning normally
• Any or all occur in combination
• This reflects in the EDX
Demyelination in CTS causing slowing

• When stimulated at wrist
  – *Increased latency – motor & sensory*
  – *Decreased amplitude: CMAP: SNAP:CNAP*
  – *Rise time & duration - increased*
Demyelination causing Conduction Block

- When median nerve is stimulated at wrist (proximal to carpal tunnel)
  - Decreased CMAP
  - Decreased SNAP
  - Decreased CNAP

- Reduced recruitment with needle EMG
Death of Axons is shown

- WHEN median nerve is STIMULATED **DISTAL** TO COMPROMISE
- Axon death results in decreased amplitudes:
  - SNAP
  - CNAP
  - CMAP
- Needle EMG – positive waves & fibrillation potentials; reduced recruitment
Prognosis

• Not related to latency or fibrillations
• Not related to MU recruitment
• **DIRECTLY RELATED TO CMAP/SNAP/CNAP AMPLITUDE** when median nerve is stimulated distal to the carpal ligament
IS THERE *edx* TO SCREEN FOR *cts*?

Yes!

And here’s How -
Radial nerve
Screen for CTS

• Median & radial nerves to dig 1
• 95% of latencies will differ by =/<.3 ms
• Note amplitude will be 3:1 median to radial
  – Sum will be >25 uV* (if less and latency is normal – consider axonal neuropathy or spinal nerve compromise distal to dorsal ganglion)

*’Pannozzo index’
Antidromic 10cm Technique To Digit I
Reference values for dig 1

- N= 78 latency (ms) ampl. (uV)
- Median n. 2.59 +/- .24 30.4 +/- 1.9*
- Radial nerve 2.44 +/- .23 11.6 +/- .6*
- 95% difference =/< .3 ms
- *’Pannozzo Index – total =/< 25uV
"bactrian sign"
If one stimulates both median & radial nerves at same time and place — radial SNAP will arrive slightly ahead of median 2d distance.
Bactrian sign
NB. Dur Of SNAP Is <2ms
Camel—A big animal with one or two humps on its back.

BACTRIAN CAMEL (ASIA)

ARABIAN CAMEL
How to Tell a Camel

The Dromedary has one hump,

The Bactrian has two.

It’s easy to forget this rule,
So here is what to do.
Roll the first initial over
On its flat behind:

The Bactrian is different from
The Dromedary kind.
Next step – Long finger

- Best to stimulate at 7 cm and 14 cm antidromic (NB. Proximal & distal to CT)
- Distal latency will be >1/2 of total
  - Distal nerve is narrower
  - Distal hand is cooler
- This is longest portion of median nerve
Antidromic 7cm, 14cm Technique To Digit III
Dig 3 SNAP 7 & 14 cm

- Mean latency 1.6 ms; 3.1 ms (±/- .3 ms)
- Mean amplitude 50 uV; 40 uV
- Cold increases amplitude and latency

- NB. Patients with Raynaud phenomenon or over-active sympathetics will have marked increases in ampl & latencies
Stimulation Proximal & Distal to Carpal Tunnel

• Sensory fibers
  – 14 cm; 7 cm rings separated by 4 cm on digit 3
  – Distal amplitude is =/< 30% greater than wrist stimulation
  – NB. Duration of negative spike is most sensitive to blocking in carpal tunnel.
Best electrode separation is 4 cm
**Recording Site:** digit 3

<table>
<thead>
<tr>
<th>Stimulus Site</th>
<th>Dur (ms)</th>
<th>Amp (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1: 4 cm separation</td>
<td>1.7</td>
<td>39.74</td>
</tr>
<tr>
<td>A2: 3 cm separation</td>
<td>1.5</td>
<td>32.19</td>
</tr>
<tr>
<td>A3: 2 cm separation</td>
<td>1.2</td>
<td>29.79</td>
</tr>
<tr>
<td>A4: 1 cm separation</td>
<td>1.2</td>
<td>17.45</td>
</tr>
</tbody>
</table>
Cool hand will change ratio of latencies distal and proximal

- Normal – distal 7 cm is slightly more than \( \frac{1}{2} \) (smaller diameter and cooler)
- If hand is very cool (sympathetic ++), the proximal latency can cover up the mild CTS.
- Cool hands will increase amplitudes and durations as well as latencies.
Calibr: 1ms; 20 uV
Top trace – dig 1 midpalm (7cm)
Bottom trace – dig 1 wrist (14 cm)
Digit 3
20 µV
7/14 cm
1 ms
7/14 cm Digit 3
Kimura’s “Inching” Technique
Why “inching” doesn’t work with surface stimulation

- Course of median nerve
  - Superficial at wrist
  - Deep in carpal tunnel
  - Superficial in palm
Surface stimulation will NOT activate nerve equally
Why onset latency is NOT the best measurement

- If some of axons are normal –
  - Onset latency will be normal
    - **BUT** -
      - Rise time will be increased
      - Peak latency will be increased
      - Duration of negative spike will be increased
- Rise Time
- Peak
- Duration
All axons are OK

Some axons are OK. Some are abnormal.
Reference values
digit 3 - 7cm/14 cm

- Amplitudes – 7cm: 51 uV, 14 cm: 63 uV
- *Unless cool hand* – always <30% incr at 7 cm

- Latencies – 7 cm 1.6 ms; 14 cm 3.1 ms

- Duration neg spike - .9 (distal) – 1.2 ms (wrist)
  - NB. *1st abnormality to occur in demyelination*
Distal motor latency

D.L. = 3.7 ± .3 for both Ulnar & Median

4 cm

8 cm

4 cm
Importance of Electrode placement
Difference in latency median and ulnar nerves

- If one measures carefully, the ulnar latency will be slightly shorter
- Median nerve travels longer as it curls back to thenar muscles
- DIFFERENCE =/< .5 ms
Martin-Gruber anomaly

• **3 red flags** of M-G anomaly in **CTS**
  – CMAP has initial positive deflection at elbow stimulation
  – CMAP larger at elbow stimulation
  – CV is falsely fast (can even be negative)

  – NB. In **normals** only sign is larger CMAP at elbow stimulation
Martin-Gruber

Elbow

Wrist

2.0 mV  5 ms  

2.0 mV  5 ms
CMAP proximal and distal to the Carpal Ligament

- AXIOM OF ENTRAPMENT SYNDROMES

- Stimulate proximal and distal to entrapment and note latency and amplitude (CMAP)
  - Slowing
  - Blocking
  - Death of axons
Stimulation of median nerve distal to carpal ligament
Pin stimulation will locate exact site for Nerve stimulation
Wrist and midpalm stimulation

- Best way to show *conduction block* of motor axons
- Can be ‘acute’ CTS
  - Hx of vigorous use of wrist or hand eg.
    playing hockey for 6 days in a row
    Or using hand sprayer for 8 hours a day

  NB. Normal increase of CMAP <1 MV (10%)
  Normal increase of SMAP <30%
Mid-palm

CMAP, abd pol br

wrist
Median Nerve

NB Gain is 5 K

Wrist

5.0 mV 2 ms

NB Gain is 10 K

Midpalm

10.0 mV 2 ms
CMAP THENAR

CTS Stimulate Median Nerve at Wrist

Stimulate Median Nerve Mid Palm
CMAP SHAPE MUST BE SAME
FOR WRIST AND MID-PALM
OR ULNAR NERVE IS STIMULATED
“Expected normal amplitude of Median CMAP if bilateral CTS is present

• Mid palmar strimulation will give approximate CMAP for “living” axons
• However, if patient has bilateral CTS
  – Best estimate of expected normal will be within 1 millivolt of ulnar hypothenar CMAP
MIXED Nerve Latency (Mayo technique)

• Remember! This is a mixed nerve
• It does not belong in “sensory action potential – ”SNAP”
  – This is a compound nerve action potential – CNAP
    • Median CNAP will be large (>100 uV) if surface recording electrode is at base of wrist where nerve is superficial!
    • Ulnar CNAP will be smaller(<40 uV) – ulnar nerve is deep, under the flexor carpi ulnaris tendon.
Mixed Nerve 8cm Technique

(Trans-carpal)
Median nerve

Ulnar nerve
Trans-carpal values

- Latency = 1.8 ms +/- .2
- Amplitudes – median 80 – 150 uV; ulnar – 20 - 40 uV

- NB. Latency difference =/< .3 ms (EWJ)
  (Stevens - .2 ms; Wertz - .4 ms)
Mild CTS

Ulnar nerve

Median nerve
What’s wrong with MIXED NERVE LATENCY?

- IT includes both motor (to lumbricals) and sensory nerve fibers
  - Unless motor and sensory are equally affected – values can be misleading
  - If motor is OK and sensory latency prolonged – diagnosis can be erroneous!
Median/Ulnar SNAP Digit 4

- Useful in questionable cases
- Helpful in CTS with underlying neuropathy
- Some say “best single test” for CTS

**NB. “we prefer median /radial to thumb”**
WW II study on war wounds involving median and ulnar Nerves
Original study – ulnar & median to digit 4

Johnson, Kukla, Wongsam, Piedmont
Arch Phys Med & Rehab 1981
Digit 4 SNAP (14 cm)

- Amplitude – 30 uV w/median>ulnar
- Latency – 3.0 ms +/- .2 ms

- 95% difference =/<= .3 ms
Recording Site: Ring Finger

Stimulus Site
A1: Median Wrist
A2: Ulnar Wrist
Median/Ulnar CMAP to intrinsic muscles

- 10 cm from Lumbrical I or II
- Stimulate median nerve
  - CMAP will be 1-2 millivolts
- Stimulate ulnar nerve
  - CMAP will be 4-6 millivolts
  - Latency difference => .5 ms
MOTOR
MEDIAN/ULNAR TO INTRINSICS
NB. We use 10 cm instead of 12
E₁  L-1 Median N. Stim.

10 cm
E₁  L-1 Ulnar N. Stim.

10 cm
ULNAR \text{ MED} \quad \text{LATENCY DIFF.} \quad \lessdot 0.5 \text{ms}
Recording Site A: ABD POLL BR
Recording Site B: ABD DIG V

<table>
<thead>
<tr>
<th>STIMULUS SITE</th>
<th>LATI ms</th>
<th>DUR ms</th>
<th>AMP mV</th>
<th>AREA mVms</th>
<th>TEMP °C</th>
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<tbody>
<tr>
<td>A1: PALM</td>
<td>2.3</td>
<td>7.0</td>
<td>7.682</td>
<td>29.60</td>
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<tr>
<td>A2: WRIST</td>
<td>6.2</td>
<td>6.4</td>
<td>2.630</td>
<td>9.365</td>
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<tr>
<td>A3: ELBOW</td>
<td>11.4</td>
<td>6.2</td>
<td>2.539</td>
<td>8.455</td>
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<tr>
<td>B4: ELBOW</td>
<td>3.3</td>
<td>5.9</td>
<td>8.891</td>
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<td>B5: W-ULNAR</td>
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<td></td>
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<tr>
<td>B6:</td>
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<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>DIST mm</th>
<th>CV m/s</th>
<th>fAMP</th>
<th>fAREA</th>
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<tr>
<td>PALM-WRIST</td>
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<td>31.6</td>
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<td>WRIST-ELBOW</td>
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<tr>
<td>ELBOW-W-ULNAR</td>
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<td>350.1</td>
<td>276.7</td>
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<tr>
<td>W-ULNAR-B6</td>
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</table>
Lumbrical Midpalm Amplitude: 2128 uv

Lumbrical Latency: 3.4 ms
Amplitude: 2128 uv
Another technique if there is question (recurrent or post-op)

- Lumbrical I or II recording
- Stimulate median nerve
- Increase GAIN to 50 uV/cm
- SNAP recorded is from palmar branch of median nerve (escapes carpal tunnel)
- Compare with median SNAP digit I (same distance but goes thru CT)
PALMAR BR.
DIGIT 1 BR.  }   DIFF.   }  \leq 0.3\text{ms}
LATENCY IS NOT THE BEST MEASURE

- Latency ONLY reflects the demyelination in the carpal tunnel
- Latency is NOT a measure of dead axons
Wrist dimensions: Correlation with latencies

Johnson, Gatens, Poindexter, Bowers
Arch Phys Med & Rehab 1983
CROSS SECTIONS THROUGH WRIST

\[ \frac{T}{W} = \text{RATIO} \]

RATIO = 0.60

RATIO = 0.76
Wrist Dimensions: Correlation with Median Sensory Latencies

Men (n=29)

L = 9.96R - .83
Correlation factor 0.76 (p<0.001)
Wrist Dimensions: Correlation with Median Sensory Latencies

Women (n=38)

\[ L = 9.25R - 2.10 \]

Correlation factor 0.70 (p<0.001)
Plot of Median Motor Latency vs Wrist Ratio Showing a Moderate Positive Correlation Between Latency and Wrist Ratio
BEST EDX for CTS
(ala Johnson)

• Screen “numb thumb”
• Median SNAP digit 3 at 7 and 14 cm
• CMAP thenar, proximal and distal to CT

• If need more data of nerve function- sensory
  - Ulnar SNAP to digit 5 (or compare median and ulnar to digit 4)
• Motor – median/ulnar to interossei
If I’m still doubtful

- Review the Hx and Px
- What am I thinking?
  - Generalized?
  - Co-incident condition?
- Rarely in simple CTS – Needle EMG!
Bottom line

- ABNORMAL – for diagnosis
  - Sensory diff =/> .3ms
  - Motor diff =/. .5 ms
  - NB. THESE ARE “RED FLAGS” for diagnosis

FOR SEVERITY - amplitudes on both sides of carpal ligament!
Treatment of CTS

Surgery or ???
Wrist orthosis
USE TB SYRINGE
NO ANESTHESIA!
0.5 ml decadron
TREATMENT

Severity = amplitude

• Latency IS IRRELEVANT TO severity

• Severity is determined by amplitude of SNAP & CMAP distal to the carpal tunnel

• Loss of amplitude –
  – >50% “severe”
  – Operation = clinical symptoms & EDX
IF ANY RED FLAGS -

- Needle EMG
- Sural nerve SNAP
- Ulnar nerve F wave
- Try other techniques
  - T-C mixed CNAP
  - Dig 4 –Ulnar/median SNAP
  - Lumbar/interossei CMAP
DON’T FORGET

• Amplitude
• Amplitude
• Amplitude
• Amplitude
• Amplitude
• Amplitude
• Amplitude
• Amplitude
• Amplitude
References

References

References

• Kimura, J: A method for determining median nerve CV across the carpal tunnel. 1978. J Neurol Sciences 38:1