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 gripping
  - Symptoms more prominent at night

81 y/o lady being treated for ‘arthritis’ for 8 years
Definition of CTS

- Pain and numbness
- Secondary to median nerve dysfunction in the carpal tunnel
- If there is dysfunction, EDX will identify pathology
Signs of CTS - PX

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

Kuhlman & Hennessey found best:
d>a>e>b>c
Review of 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
IN CTS - 3 Things can occur

- Some axons die
- Some axons block
- Some axons slow
- Some are functioning normally
- *Any or all occur in combination*

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
Demyelination in CTS causing slowing

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

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 recruitment
- **DIRECTLY RELATED TO CMAP/SNAP/CNAP AMPLITUDE distal to the carpal ligament**

IS THERE edx TO SCREEN FOR cts?

Yes!
And here’s How -
Radial nerve

E1

E2

Antidromic 10cm Technique To Digit I
Screen for CTS

- Median & radial nerves to dig 1
- 95% of latencies will differ by =/<=0.3 ms
- Note amplitude will be 3:1 median to radial
  - Sum will be >25 uV* (if less and latency is normal
    - consider neuropathy or spinal nerve compromise
distal to dorsal ganglion)

*’Pannozzo index’
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
If one stimulates both median & ulnar nerves at one time – 'abortive Bactrian sign'.

If one stimulates both median & radial nerves at the same time and place – radial SNAP will arrive slightly ahead of median.
Bactrian Sign

NB. Dur Of SNAP Is <2ms

20.0 µV 1 ms

Bactrian camel

hump on the back: DROMEDARY (C. bactrianus) with two humps
family Camelidae: a watertight
or cylinder) used esp. to lift
attached to the object to be raised,
ater: a variable color averag-
that is slightly redder and very
ki, yellower and less strong than
n less than walnut brown.
Camel—A big animal with one or two humps on its back.

ARABIAN CAMEL

BACTRIAN CAMEL (ASIA)

How to Tell a Camel

The **D**romedary has one hump,
The **B**actrian 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 **B**actrian is different from
The **D**romedary kind.

—J. Patrick Lewis
Next step – Long finger

- Best to stimulate at 7 cm and 14 cm antidromic \textit{(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
**Dig 3 SNAP 7 & 14 cm**

- Mean latency 1.6 ms; 3.1 ms (+/- .3ms)
- 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.
Cool hand will change ratio of latencies distal and proximal

- Normal – distal 7 cm is slightly more than ½ (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.
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>
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</thead>
<tbody>
<tr>
<td>A1: 4 cm separation</td>
<td>1.7</td>
<td>39.74</td>
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<tr>
<td>A2: 3 cm separation</td>
<td>1.5</td>
<td>32.19</td>
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<tr>
<td>A3: 2 cm separation</td>
<td>1.2</td>
<td>29.79</td>
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<tr>
<td>A4: 1 cm separation</td>
<td>1.2</td>
<td>17.45</td>
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Digit 3  7/14 cm  20 µV  1 ms
Calibr: 1ms; 20 uV
Top trace – dig 1 midpalm (7cm)
Bottom trace – dig 1 wrist (14 cm)
Why “inching” doesn’t work

- 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*
  - Rise time will be increased
  - Peak latency will be increased
  - Duration of negative spike will be increased
- Rise Time
- Peak
- Duration

Onset vs. Peak
SNAP Latency
Reference values
digit 3  7/14 cm

- Amplitudes – 7cm: 51 uV, 14 cm: 63 uV
- Latencies – 7 cm 1.6 ms; 14 cm 3.1 ms
- Durations - .9 (distal) – 1.2 ms (wrist)

Numbers to remember

- SNAP will increase <30% at 7 cm stim
- Duration of negative spike is most SENSITIVE for slowing in carpal tunnel
  - 1.1 ms at wrist stim (14 CM)
  - .9 ms at mid palm 7 cm
Distal motor latency

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 **normal** only sign is larger CMAP at elbow stimulation
Stimulation of median nerve distal to carpal ligament
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%)
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
CMAP must have same shape at both wrist and midpalm stimulation OR ulnar nerve is being stimulated
“Expected amplitude of Median CMAP if bilateral CTS is present

- Mid palmar stimulation 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 CMAP*

Numbers to remember

- CMAP will increase 10% or less at mid palm stimulation
- NB. Shape of CMAP must be same or ulnar nerve was stimulated
- If uncertain re: expected (normal) amplitude; CMAP of hypothenar will be w/in 1 millivolt
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)
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 – can be missed diagnosis

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

<table>
<thead>
<tr>
<th>AGE RANGE</th>
<th># SUBJ</th>
<th>F</th>
<th>M</th>
<th>DOM. HAND</th>
<th>NON-DOM. HAND</th>
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<td>5</td>
<td>3.12±1.8</td>
<td>3.11±1.5</td>
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<td>3.15±1.8</td>
<td>3.06±1.6</td>
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<td>30-39</td>
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<td>4</td>
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<td>4</td>
<td>3</td>
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<td>3.04±.20</td>
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<td>3.19±.29</td>
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<td>3.30±.23</td>
<td>3.08±.23</td>
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<td></td>
<td></td>
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<td>3.28±.24</td>
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<tr>
<td>Total</td>
<td>37</td>
<td>18</td>
<td>19</td>
<td>3.14±.24</td>
<td>3.03±.21</td>
</tr>
</tbody>
</table>

MEAN LATENCY ± SD
(MEAN + 2 SD)

FINAL STUDY
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

MOTOR
MEDIAN/ULNAR
TO INTRINSICS
Median/Ulnar CMAP to intrinsic muscles

- 12 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
LUMBR. I or II
12 cm
ULNAR MED } LATENCY DIFF. } ≤ .5ms
Another technique if there is question

- 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)
LATENCY IS NOT THE BEST MEASURE

- Latency ONLY reflects the demyelination in the carpal tunnel
- Latency is NOT measure of dead axons

Wrist dimensions – correlation with median N latencies

Johnson, Gatens, Poindexter, Bowers
Arch Phys Med & Rehab 1983
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 v Wrist Ratio Showing a Moderate Positive Correlation Between Latency and Wrist Ratio
BEST TESTS

- Most sensitive and specific **screen**
  - I used to say (good studies support) – digit 1 median/radial SNAP
  - Some say – digit 4 median/ulnar SNAP
  - Robinson – 3 techniques 2/3 will be best
  - **NOW** – I say digit 1 for screen; then one must stimulate proximal and distal to carpal lig. ie. 7/14 cm digit 3; CMAP proximal & distal to carpal lig

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!**
Severity = amplitude

- Latency IS IRRELEVANT TO severity
- Severity is determined by amplitude of SNAP & CMAP \textit{distal} to the carpal tunnel

DON’T FORGET

- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
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

References

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Johnson-48@medctr.osu.edu

Super EMG Kauai
11 Feb – 18 Feb, 2006