

Neurography, Introduction and update

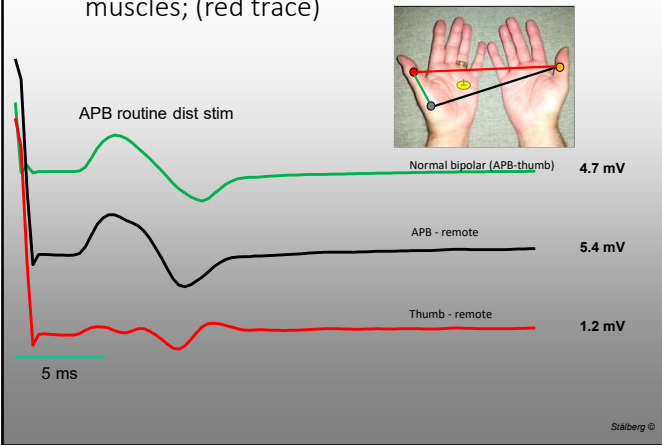
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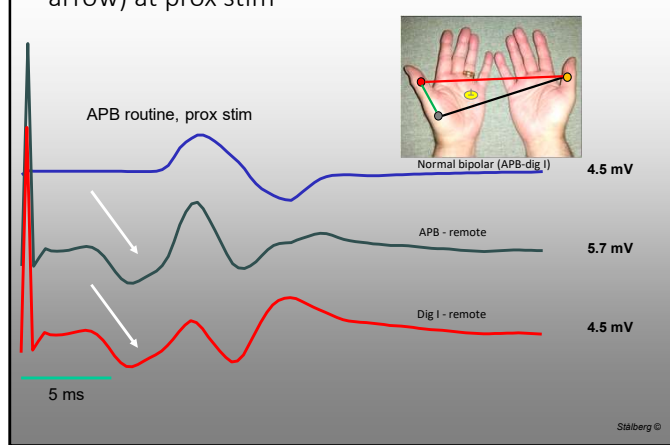
What physiological and anatomical functions motor neurography reflects

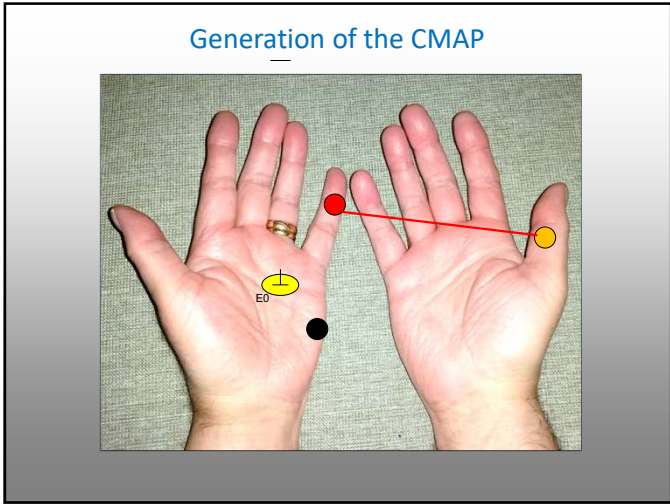
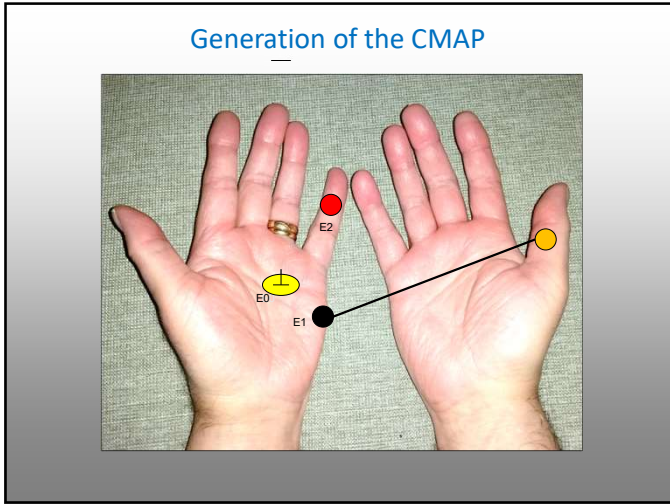
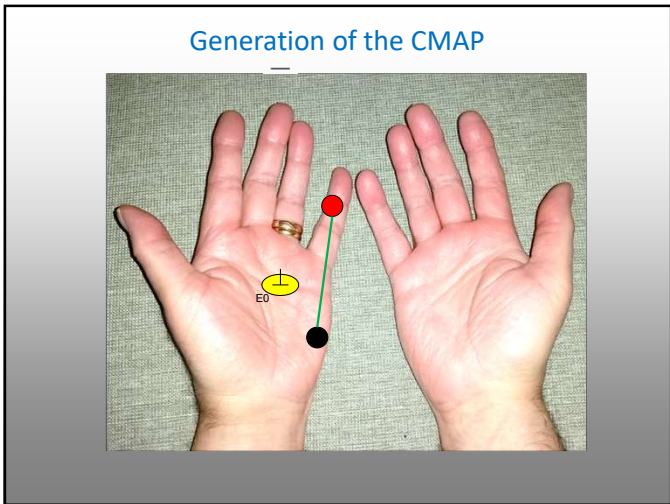
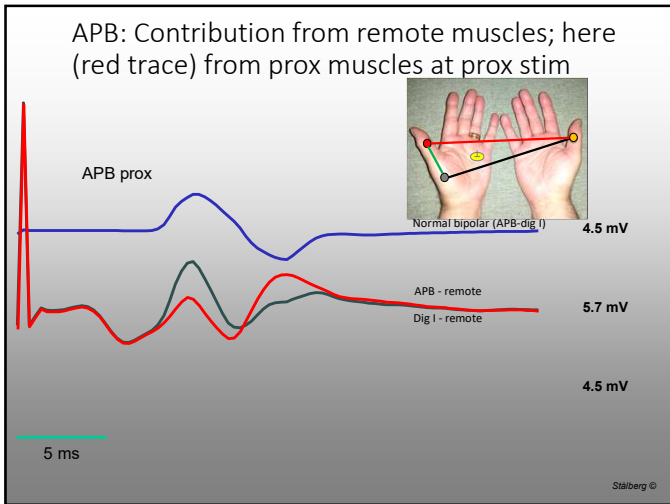
- | | |
|---------------------|---|
| Amplitude | <ol style="list-style-type: none"> 1. Number of Mus 2. Size of Mus 3. Diameter of muscle fibres 4. Dispersion of CV |
| Conduction velocity | <ol style="list-style-type: none"> 1. State of the myelin 2. Axon diameter (MU size) |
| Duration | <ol style="list-style-type: none"> 1. Dispersion of CV |
| Distal latency | <ol style="list-style-type: none"> 1. CV in distal segment 2. Length of distal segment 3. Nm transmission time |
| Decay | <ol style="list-style-type: none"> 1. Dispersion of CV 2. Conduction block |

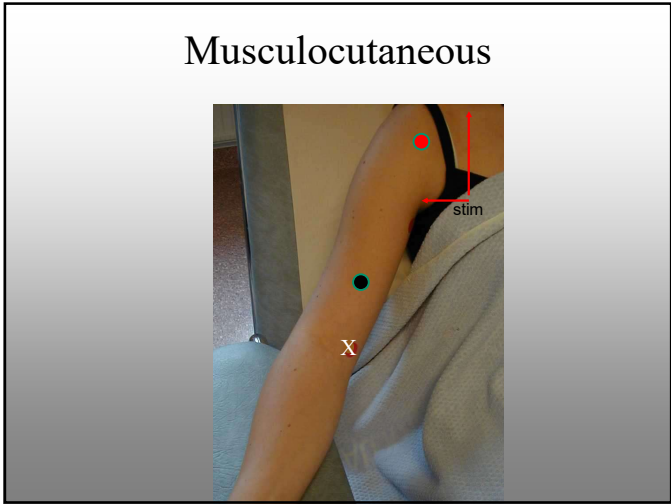
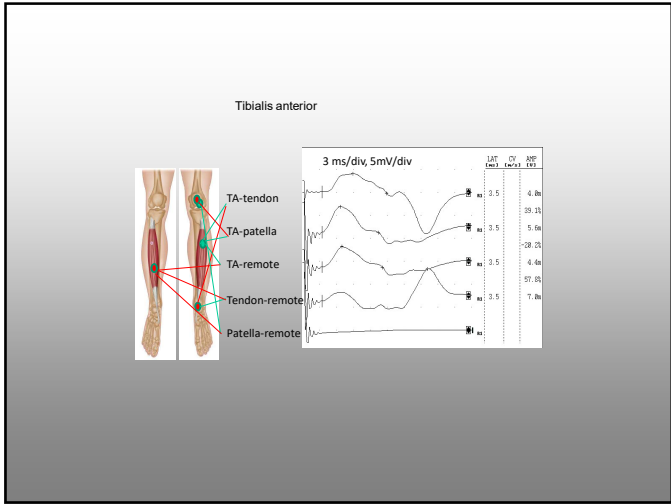
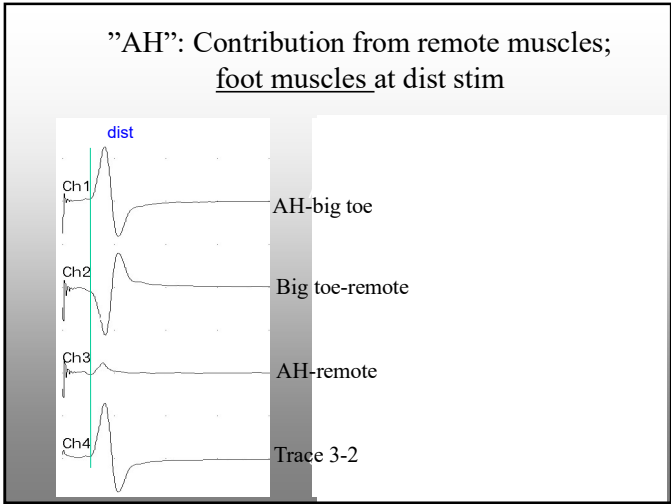
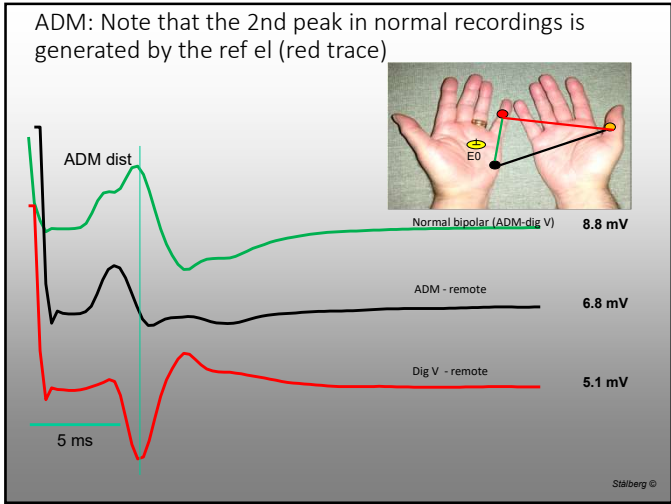
APB: Contribution from adjacent muscles; (red trace)



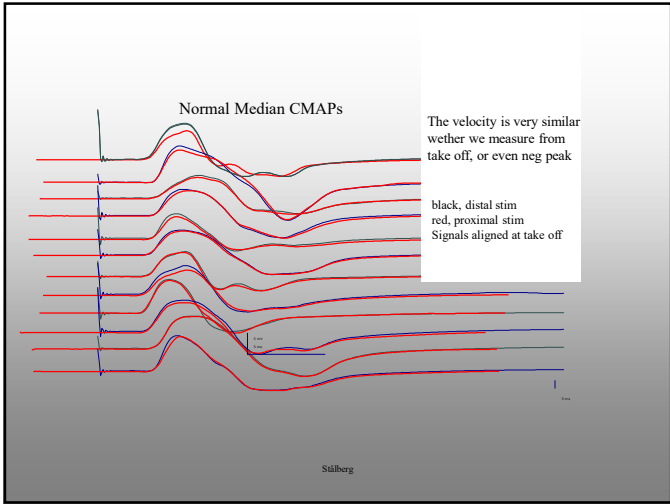
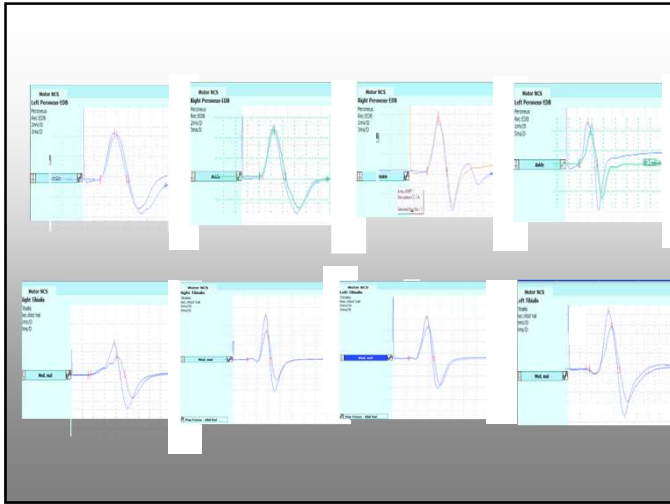
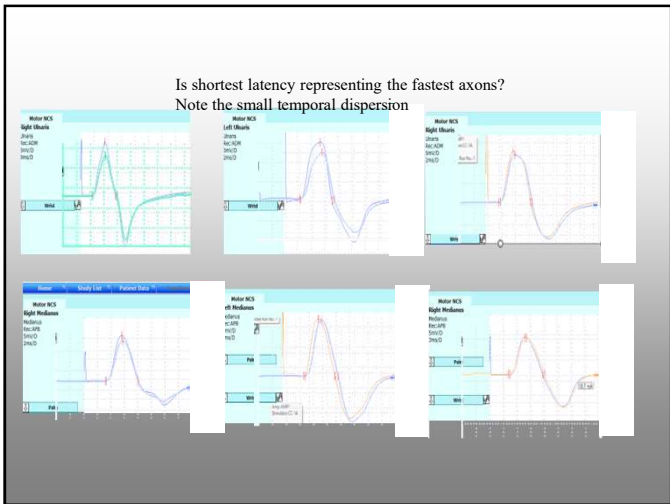
APB: Contribution from forearm flexors (green arrow) at prox stim







CMAP Take off may not represent fastest axons!



MUP in the CMAP
Is shortest latency in the CMAP really representing fastest axons?

Changed order of arrival due to different degree of slowing in distal axons
Most of the dispersion takes place distally,
note the similarity between distal and proximal CMAP duration

Stålberg, Nandedkar, Barkhaus, unpublished

Biathlon

The order of nerve action potentials may change dramatically at the terminal nerve segment with slow conduction, like reordering of competitors in skiathlon when shooting.

Final time depends on speed on ski and shooting time and accuracy

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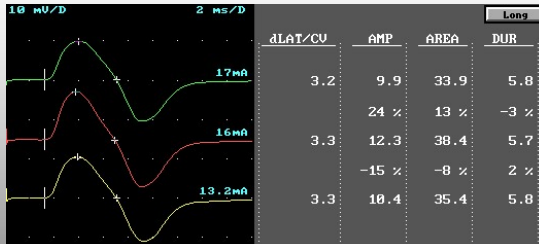
Parameters of importance for neurography

- **Technical**
 - Electrode type
 - Electrode position
 - Reference electrode position
 - Muscle length
 - Stim-rec distance
 - Stim strength
 - Distance (sensory)
 - Temperature
 - Volume conduction

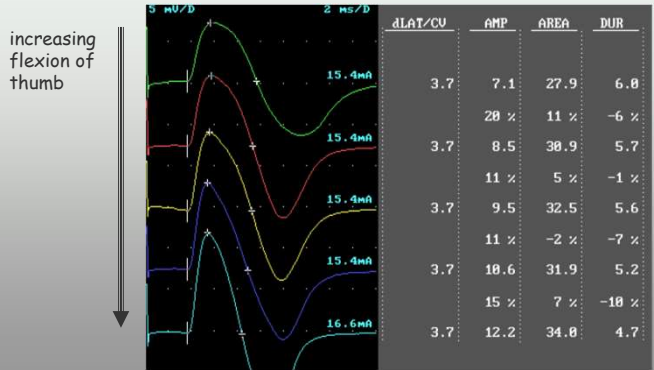
Parameters of importance for neurography

- **Biological**
 - # axons
 - Size of MU
 - N-m transmission
 - Axonal diameter
 - Myelination

Effect of electrode type



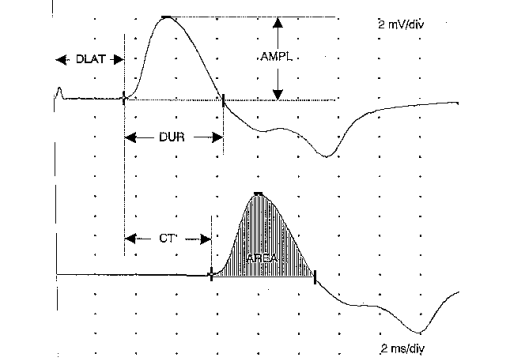
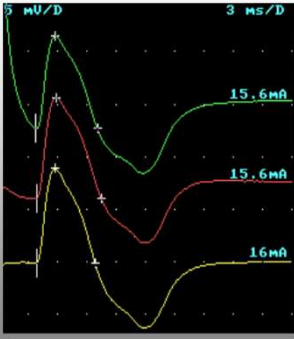
Effect of muscle length on the M wave

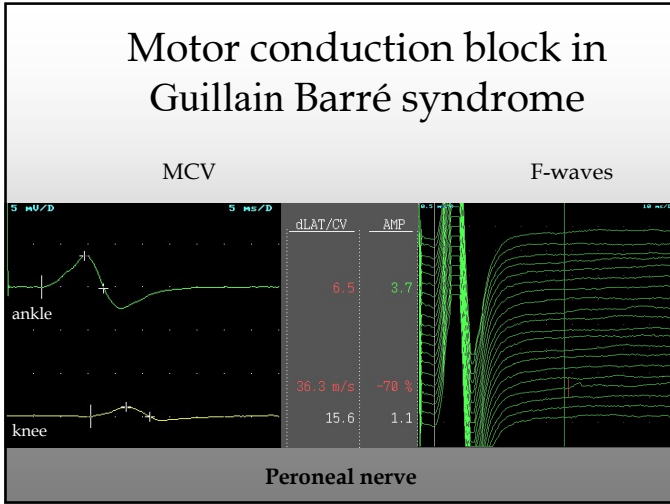
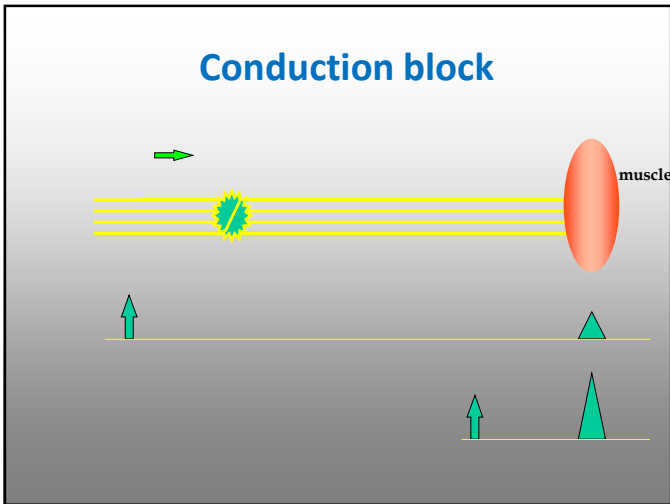
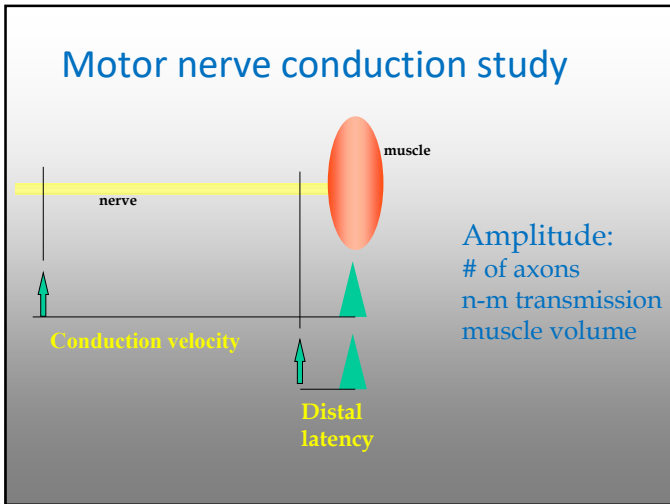


Recording from thenar muscles - median nerve

Dealing with stimulus artefact

1. poor initial baseline
2. ground electrode between stimulating and recording electrodes
3. rotation of the anode of the stimulating electrode
4. biphasic stim pulse



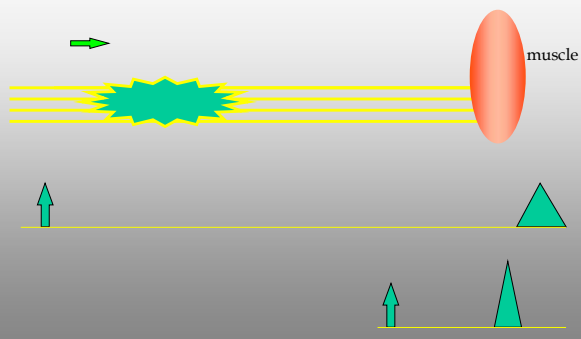


- ### Practical criteria of conduction block Uppsala
- Motor decay abnormal without dispersion
 - Arm: >25% decay and <15% dispersion
 - Leg:
 - Fibular nerve >30% decay and <30% dispersion
 - Tibial nerve > 55% decay and <45% dispersion
 - Reduced number of F waves

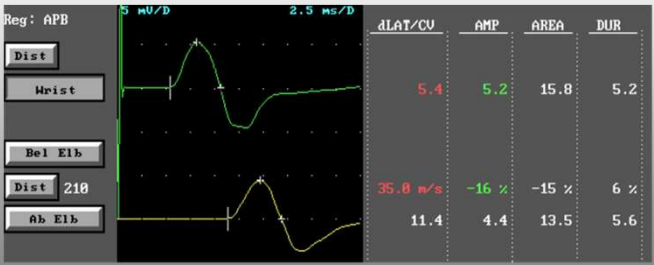
Block vs temporal dispersion (TD)

- Block is associated with weakness
- TD not associated with weakness
- Block is associated with IVIg response

Demyelination



Demyelinating neuropathy



median nerve in a patient with HMSN 1

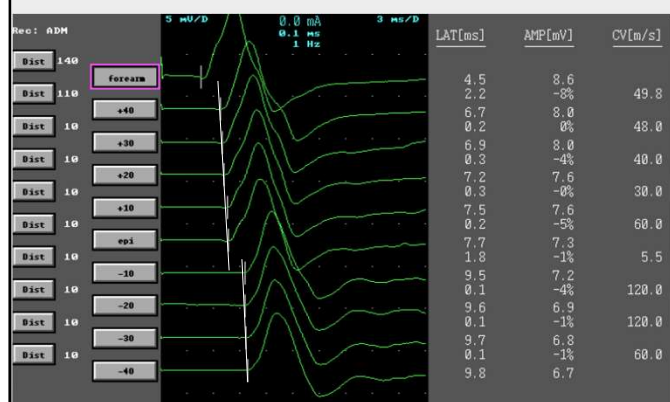
Demyelinating neuropathy

- CV reduced to < 60% mean velocity
 - median nerve CV < 38 m/s
- distal latency > 7 ms
- normal or reduced amplitudes

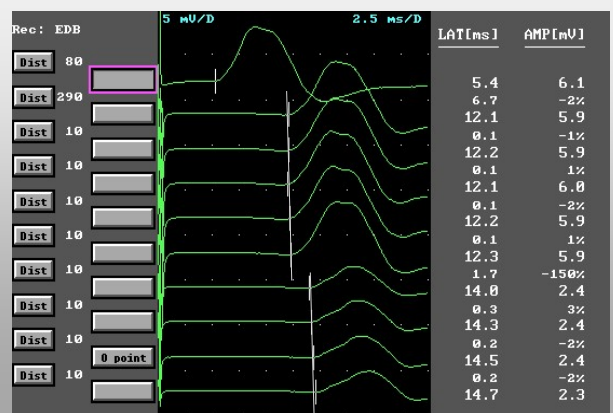
Ulnar nerve short segment study



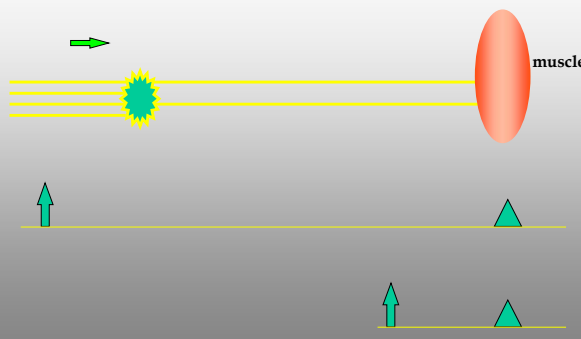
Retroepicondylar ulnar nerve lesion



Slimmer's palsy



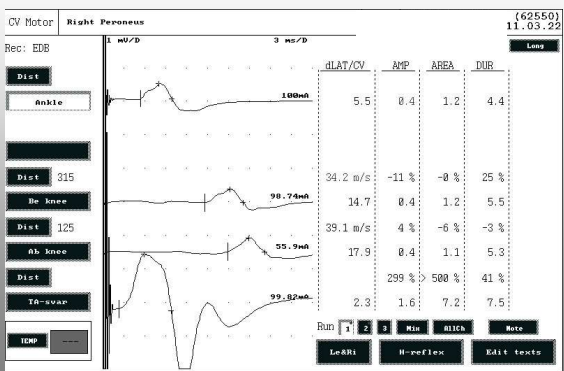
Axonal degeneration



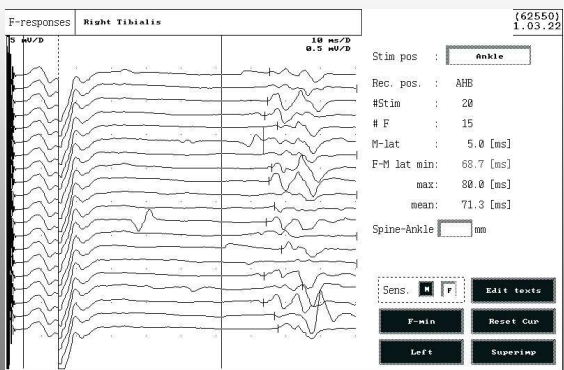
Axonal neuropathy, focal or generalized

- Reduced motor and sensory amplitudes
- Conduction velocity normal or slightly reduced
 - median motor > 40 m/s
- Distal latency normal or slightly prolonged
- No decay

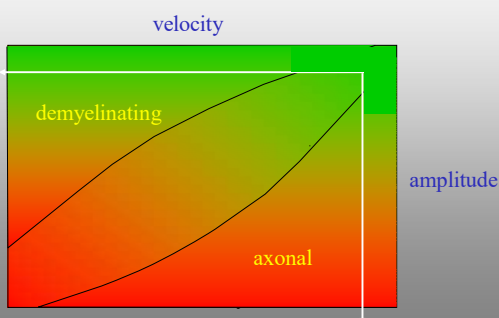
Axonal neuropathy, uremic



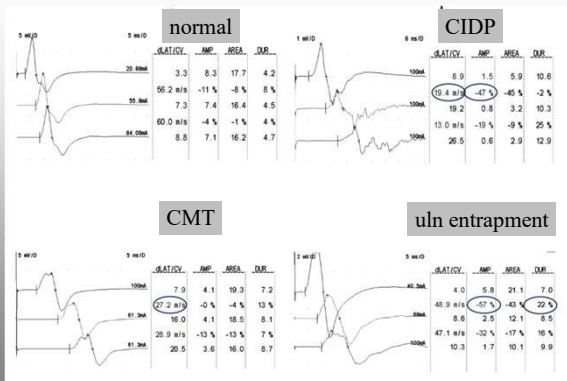
Axonal neuropathy, uremic



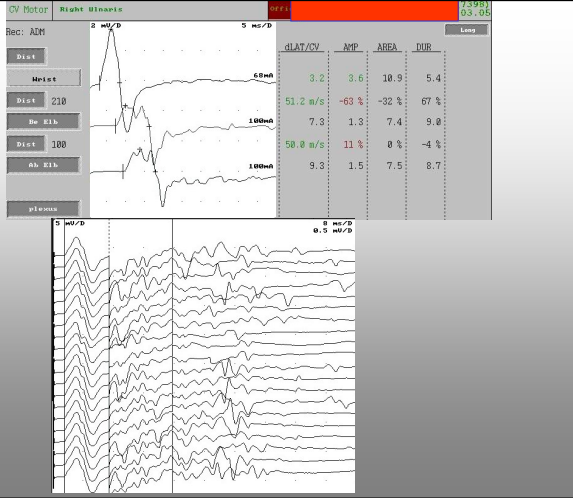
Demyelinating or axonal neuropathy? Velocity vs Amplitude



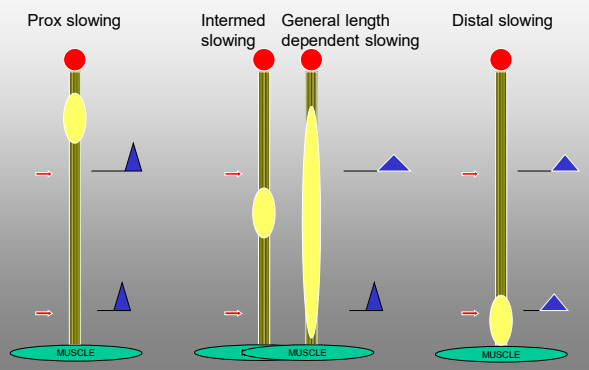
Examples of CMAPS



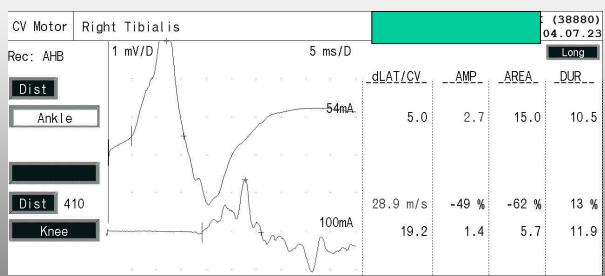
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Distal, general or proximal slowing



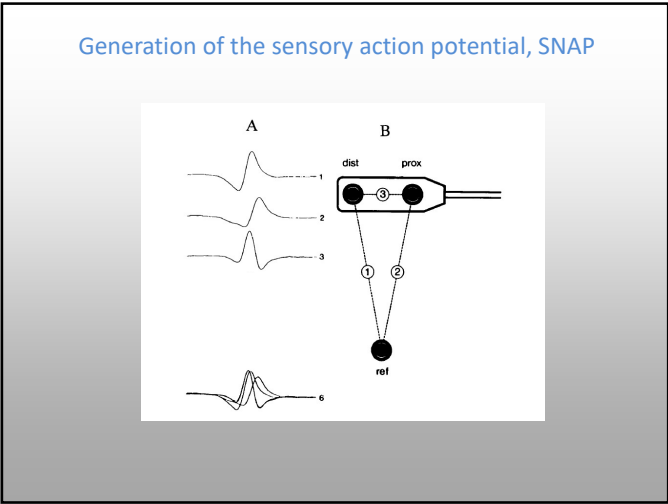
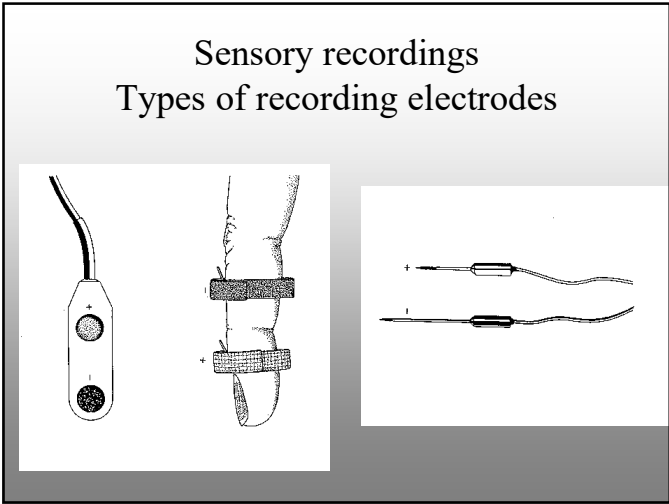
Dispersion in CIDP



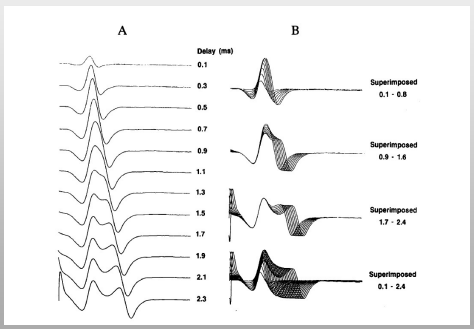
Sensory recordings

Orthodromic vs. antidromic SCS

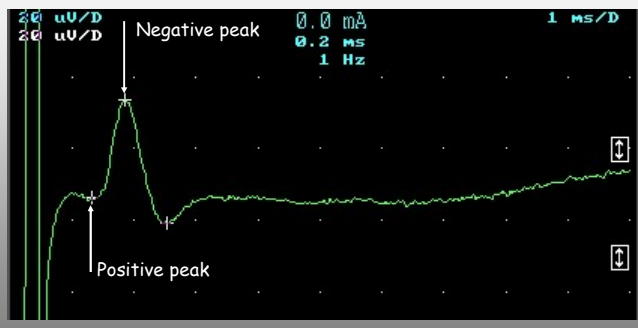
<p>Antidromic</p> <ul style="list-style-type: none"> : less painful : larger amplitude ◆ muscle artifact in mixed nerves 	<p>Orthodromic</p> <ul style="list-style-type: none"> : no muscle artifact ◆ more painful ◆ lower amplitude
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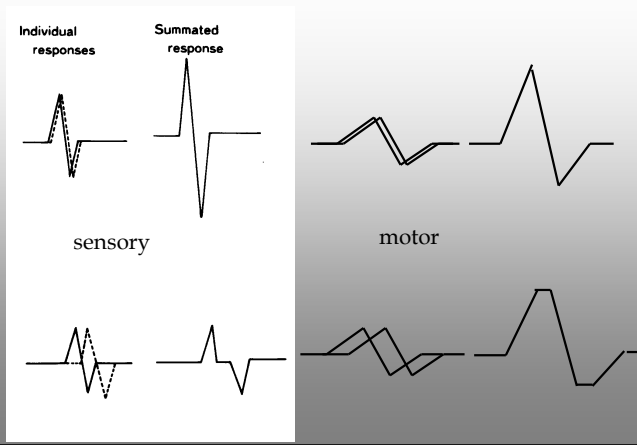
Effect of inter-electrode distance or reduced cond vel



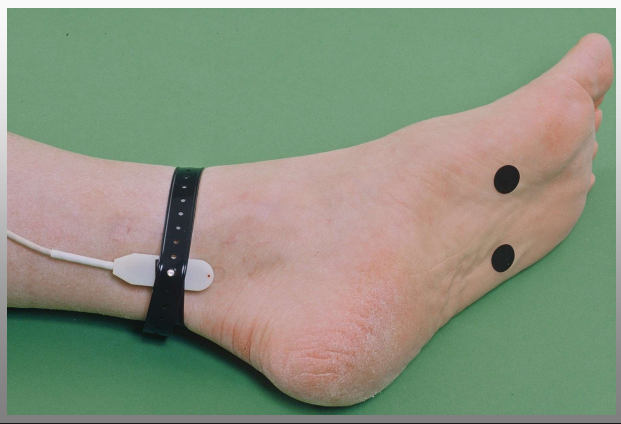
Latency



Phase cancellation



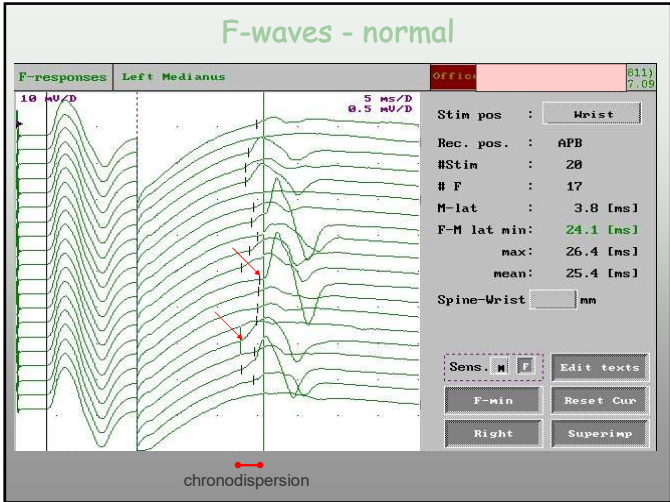
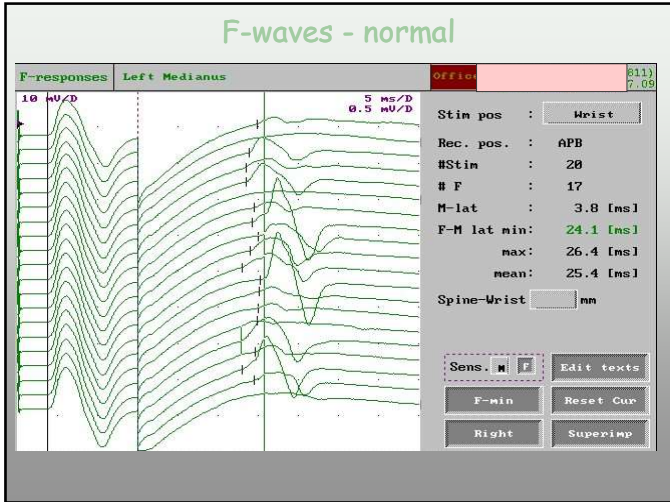
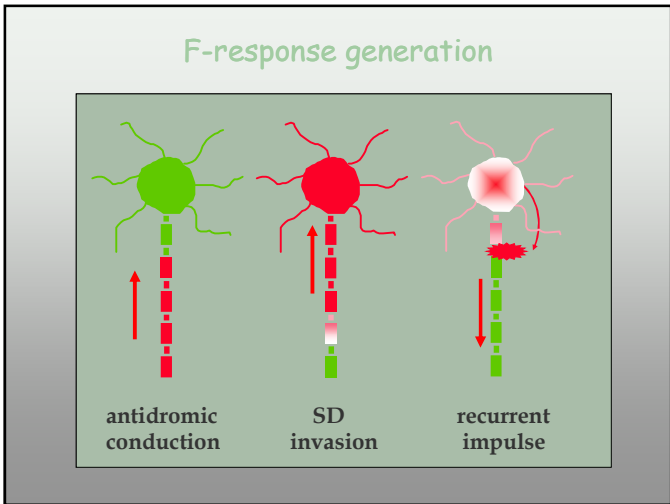
Medial and lateral plantar nerves

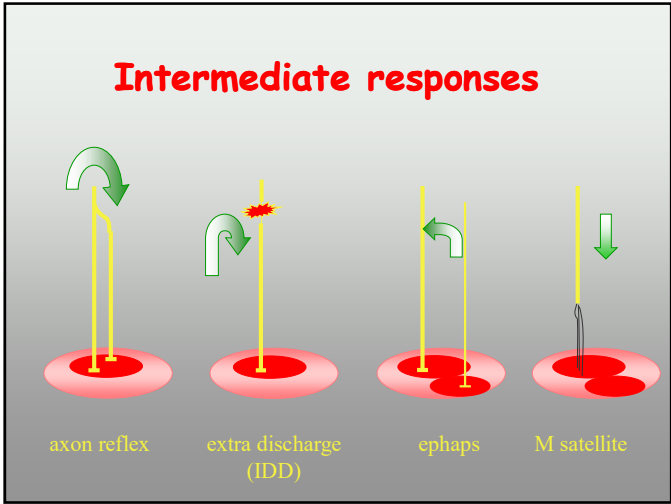
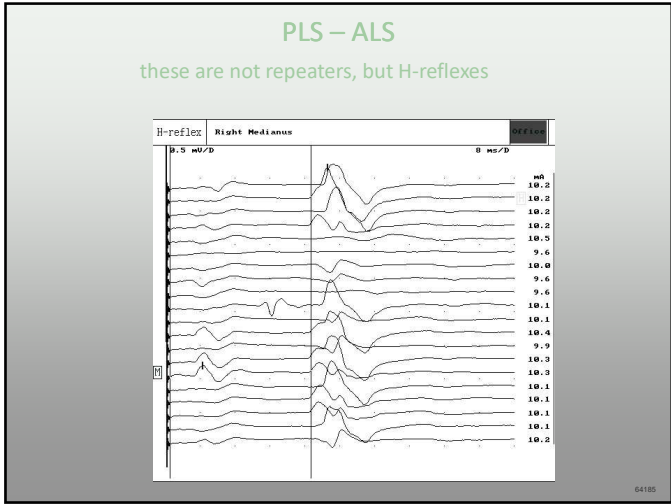
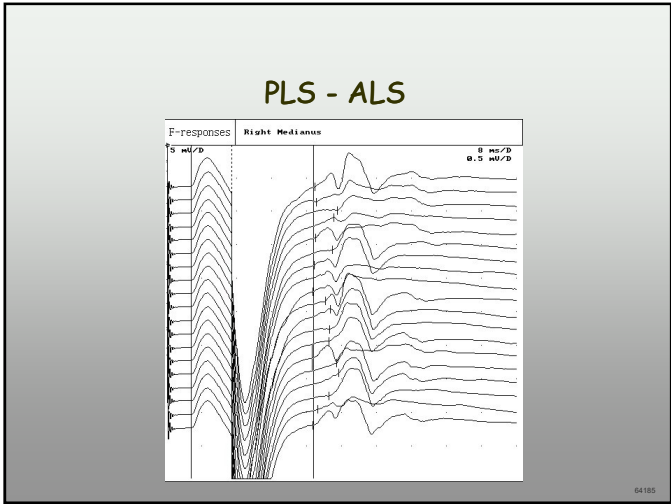
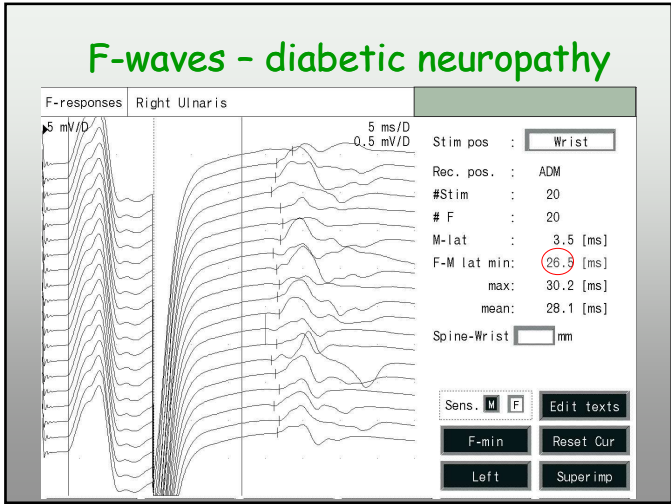


Late responses & Reflexes

- F-wave
- Repeaters
- A-wave
- CMAP followers
- H-reflex
- T-wave
- Blink-reflex
- Flexion-reflex
- Interlimb reflex
- C-wave

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A waves and CMAP satellites

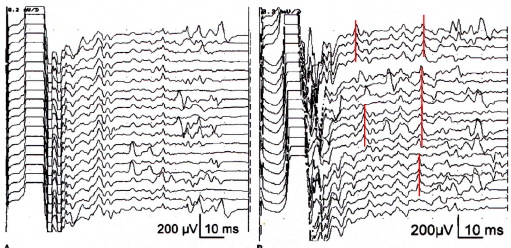
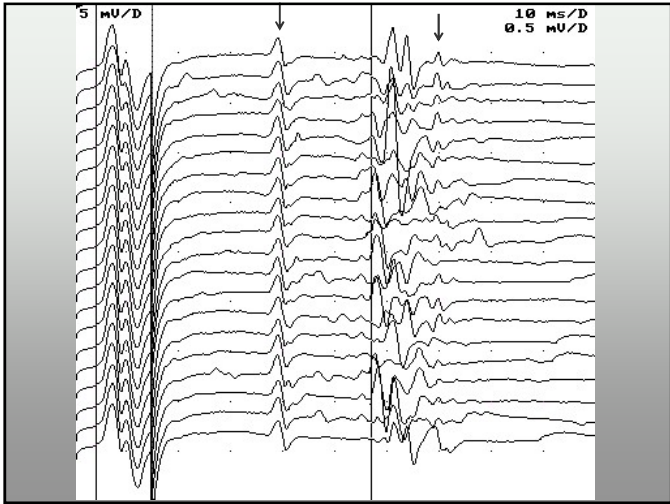


FIGURE 1. (A) Surface recordings from the abductor hallucis muscle of a patient with Guillain-Barré syndrome following 20 supra-maximal stimuli to the tibial nerve at the medial malleolus. Note the number and constancy of onset latencies of late waves following the M response. (B) Same nerve and recording conditions as in Fig. 1A but with stimulus site moved 2 cm proximally along the nerve each 10th trace. The constant responses shifting to the left are A waves, whereas those shifting to the right may be late components of the M response or A waves generated distal to the stimulus site.



A waves, F-waves, Repeaters, H-reflex

- CMAP satellite: (CMAP dispersion)**
the late comp. follow the CMAP with change in cathode position
- A-waves (> 7/20 stim): (axonal hyperexcitability)**
start in the axon. Latency varies from CMAP to after the F-waves
- F-waves latency (conduction over long segment)** from the motor neuron, generated
- Repeaters (loss of axons):**
repeating F-waves (2-7 per 20), latency = F
- H-reflex (pnp, radiculopathy, spasticity):**
same latency as F-waves. Constant shape seen with low stim and low CMAP

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Difference between A-waves, F-waves and H reflexes

<i>name</i>	<i>generator site</i>	<i>physiology</i>
A-wave	peripheral nerve	ion channel
F-wave	motor neuron	neuron excitability
H-reflex and	sens+motoraxon +motor neuron	sensory+motor cond. +excitability

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More reading

Standards for quantification of EMG and neurography. Stalberg E, van Dijk H, Falck B, Kimura J, Neuwirth C, Pitt M, Podnar S, Rubin DI, Rutkove S, Sanders DB, Sonoo M, Tankisi H, Zwarts M. Clin Neurophysiol 2019;130(9):1688-1729.

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