Technical Pitfalls in NCS/EMG

오 지 영
건국대병원

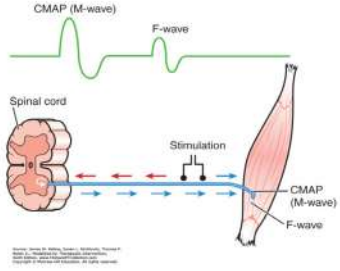
Procedure of electrodiagnosis

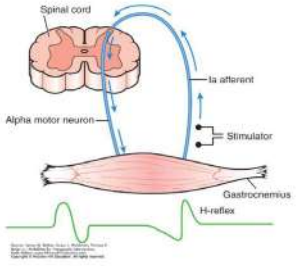
Motor NCS

F-reflex

Sensory NCS

EMG





Check up

Before procedure

- 환자 병력 청취, 진찰
- 검사 이유 설명
- 검사 과정, 방법 설명
- Routine vs. special study

During procedure

- 체온 측정
- 환자 불편, 움직임 최소화

After procedure

- 검사 후 과정 설명

General features in NCS

Nerve conduction velocity

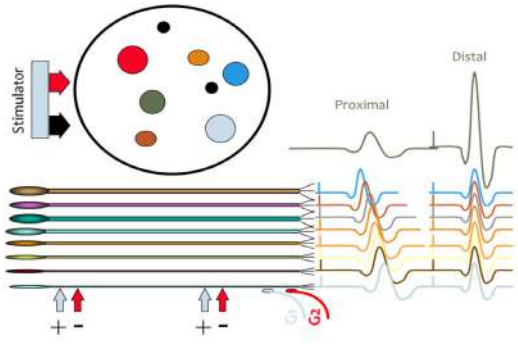
UE (50 m/s) > LE (40 m/s)

Proximal> Distal

Amplitude

Distal > Proximal

Short segment > long segment



Factors affecting NCS data

Physical factors

- body temperature
- height
- age

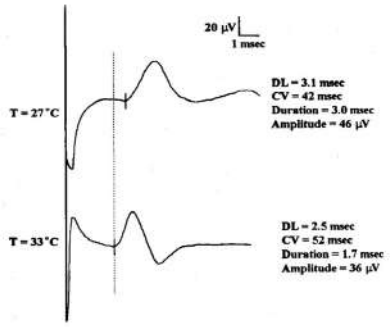
Technical factors

- electrode
- stimulation
- machine setting
- distance measure

Body temperature

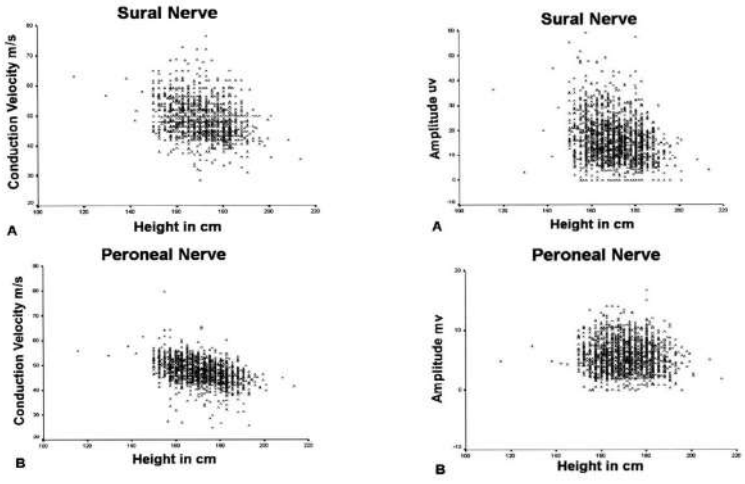
- Most important factor – effect of cool temperature
- Conduction velocity : 1.5-2.5 m/s/°C 감소
- Distal latency : 0.2 /°C 연장
- Amplitude : increased
- Duration : increased

Maintain skin temperature 32~34 ℃



Height

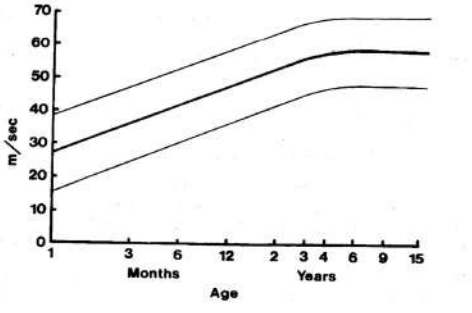
Slower conduction velocity in taller individual



Rivner MH, et al. Muscle Nerve 2001;24:1134-1141

Age

- Full term infant NCV : 1/2 of adult
- 4 year : adult NCV
- > 40 y : decrease of 0.5 - 4 m/s/10y
- by age 70 :↓ SNAP up to 50%



Checkpoint in Nerve conduction study

- Stimulation
- Recording
- Measurement
- Amplification/ filtering
- Display

Stimulation

Constant current stimulation (mA)

Cathode

- Negatively charged
- Depolarizes the axon
- Larger axons are more easily stimulated
- Myelinated axons are more easily stimulated

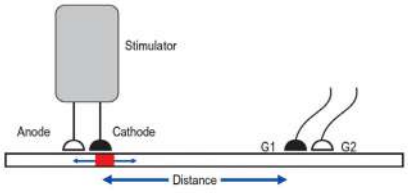
Anode

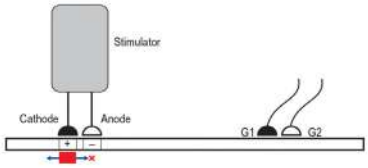
- positively charged
- Hyper-polarizes the axon
- Anodal block

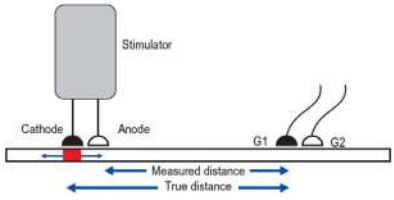
Position of stimulator

Anodal block

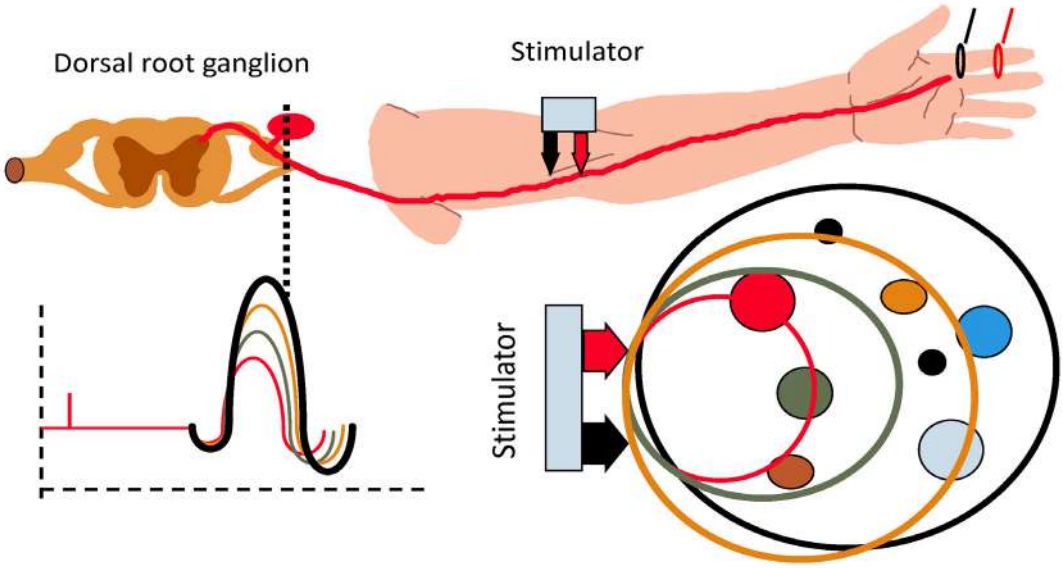
↓ amplitude, ↑ DL : 0.3-0.4ms, ↓ SNCV : 10 m/s







Supramaximal stimulation



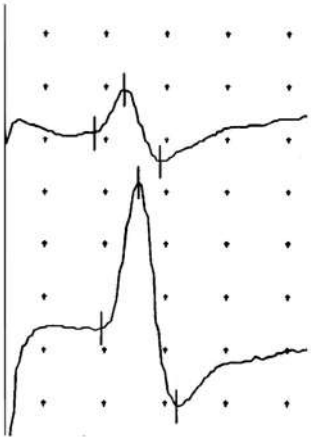
Overstimulation

Result	Solution
• Erroneous high CMAP amplitude • Alteration in CMAP morphology • Inaccurate onset latency and CV • Possibly mimicking anomalous innervation	• Reducing impedance with skin preparation • Using sliding technique to localize the nerve • Increasing stimulus intensity by small increment • Observing waveform morphology • Observing muscle contraction

Stimulation artifact

- Same type of active and reference electrode
- Clean dirt and oil from skin
- Conducting electrode jelly
- Firm contact electrode to skin
- Use coaxial recording cable

Antidromic vs. Orthodromic stimulation



Orthodromic technique

- low Amplitude
- high diagnostic yield
- same NCV

Antidromic technique

- high Amplitude
- low diagnostic yield
- same NCV
- muscle artifacts

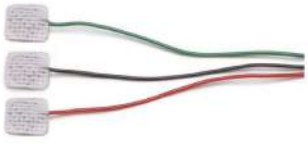
Recording electrode

Surface - size matches source

- G1 - varied size and shape
- G2 - should have same characteristics as G1
- Ground - “bigger is better”

Wires or connectors

- Black - G1-”active”
- Red - G2 - “inactive” or “reference”
- Green - ground



Recording electrode placement

Motor

"***belly-tendon***"

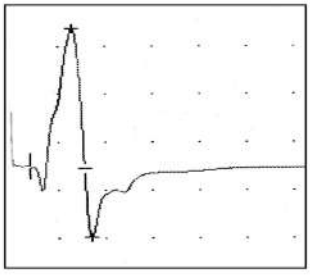
- G1: over the motor end plate (belly)
- G2: distal over the tendon
- Ground: between G1 and G2

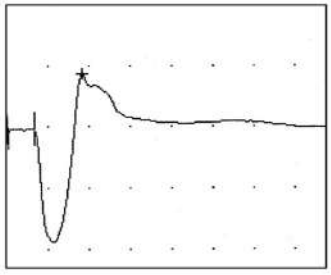
Sensory

- G1: over the nerve
- G2: 3.5 to 4 cm farther along the course of the nerve
- Ground: between G1 and G2

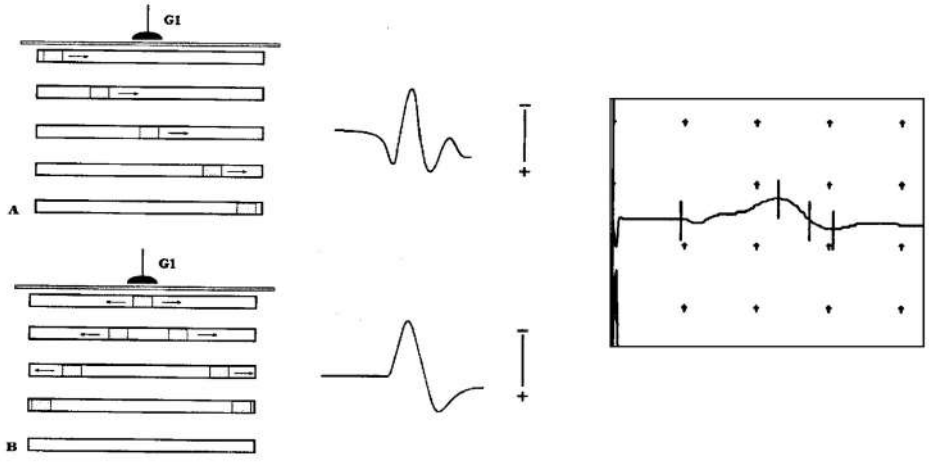
Electrode position – motor

- Incorrect placement of active electrode
- Transposition of the active and reference electrodes
- 2 belly of muscle





Volume Conduction



If initial positivity of CMAP

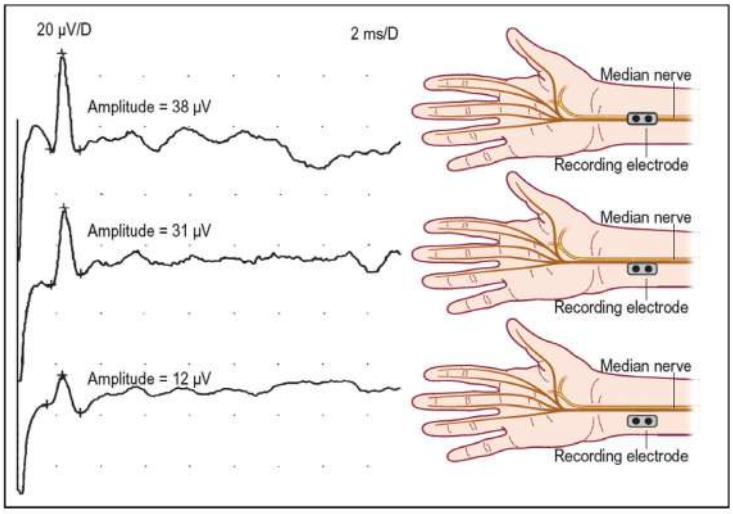
Proximal and Distal stimulation sites:

- G1 not over endplate
- Atrophic muscle (nerve or muscle disease)

Proximal sites only:

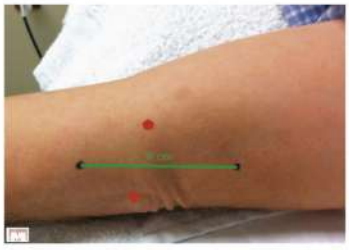
- Check for overstimulation at the proximal site
- Check for under-stimulation at the distal site
- Normal volume conduction from calf muscles

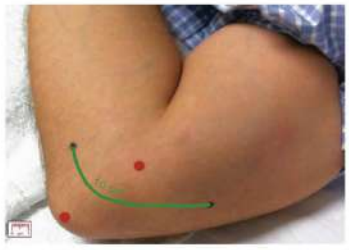
Electrode position – sensory



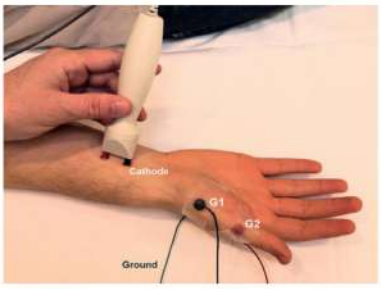
Distance measurement

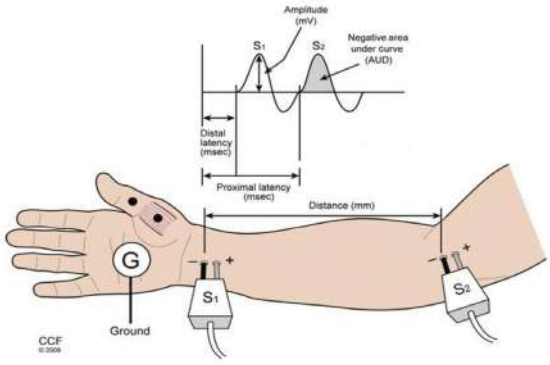
- Ideal segment: > 10 cm
- Measured distance vs. anatomical distance
- Movement of skin
- Limb position





Motor NCS

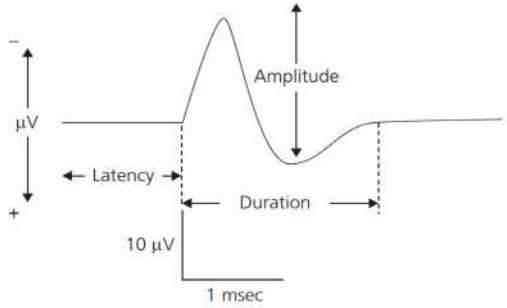


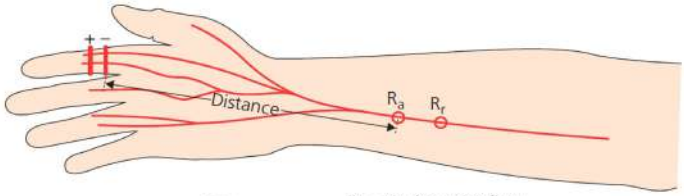


Conduction velocity (m/s) =

distance (mm)/proximal latency – distal latency (ms)

Sensory NCS





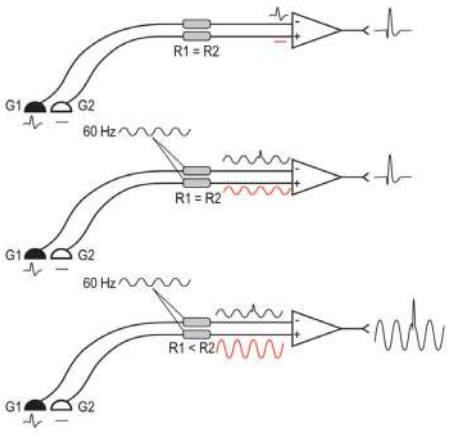
$$\text{Velocity} = \frac{\text{Distance}}{\text{Latency}}$$

R_a = Active recording
R_r = Reference recording
– = Cathode
+ = Anode

Electrode Impedance and Noise

60-Hz Artifact

- Same type of active and reference electr
- Clean dirt and oil from skin
- Conducting electrode jelly
- Firm contact electrode to skin
- Use coaxial recording cable

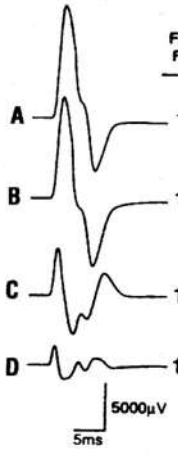


Filters

- Waveforms are buried in a “sea” of noise
- Ideally filters remove noise and have no effect on signal
- High linear frequency filters - low pass filters
- Low linear frequency filters - high pass filters
- Band filters (i.e. 60 Hz)
- Tissue acts as a high frequency filter

Machine setting - Filter

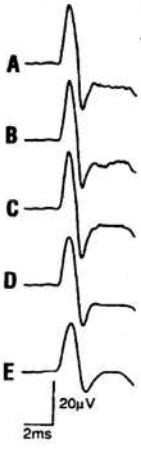
Low frequency in CMAP



	High Frequency Filter (Hz)	Low Frequency Filter (Hz)	Onset Latency (ms)	Peak Latency (ms)	Amplitude (μV)	Negative Spike Duration (ms)
A	10,000	1	3.5	5.4	11,8000	3.2
B	10,000	10	3.5	5.1	10,500	3.8
C	10,000	100	3.5	4.8	5,000	2.0
D	10,000	300	3.5	4.4	2,000	1.5

Machine setting – Filter

High frequency in SNAP



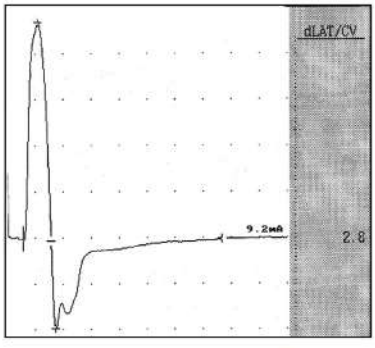
	High Frequency Filter (Hz)	Low Frequency Filter (Hz)	Onset Latency (ms)	Peak Latency (ms)	Amplitude (μV)	Negative Spike Duration (ms)
A	10,000	1	2.7	3.3	28	1.3
B	3,000	1	2.8	3.4	28	1.3
C	2,000	1	2.9	3.5	26	1.3
D	1,000	1	3.0	3.6	22	1.3
E	500	1	3.0	3.8	21	1.5

Display

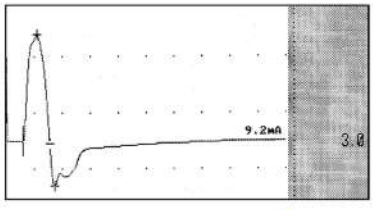
- **Sensitivity**
  - ✓ Amplifier gain = Output/Input voltage
  - ✓ Amplifier sensitivity = number of volts, millivolts, or microvolts per division
  - ✓ Waveform displayed should be 2-3 divisions high
- **Sweep speed (time base)**
  - ✓ Motor: 2-5 ms per division
  - ✓ Sensory: 1-2 ms per division
  - ✓ F waves: 5-10 ms per division

Machine setting

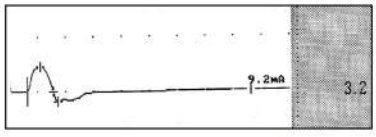
Sensitivity and Latency



2 mV/D



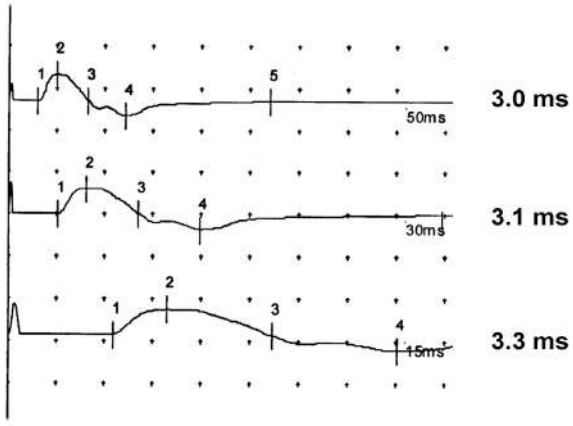
5 mV/D



20 m V/D

Machine setting

Sweep speed and Latency



Machine setting

Recommended machine setting

	Filter	Sweep speed	Sensitivity	Stimulus duration
MNCV	2-10 kHz	2-5 ms	1-5 mV	0.1 ms
SNCV	20-2 kHz	1-2 ms	5-10 uV	0.1 ms
H-reflex	20-10 kHz	10 ms	0.5-1 mV	0.5-1 ms
F-wave	20-10 kHz	10 ms	0.2 mV	0.1 ms

Electrical safety issue

- Cardiac pacemaker, indwelling cardiac catheter, implanted cardioverters
  - ✓ contraindicated due to directly reach of the current to cardiac tissue
  - ✓ placing stimulator at least 15 cm away from sensor
- Routine NCS on patients with peripheral intravenous lines is safe
- Needle stimulation
  - ✓ Generally safe
  - ✓ Avoid at Erb's point (risk of brachial plexus injury or pneumothorax)

Summary

- Do check the default setting.
- Always consider technical factors when you face unexpected result.
- You should know every single physiologic and technical pitfall.
- Test yourself regularly.