Electromyography & Nerve Conduction (EMG & NC)

By

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Objectives

At the end of the session the students should be able to:

- Understand the basic principle of EMG and NCS.
- Perform the EMG and NCS by themselves.
- For the EMG: students should know the appearance and characteristics of a normal EMG study and enumerate a few abnormalities that may be seen in neuromuscular diseases.
- For the NCS: Determine and calculate motor nerve conduction velocity of the major peripheral nerves.

Definition

EMG is an electrodiagnostic technique for recording the electrical activity (action potentials) of skeletal muscles.

Principle

EMG is performed by inserting a small sharp needle (recording electrode) through the skin into the muscle under study. The needle electrode is inserted into the belly of the muscle, near the expected region of the motor endplate. In general, the endplate region is the thickest part of the muscle belly.

Principle (cont.)

After insertion of the needle, the electrical activity of the muscle will be recorded at rest, during mild-moderate muscle activity, and during maximal muscle contraction, The recording is observed in each case. The potentials recorded upon muscle contraction are derived from the motor units of the muscle, and are known as motor unit potentials (MUPs).

In physiology student lab, surface electrodes will be used instead of needle electrodes and the same steps will be followed.

Surface electrodes record the sum of all MUPs occurring in the muscle which is called “the compound motor action potential”.

Indication of EMG

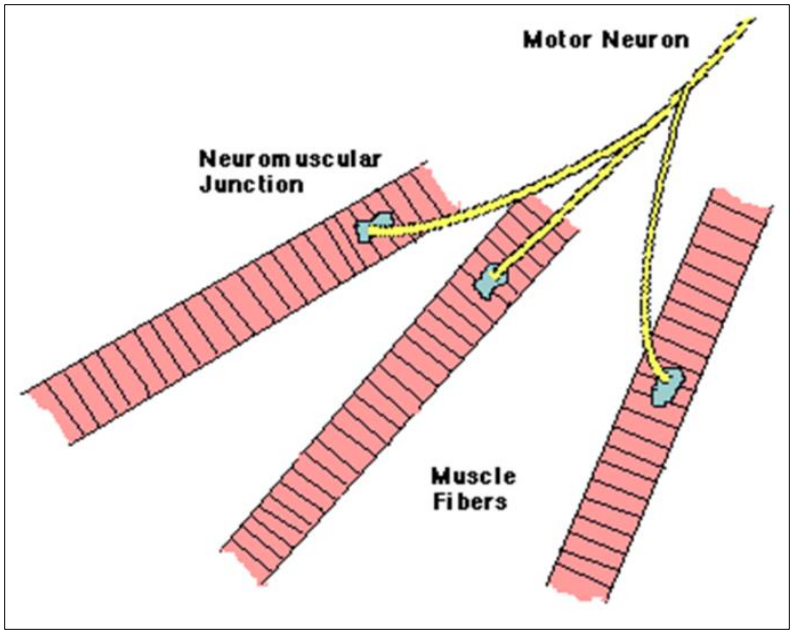
EMG is a major diagnostic tool for identifying and characterizing disorders of the motor unit, including anterior horn cells, peripheral nerves, neuromuscular junctions, and muscles.

Along with nerve conduction studies (NCS), EMG can help;

- Confirm a diagnosis.
- Grade the severity of the disease.
- Define evolution, stage, and prognosis.

Motor unit potentials (MUPs).

A motor unit is defined as one motor neuron and all the muscle fibers it innervates.



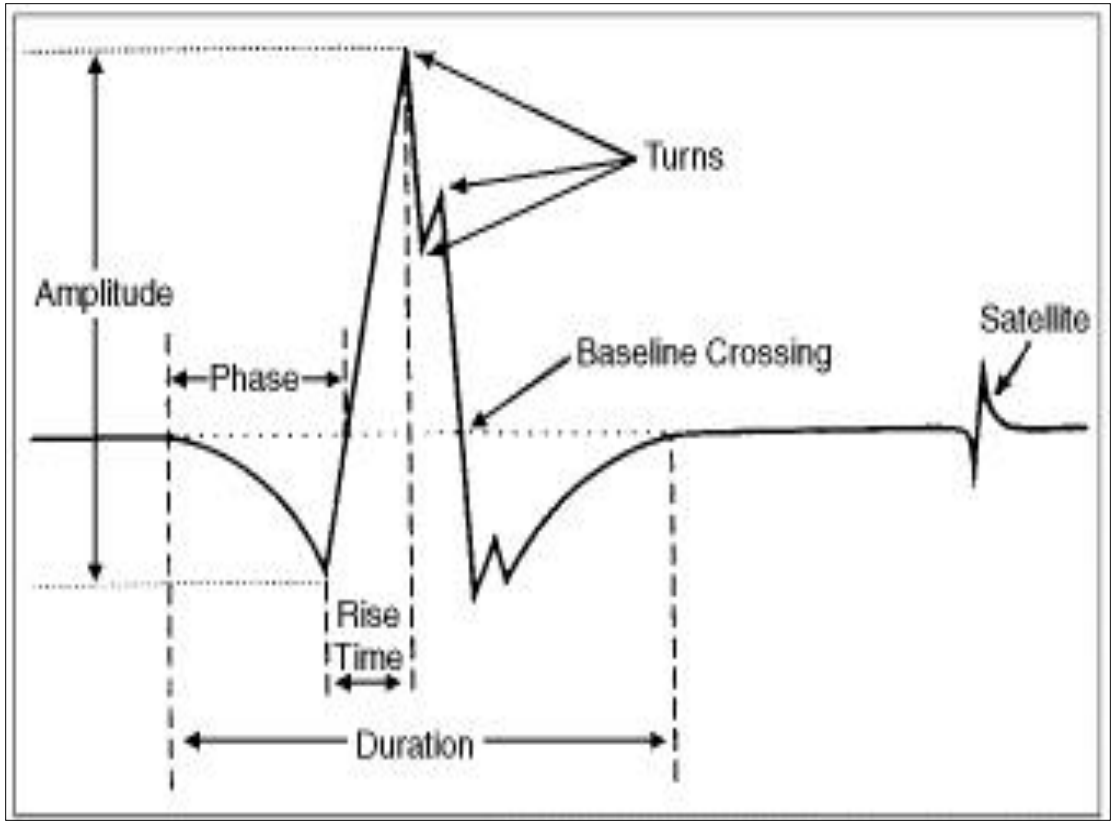
Procedure

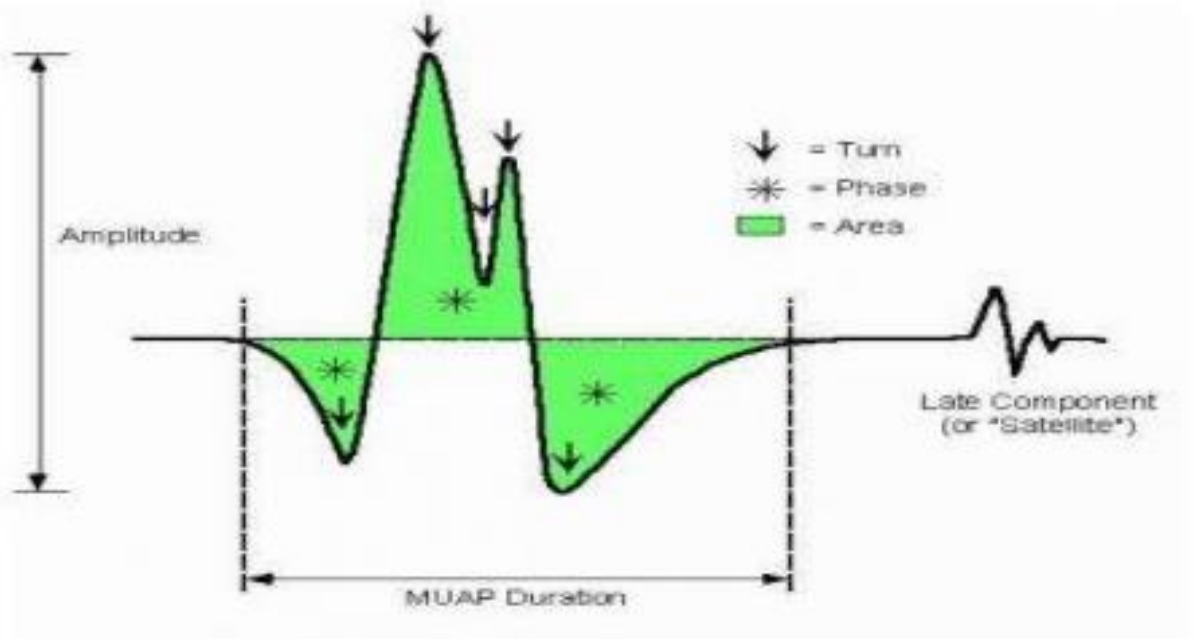
Recordings will be obtained from the Abductor Pollicis Brevis (APB) muscle in the hand

1. Select a volunteer and explain the procedure to her.
2. Three surface electrodes need to be placed on the volunteer. An electrode jell should be applied to each electrode before placement;
    a. The ground is placed on the dorsum of the hand where the muscle will be tested.
    b. The recording electrode is placed on belly of the APB “midbelly”.
    c. The reference electrode is placed approximately 2-3 cm away from the recording and on a bony prominence.

3. Once the electrodes are in place, start recording;
    a. At the beginning, ask the subject to relax (not to contract the muscle), and record the muscle electrical activity during this period.
    b. Then, ask the subject to exert mild to moderate voluntary effort while you continue recording.
    c. Finally, ask the subject to do maximum contraction of the muscle and record the electrical activity during this period.

Normal MUP

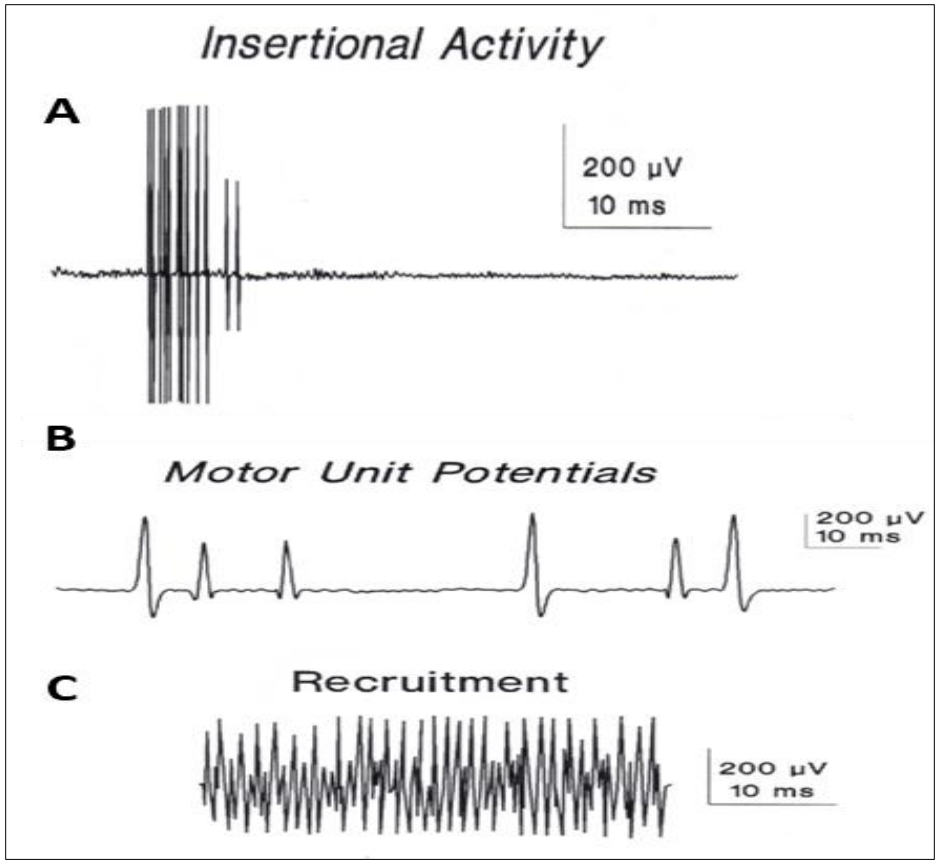

Turns
Amplitude
Phase
Baseline Crossing
Satellite
Rise
Time
Duration


= Turn
= Phase
= Area
Amplitude
Late Component
(or "Satellite")
MUAP Duration

Analysis of a motor unit potential (MUP)

MUP characteristics	Normal	Neuropathic	Myopathic
Duration (ms)	3-15ms	Longer	Shorter
Amplitude	300-5000μV	Larger	Smaller
Phases	Biphasic/triphasic	Polyphasic	May be polyphasic
Resting activity	Absent	Present	Present
Interference pattern	Full	Partial	Full with small amplitude MUPs

Normal EMG activity



Insertional activity

The electrical activity results from insertion of the electrode to the muscle. These are discharge potentials provoked by the disruption of the cell membrane itself.

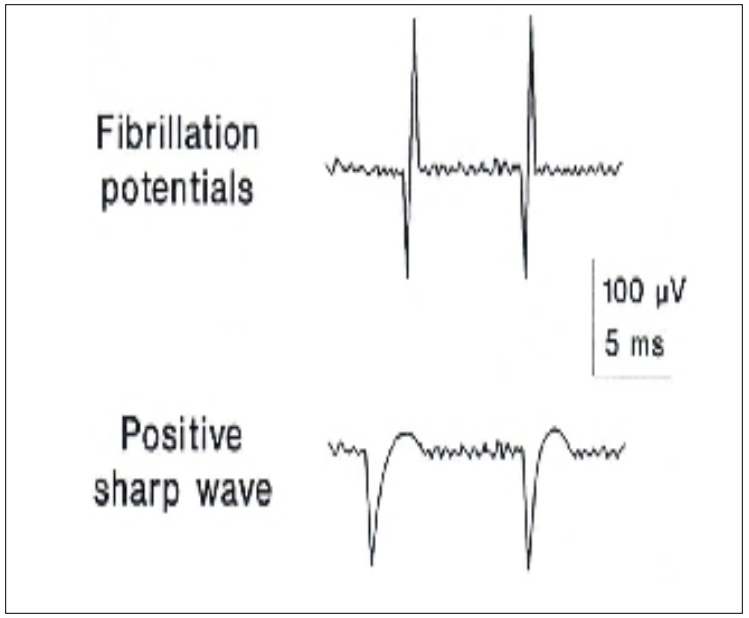
-Decreased in atrophied muscle or fatty tissue.

- Increased in many abnormal conditions that cause membrane instability, such as neuropathies, radiculopathies, and inflammatory myopathies.

Abnormalities of EMG

- At rest

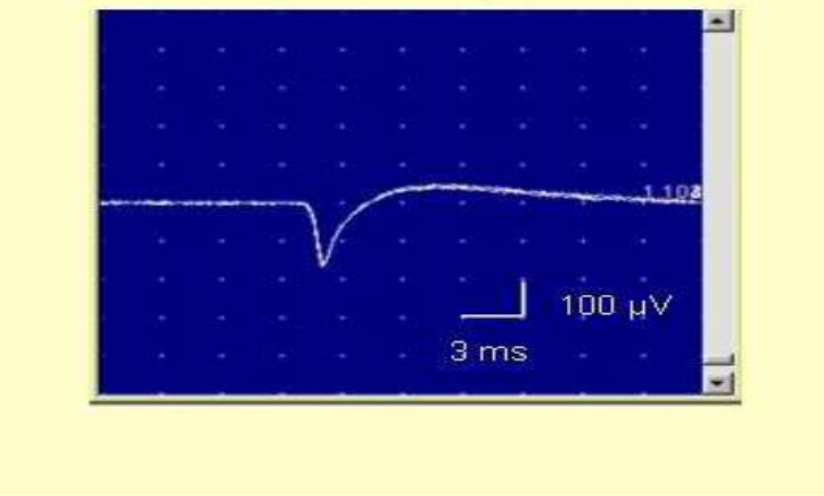
- Positive sharp waves.
- Fibrillation.
- Fasciculation.

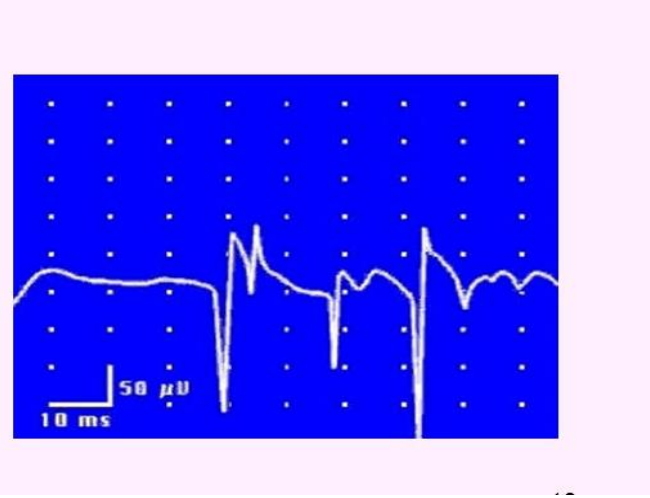


Positive sharp waves:

Positive sharp potentials with a fast downstroke and slower return to baseline.

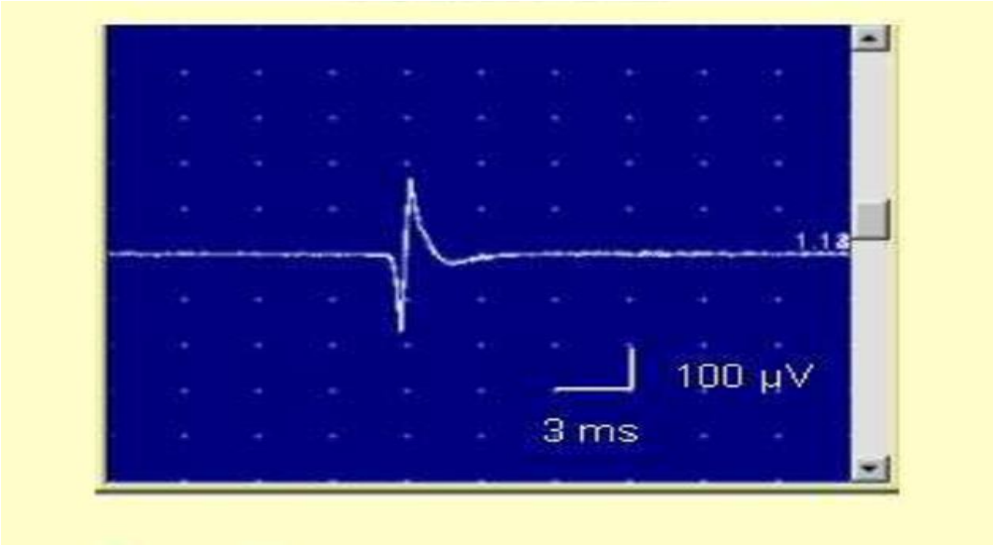
Causes: neuropathy, myopathy





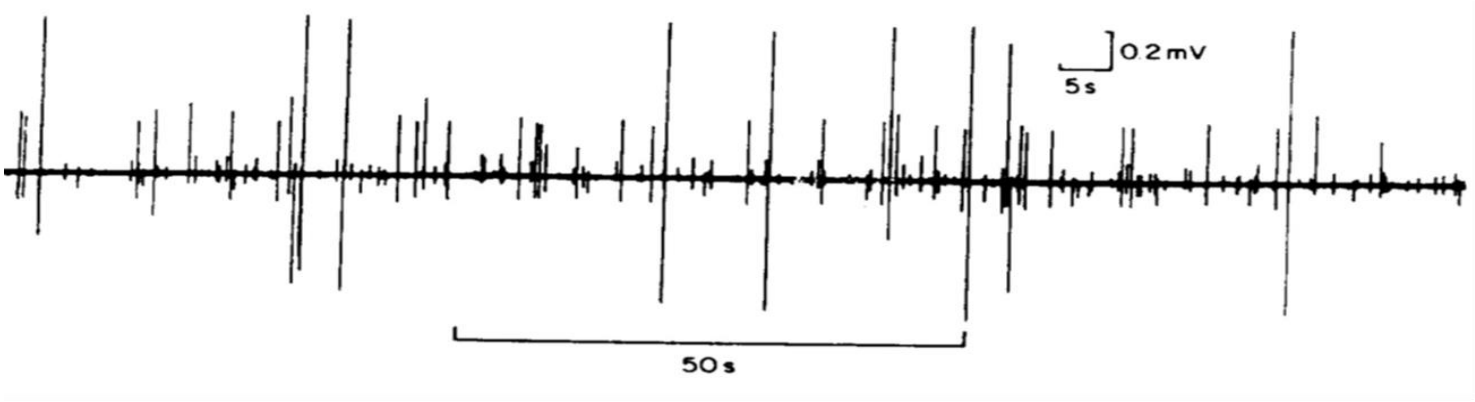
Fibrillation Potentials

- Action potential of a single muscle fiber that are twitching spontaneously in the absence of innervation
- Low amplitude, short duration, biphasic
- Not seen under the skin but recorded during EMG
- Caused by neuropathy and myopathy



Fasciculation potentials

- Randomly discharging action potentials of a group of muscle fibers due to partial re-innervation of denervated muscle fiber
- high voltage, polyphasic, long duration potentials (Giant Potentials)
- Visible, can be seen in motor neuron disease, radiculopathy and neuropathy.

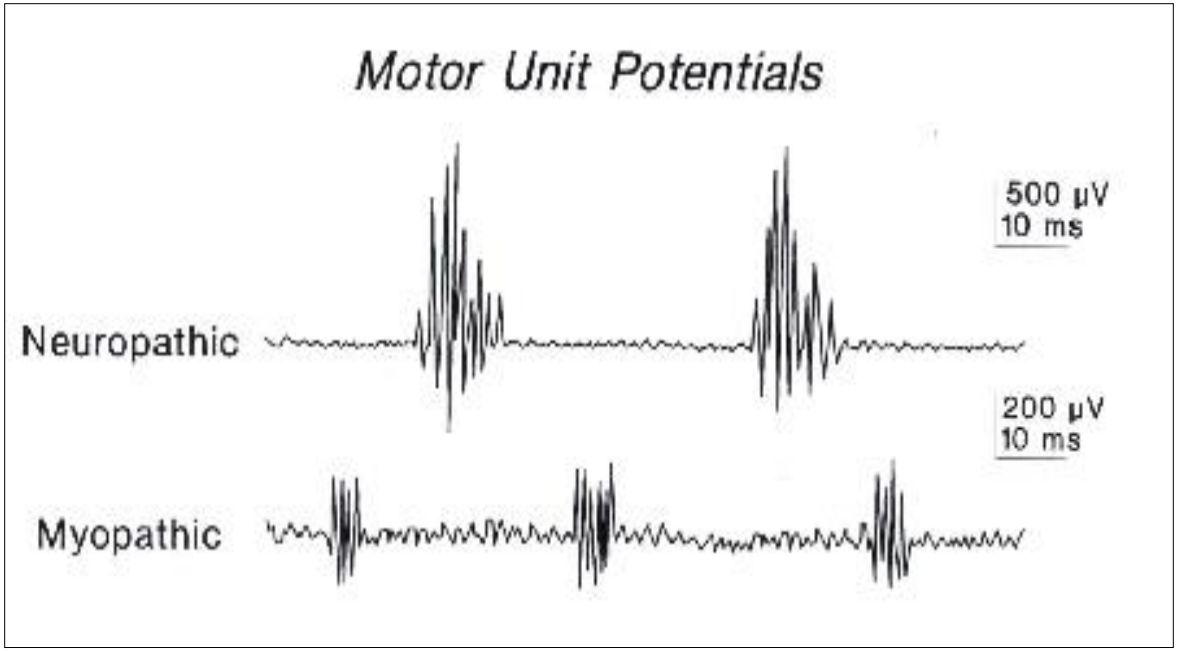


- During muscle contraction

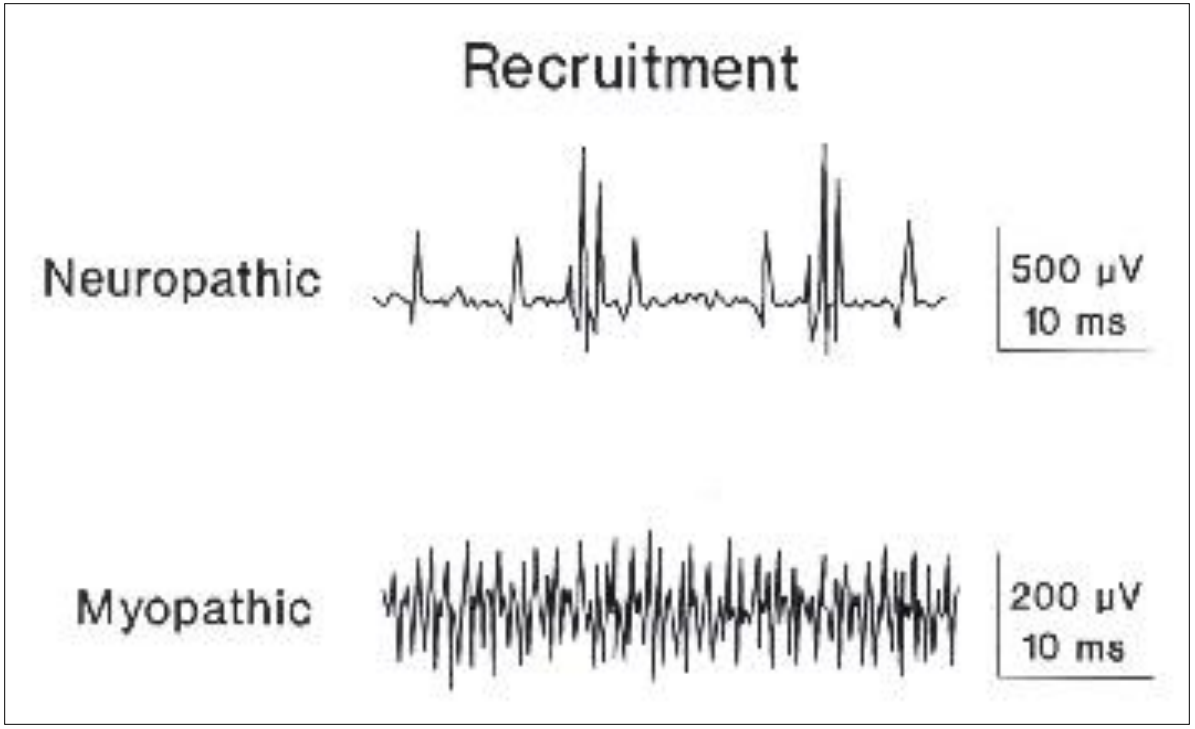
Abnormalities can be seen in the MUPs as well as the recruitment.

- Patterns of abnormal MUPs
- Patterns of abnormal recruitment

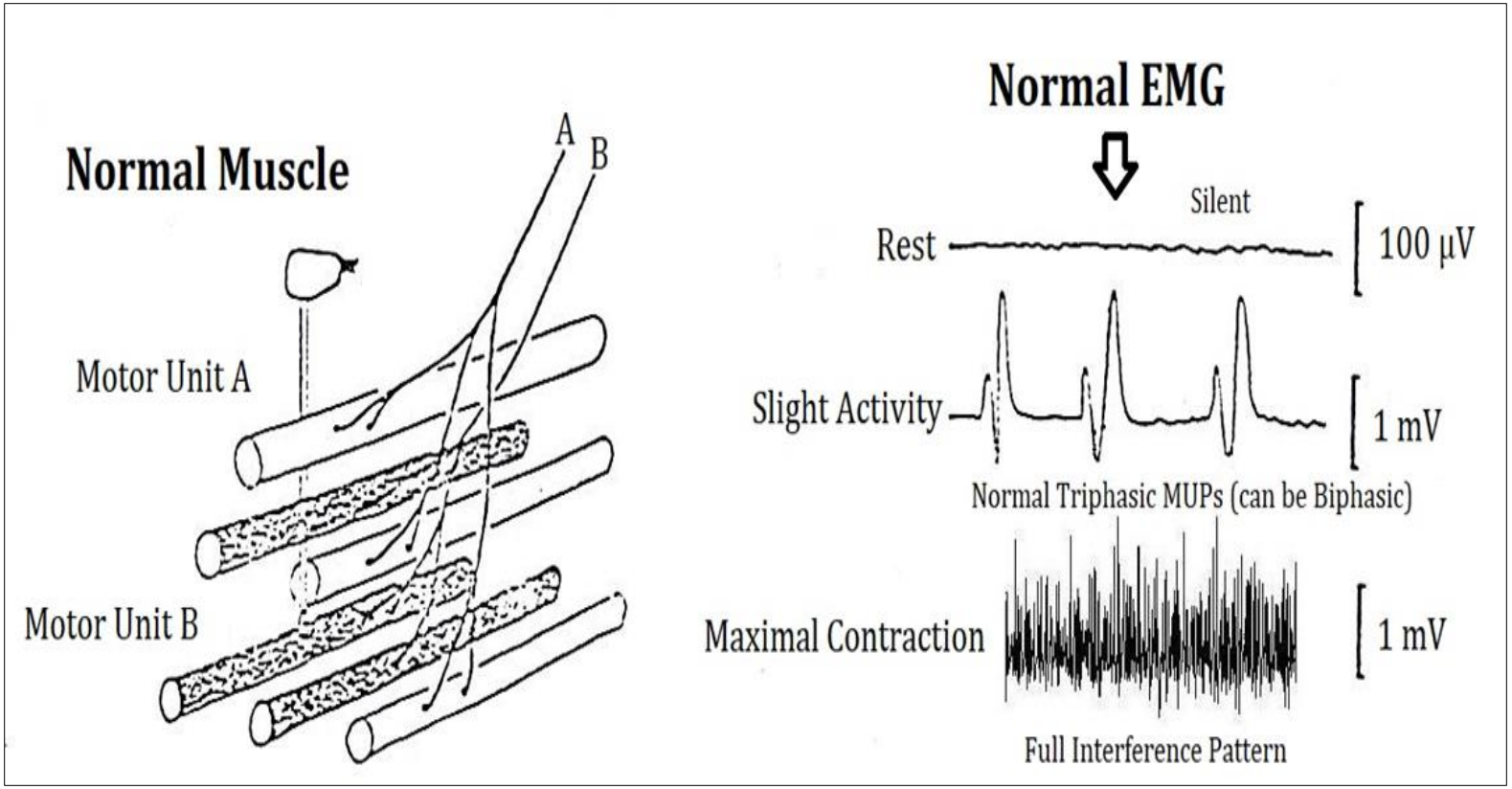
Abnormal patterns MUPs



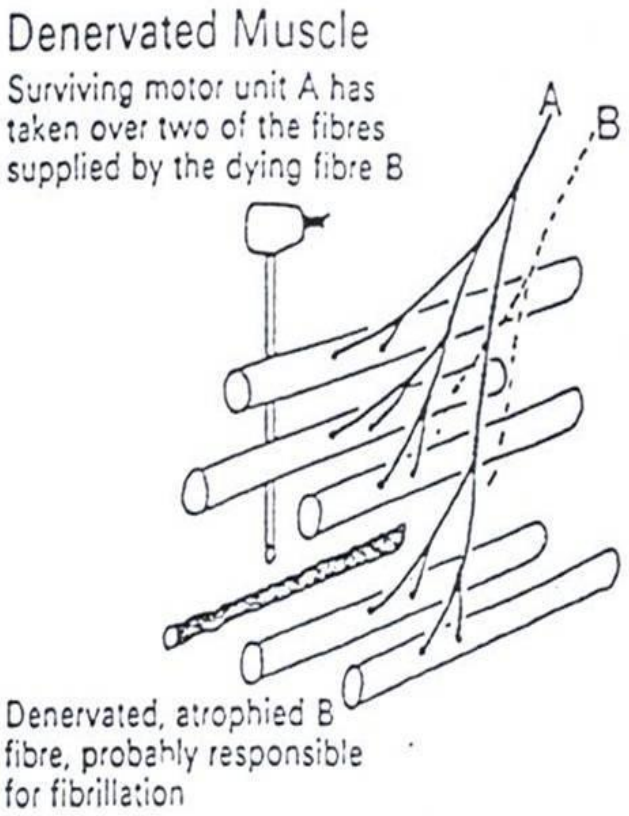
Abnormal patterns of Recruitment

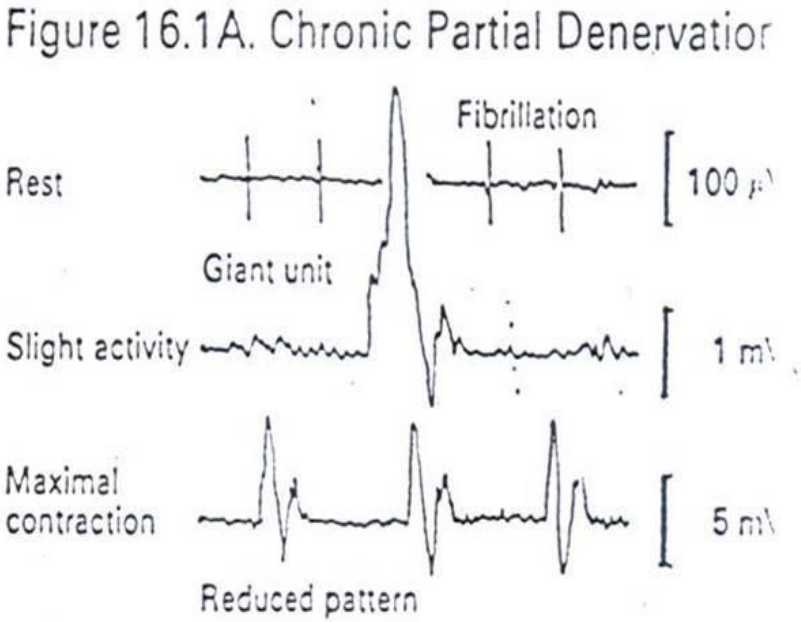


Normal EMG

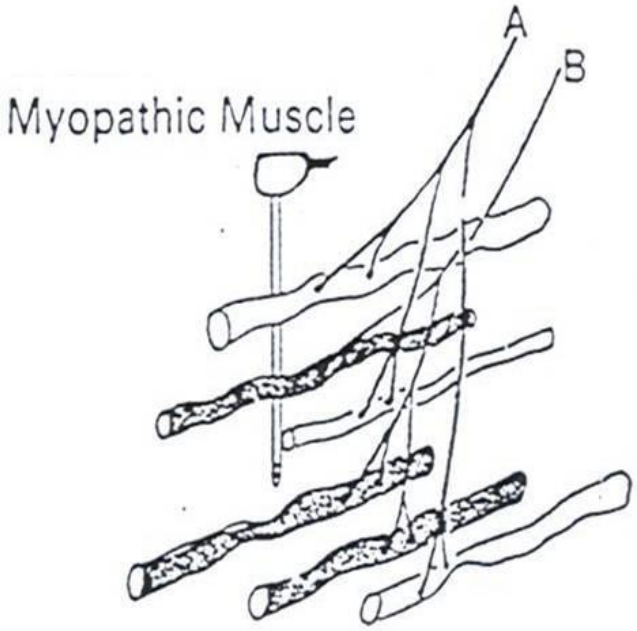

Normal Muscle
A
B
Motor Unit A
Motor Unit B
Normal EMG
Silent
Rest
100 µV
Slight Activity
1 mV
Normal Triphasic MUPs (can be Biphasic)
Maximal Contraction
1 mV
Full Interference Pattern

Neuropathic EMG changes



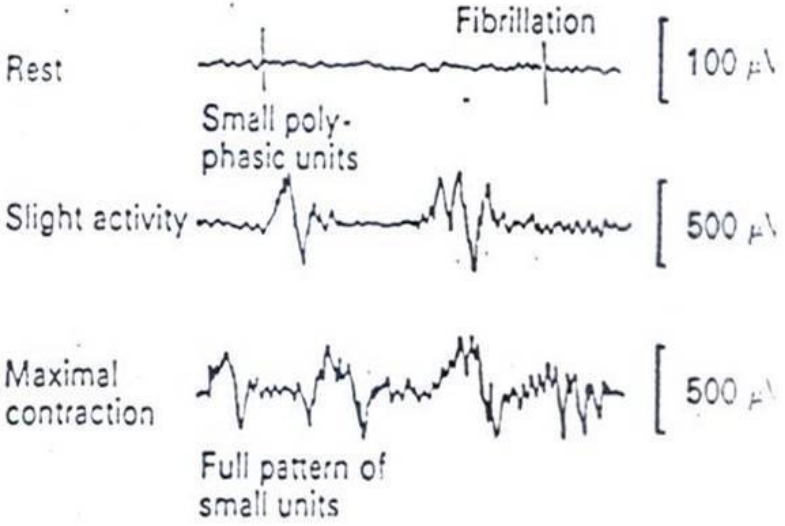


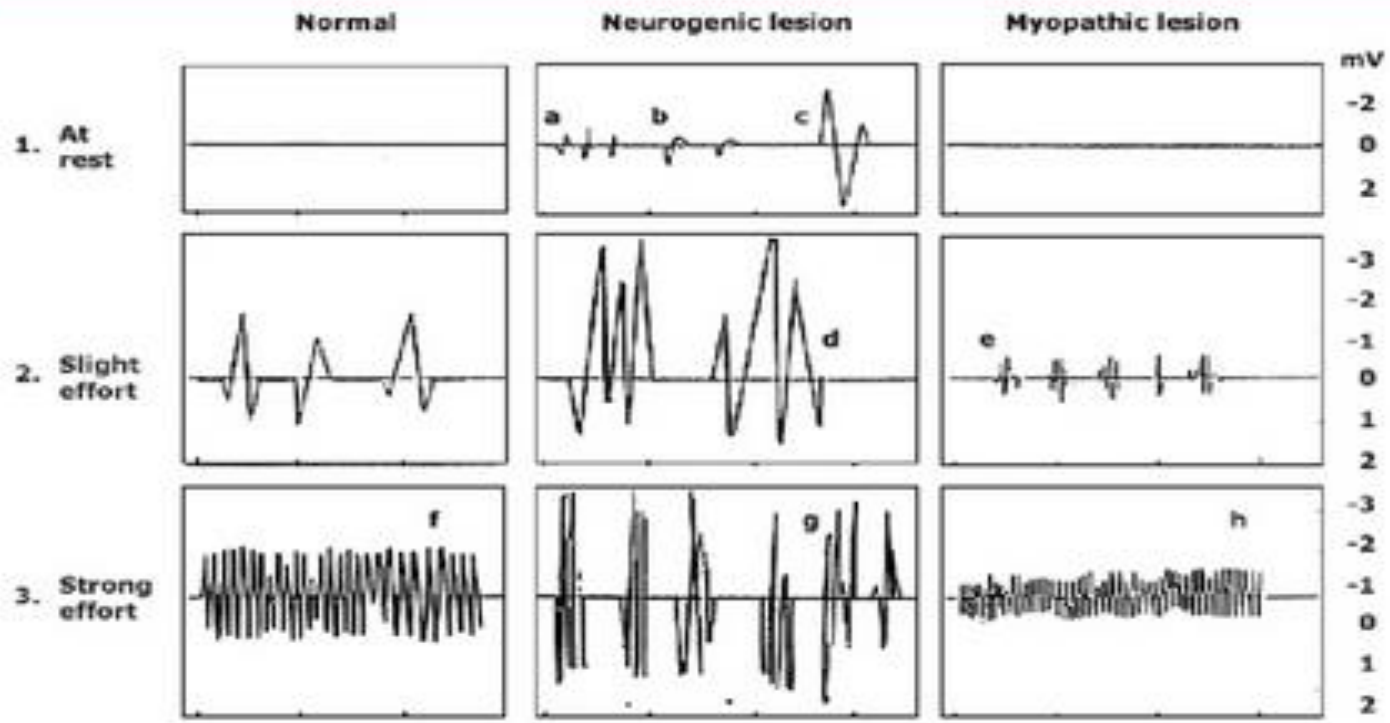
Myopathic EMG changes



Muscle fibres supplied by both A and B are indiscriminately affected, although both nerve fibres are normal

Figure 16.1B. Myopathic E.M.G.





1. At rest (spontaneous activity): a. fibrilations, b. positive sharp waves, c. fasiculation.
2. Slight effort (motor unit potentials): d. giant polyphasic, e. BSAPS (brief-small-abundant polyphasic).
3. Strong effort (interference pattern): f. full, g. reduced units, h. reduced amplitude.

* (helpful in selecting denervated muscles [in radiculopathies (myotomal), mononeuropathies (distal to lesion), generalized neuropathies (distal muscles)] and myopathies)

Nerve Conduction Studies (NCS)

A Nerve conduction study (NCS) is a test used to evaluate the function of peripheral nerves by measuring their conduction velocity and response latency.

Both sensory and motor nerve conduction can be studied.

Principle

Motor NCS are performed by electrical stimulation of a peripheral nerve and recording from a muscle supplied by this nerve. A nerve potential is initiated at the stimulation electrode and is conducted along the nerve fibers to the muscle. When the muscle contracts, the compound muscle action potential is recorded and observed on the display screen. The **latency** of the response (the time it takes for the impulse to travel from the stimulating to the recording site) is measured in milliseconds (ms). The size of the response (the **amplitude**) is also noted. The motor amplitudes are measured in millivolts (mV).

Cont.

This is repeated by stimulating the motor nerve at a second site along its path. The distance between the two stimulation points is measured and the difference in latency times determined. By dividing the distance between stimulation points by the difference in latency times, the motor nerve conduction velocity can be calculated.

Procedure

The motor nerve conduction study (MNCS) will be measured for the median nerve.

1. Select a volunteer and explain the procedure to him/her.
2. Clean the area of the skin where the electrodes will be placed to improve skin conductivity.
3. Surface electrodes are used for MNCS, after applying the electrode jell to each of the electrodes they will be placed as follows;

a. The recording electrodes are placed on the muscle supplied by the nerve under study (the APB for the median nerve) so that the cathode or negative (active) electrode is placed over the belly of the muscle, while the anode or positive (reference) electrode is placed over the distal tendon.
b. The grounding electrode should be placed between stimulating and recording electrode, preferably, over bone rather than muscle (on the dorsum of the hand)

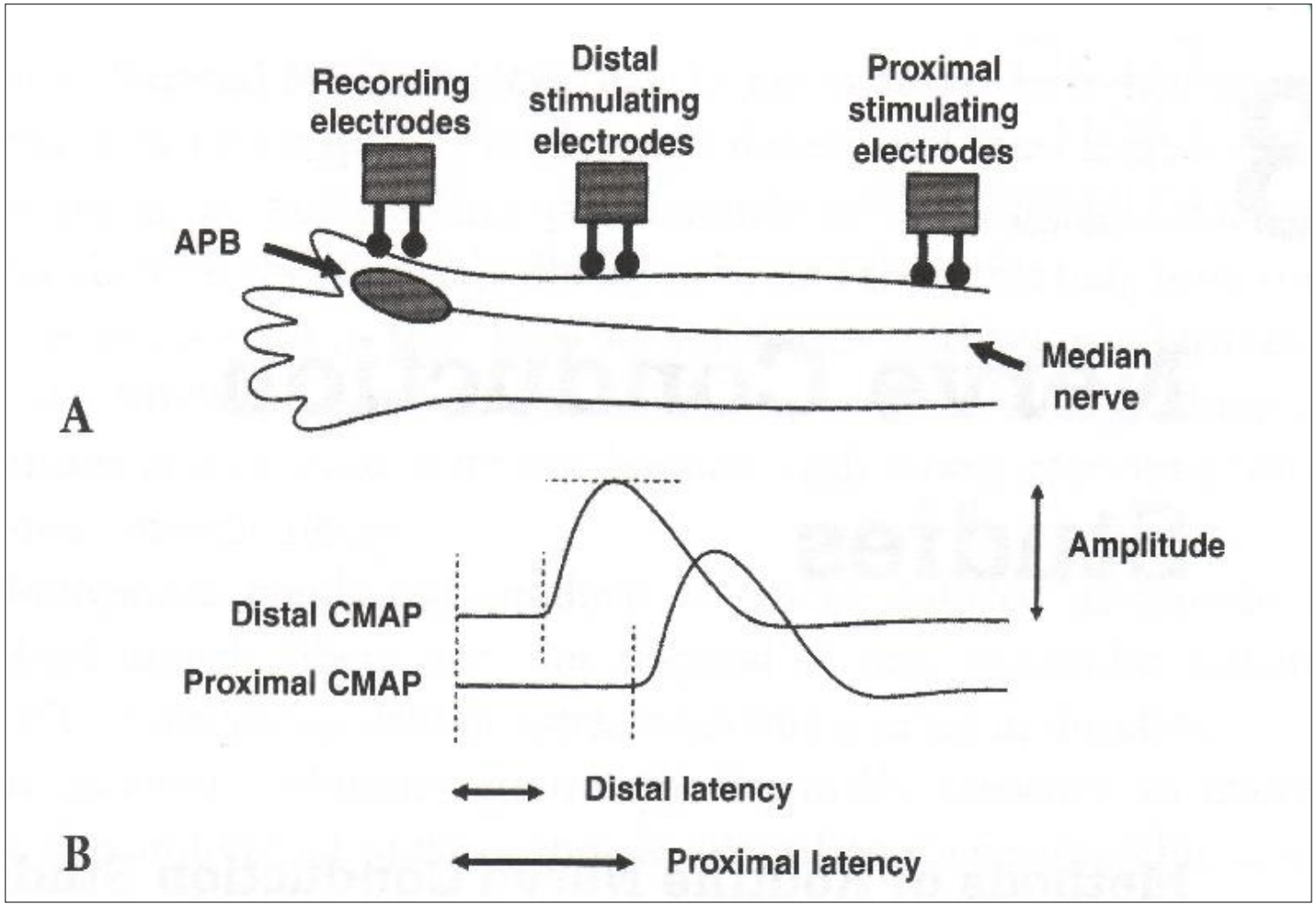
C. The stimulating electrodes are placed between the flexor carpii radialis tendon and the Palmaris longus tendon with the cathode electrode placed distally to the anode. This will stimulate the median nerve at the wrist. A recording of the compound muscle action potential (CMAP) is obtained and the latency is noted.

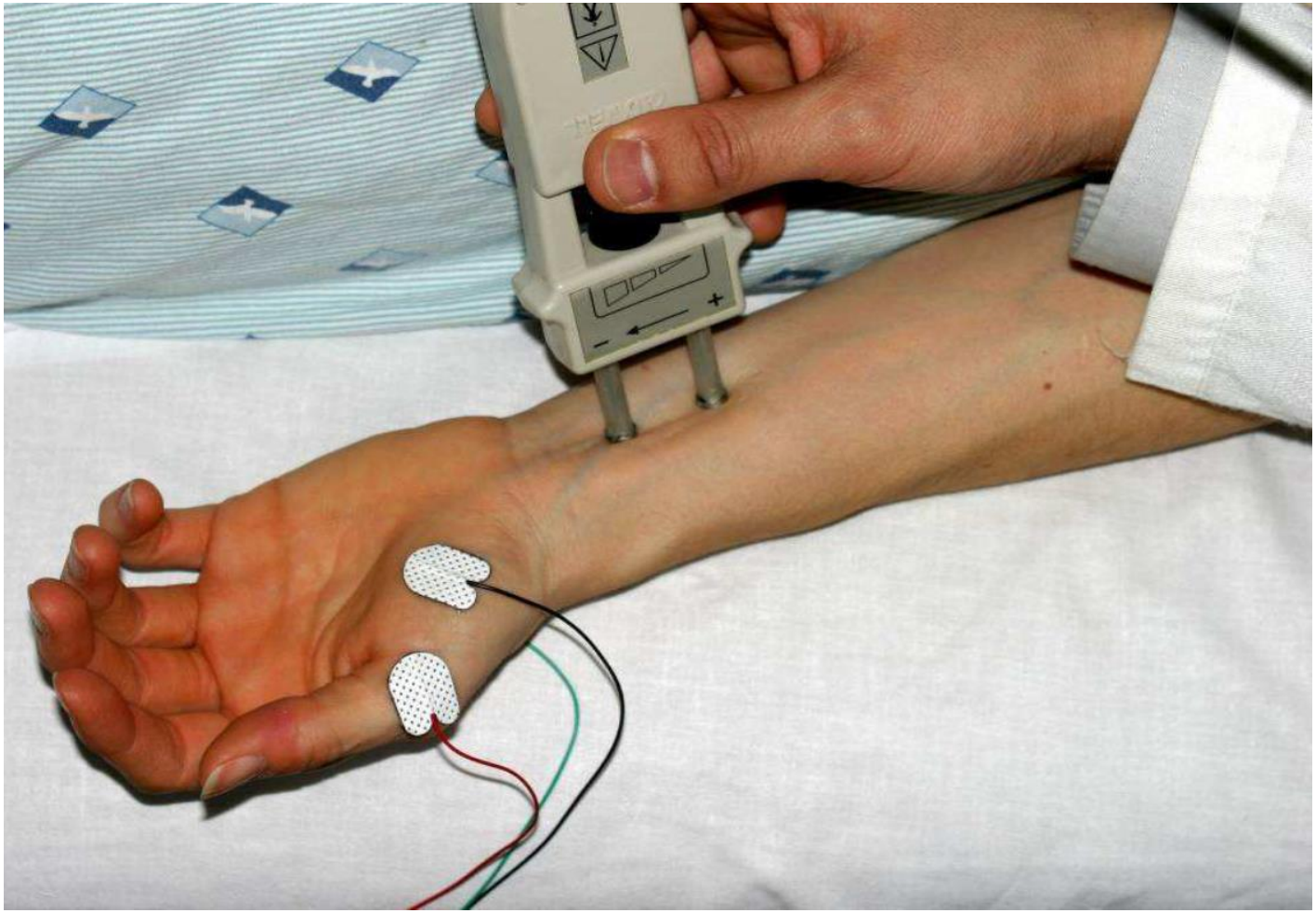
D. The median nerve is then stimulated at the elbow medial to the biceps tendon and over the pulse of the brachial artery (antecubital fossa). A recording of the CMAP is obtained and the latency is noted.

e. The distance between the two stimulating electrodes is measured. And the median nerve conduction velocity is calculated using the following formula;

$$MNCV = \frac{Distance\ (mm)}{L1-L2\ \ (msec)}$$

- MNCV= Motor nerve conduction velocity (m/sec)
- Distance= distance between the two stimulating electrodes.
- L1= latency at elbow.
- L2=latency at wrist.


Recording electrodes
Distal stimulating electrodes
Proximal stimulating electrodes
APB
Median nerve
A
Amplitude
Distal CMAP
Proximal CMAP
Distal latency
Proximal latency
B



Normal values for conduction velocity

In arm

50 – 70 m / sec.

In leg

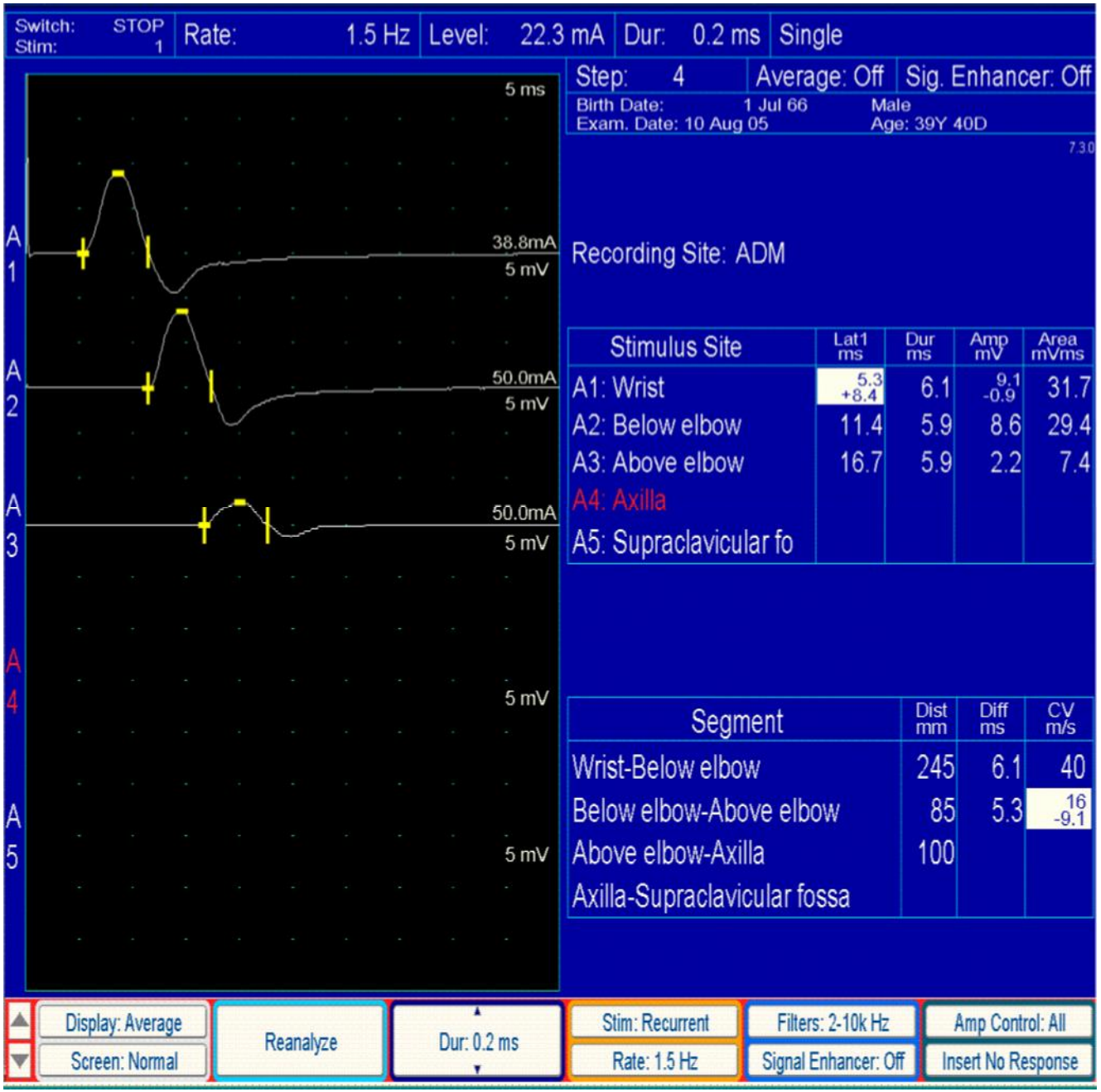
40 – 60 m / sec.

Comparing results

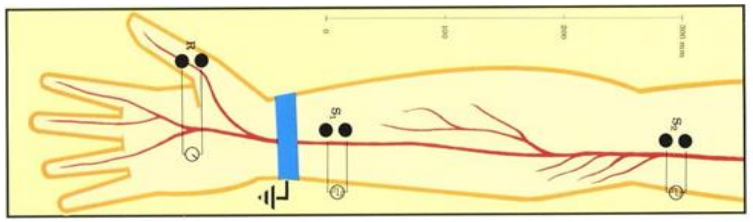
- Compare nerves same limb (hand median vs ulnar or radial)
- Compare left and right limb
- Compare upper and lower limbs
- Compare to previous results in same subject
- Compare to ‘normal’ reference values

Abnormal features

Axonal degeneration neuropathy features	Demyelinating Neuropathy features
• Low amplitudes	• Normal amplitudes
• Normal / slight delay in latency	• Significant delay in latency
• Normal / slightly low conduction velocity	• Significantly low conduction velocity

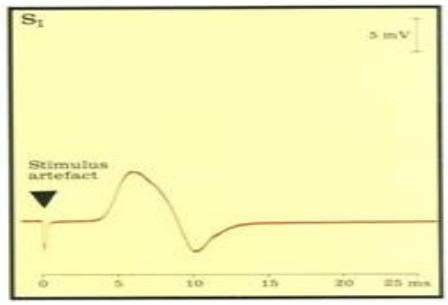

Switch: STOP
Stim: 1
Rate: 1.5 Hz
Level: 22.3 mA
Dur: 0.2 ms
Single
Step: 4
Average: Off
Sig. Enhancer: Off
Birth Date: 1 Jul 66
Male
Exam. Date: 10 Aug 05
Age: 39Y 40D
7.3.0
5 ms
A 1
38.8mA
5 mV
A 2
50.0mA
5 mV
A 3
50.0mA
5 mV
A 4
5 mV
A 5
5 mV
Recording Site: ADM
Stimulus Site | Lat1 ms | Dur ms | Amp mV | Area mVms
A1: Wrist | 5.3 +8.4 | 6.1 | 9.1 -0.9 | 31.7
A2: Below elbow | 11.4 | 5.9 | 8.6 | 29.4
A3: Above elbow | 16.7 | 5.9 | 2.2 | 7.4
A4: Axilla
A5: Supraclavicular fo
Segment | Dist mm | Diff ms | CV m/s
Wrist-Below elbow | 245 | 6.1 | 40
Below elbow-Above elbow | 85 | 5.3 | 16 -9.1
Above elbow-Axilla | 100
Axilla-Supraclavicular fossa
Display: Average
Screen: Normal
Reanalyze
Dur: 0.2 ms
Stim: Recurrent
Rate: 1.5 Hz
Filters: 2-10k Hz
Signal Enhancer: Off
Amp Control: All
Insert No Response

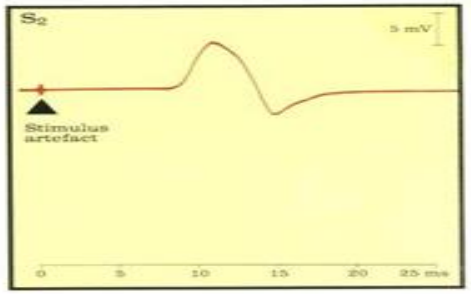
- Conduction is faster in myelinated fibers
- Conduction is dramatically slowed (20-30m/s) in demyelinated peripheral neuropathies (Diabetes, Gillain Barré) and in some nerve compression or entrapment (Carpal tunnel syndrome)



$$MNCV = \frac{Distance\ (mm)}{L1 - L2\ \ (msec)}$$

Distace = 24 Cm





Latency at wrist = 2.5 msec

Latency at elbow = 6.5 msec

MNCV =(24 × 10)÷ (6.5-2.5)

MNCV = 240/4.0 = 60 m/sec

THANK YOU