MEDICINE
KING SAUD UNIVERSITY

Physiology Team 436

Nerve Conduction Study (NCS) and Electromyography (EMG)

Revised by
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Red: very important.
Green: Doctor's notes.
Yellow: numbers.
Gray: notes and explanation.

Physiology Team 436 – Musculoskeletal Block Lecture 5

Lecture: If work is intended for initial studying.
Review: If work is intended for revision.

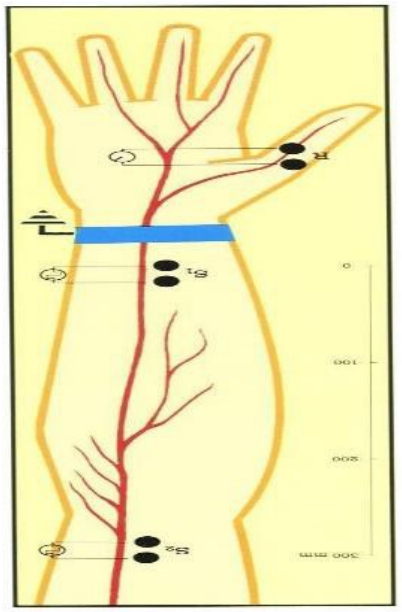
Objectives

- Define what is nerve conduction study (NCS) and electromyography (EMG) .
- Explain the procedure of NCS using Abductor Pollicis Brevis muscle .
- Define the normal conduction velocity in upper limb and lower limb nerves .
- Define the motor unit potentials (MUPs) and how they are changed in muscle and nerve diseases .

Nerve Conduction Study (NCS)

- A nerve conduction study (NCS) : is an electrophysiology test commonly used to evaluate the function of peripheral nerves of the human body.
- It could be
  - Motor NCS
  - Sensory NCS
  - Mixed NCS

Nerve conduction velocity (NCV) is a common measurement made during NCS



Motor Nerve Conduction Study

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In this lecture, only motor nerve conduction study will be discussed.

- Based on the nature of motor nerve conduction abnormality, two lesions may be identified:

1. Axonal degeneration and 2. Segmental demyelination.

- These tests are considered as an extension of the physical examination in patients with muscular weakness, muscle atrophy, and traumatic or metabolic neuropathy, rather than a simple laboratory procedure.

Motor nerve conduction velocity of peripheral nerves may be closely correlated to their functional integrity or to their structural abnormalities.

Motor Conduction Studies: Compound Muscle Action Potential (CMAP)

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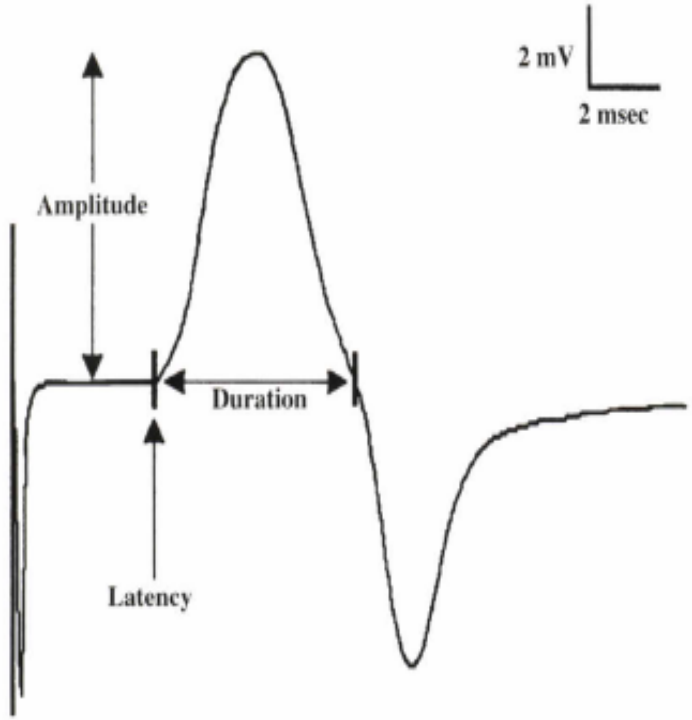
- Muscle CMAP is the recorded potential in the motor test.
- Represents the summation of all underlying muscle fiber action potentials.
- It is a biphasic (ثنائية الموجة) potential with an initial upward deflection from baseline.
- For each procedure we measure
  - Amplitude
  - Latency
  - Duration
  - Conduction Velocity



For each stimulation site: the latency, amplitude, duration, of the CMAP are measured .

A motor conduction velocity can be calculated after two sites of stimulation, one distal and one proximal.

Important Notes:

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Amplitude

• it is most commonly measured from baseline to the peak (baseline-to-peak) and less commonly from the first upward peak to the next downward peak (peak-to-peak).

CMAP amplitude reflects the number of muscle fibers that depolarize.

• low CMAP amplitudes most often result from loss of axons (as in a typical axonal neuropathy)

• average CMAP amplitude 3 mv

Conduction Velocity

• It's measurement of the speed of the fastest conducting nerve axons

• It is calculated by dividing the change in distance (between proximal stimulation site & distal stimulation site in mm) by the change in time (proximal latency in milliseconds (ms) minus distal latency in ms)

Latency

• The latency is the time from the stimulus to the initial deflection from baseline

•Latency measurements usually are made in milliseconds (ms).

Duration

• This is measured from the initial deflection from baseline to the final return

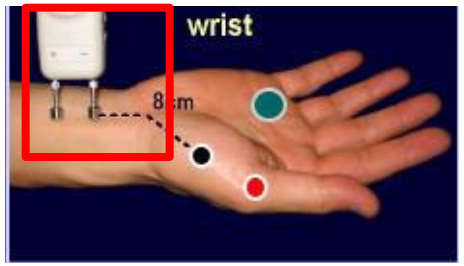
• Duration characteristically increases in conditions that result in slowing of some motor fibers (e.g., in a demyelinating lesion).

MCS Procedure

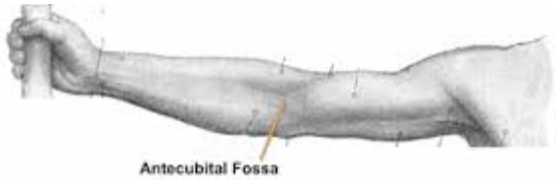
- An electrical stimulus is applied over a nerve (e.g., median nerve)

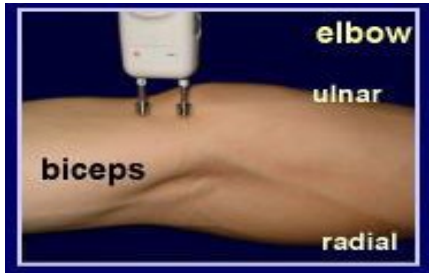
at two sites :

1- a distal site (wrist).



2-proximal one (antecubital fossa , elbow).





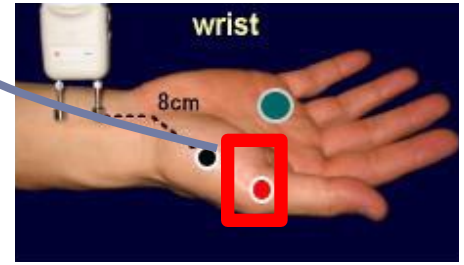
- An **active recording electrode (G1)** is place over the belly of the muscle supplied

by that motor nerve (over the motor endplate) .The muscle is the thenar eminence which consist of multiple muscle one of them is the Abductor Pollicis Brevis (the muscle that we use in a routine test).

Thenar :"palm of the hand" and the Latin word "eminentia : projection" refers to the group of muscles on the palm of the human hand at the base of the thumb)

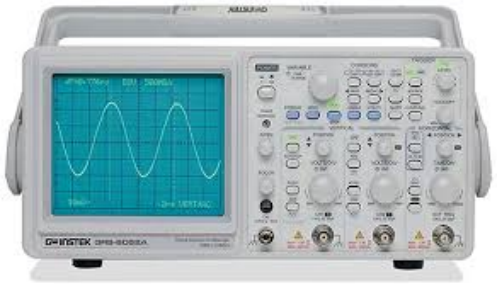
Procedure (cont.)

- The **reference recording electrode** (G2) about 3-4 cm away from G1 .
- The stimulator then is placed over the nerve that supplies the muscle.
- The oscilloscope (CRO for cathode-ray oscilloscope) sweep speed is adjusted to 2 ms/cm.



Oscilloscope : used to observe the change of an electrical signal over time.

- The stimulus duration used is 0.2 ms(milliseconds) and stimulus frequency to 1 / sec.
- As current slowly increases (from a baseline), more nerve fibers reach stimulation threshold (brought to Action Potential). This will lead to more muscle fiber action potentials.



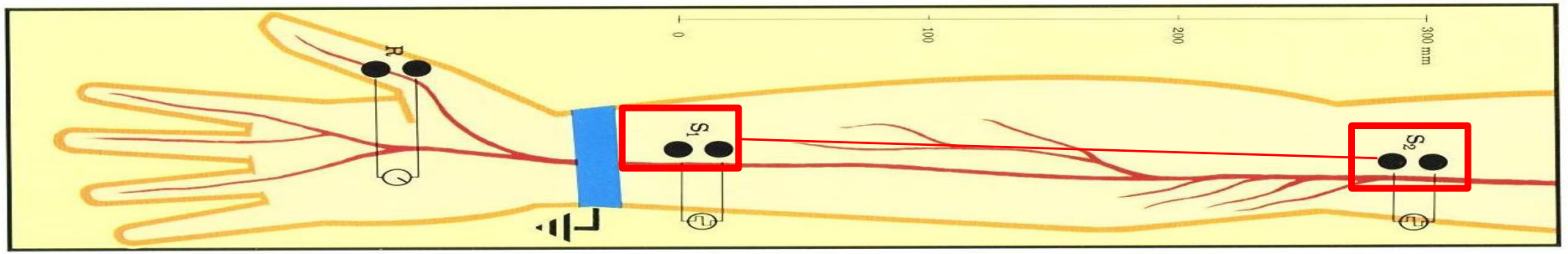
Procedure (cont.)

- Most nerves require a current in the range from 20 to 50 mA to achieve supramaximal stimulation.
- When the current reaches the point where CMAP no longer increases, we assume reaching the supramaximal stimulation. The current is increased by 20% to be sure.
- 1- Apply the stimulus and record the response from stimulation at the wrist.
- Store the CMAP (compound muscle action potential) in the first channel of the oscilloscope .
- 2- Change the stimulating site from wrist to antecubital fossa (elbow).
- Stimulate the nerve & record the CMAP for median nerve stimulation at the elbow.

Procedure (cont.)

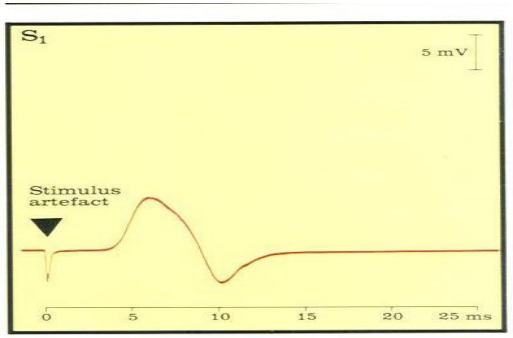
- Measure the distance from elbow to wrist with a measuring tape.

Distance
D1= 284 mm

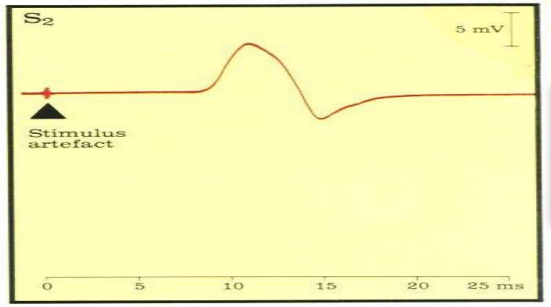


- Measure the latency in first CMAP & in the next CMAP.

Latency is a time interval between the stimulus artifact and AP.



L1 Latency At wrist = 3.5 ms



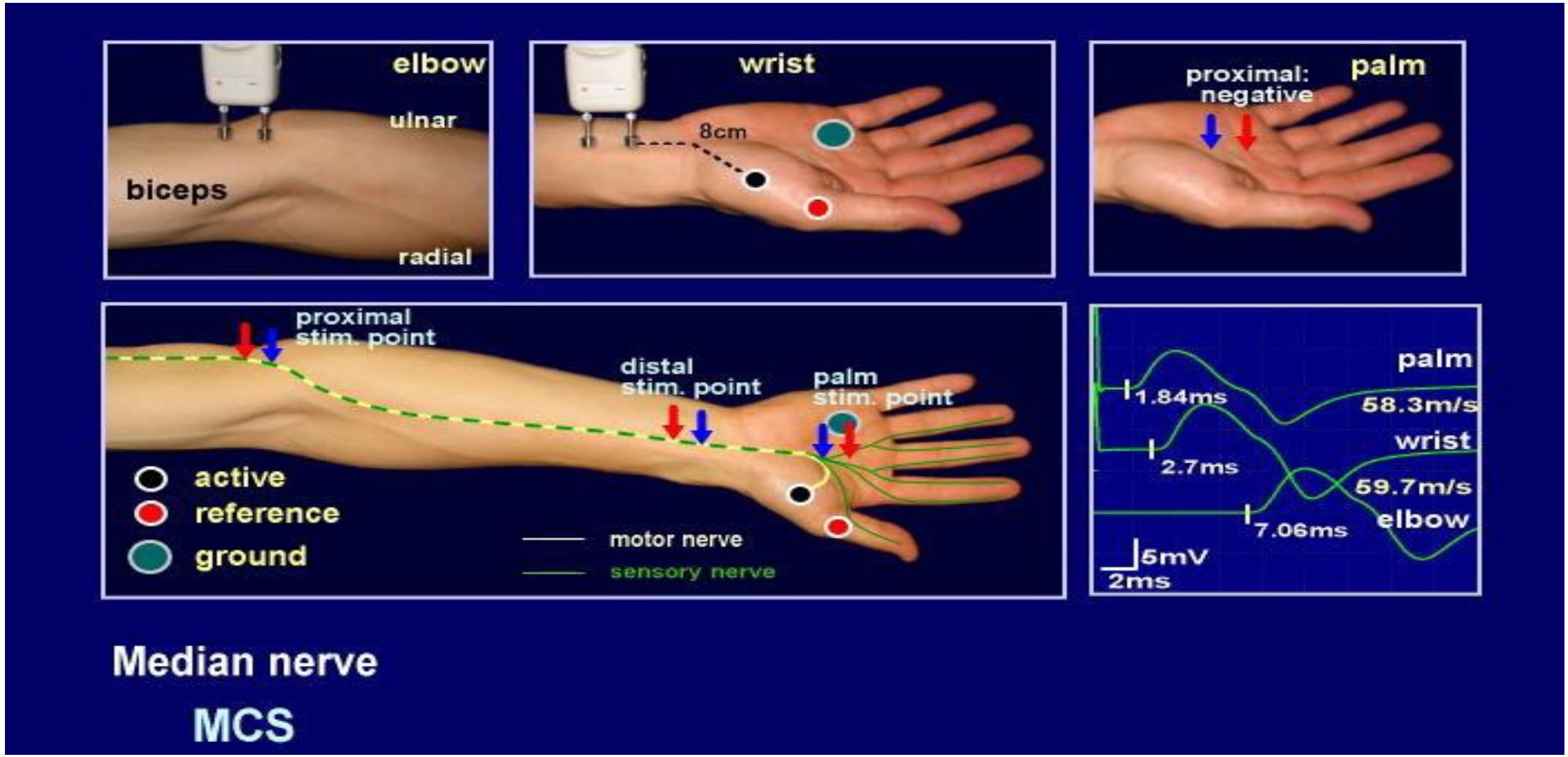
L2 Latency At elbow = 8.5 ms

- Enter the distance between the elbow and wrist (D1)

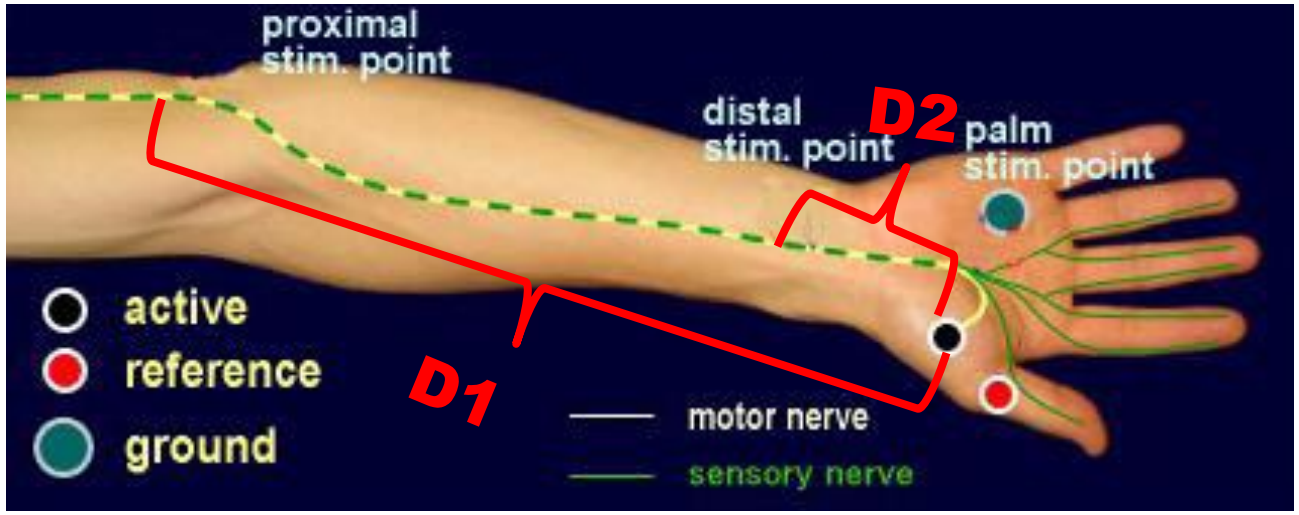
$$NCV = \frac{D1-D2}{L1-L2}$$

*D2 : the distance between the median nerve (in wrist) and thenar eminence.

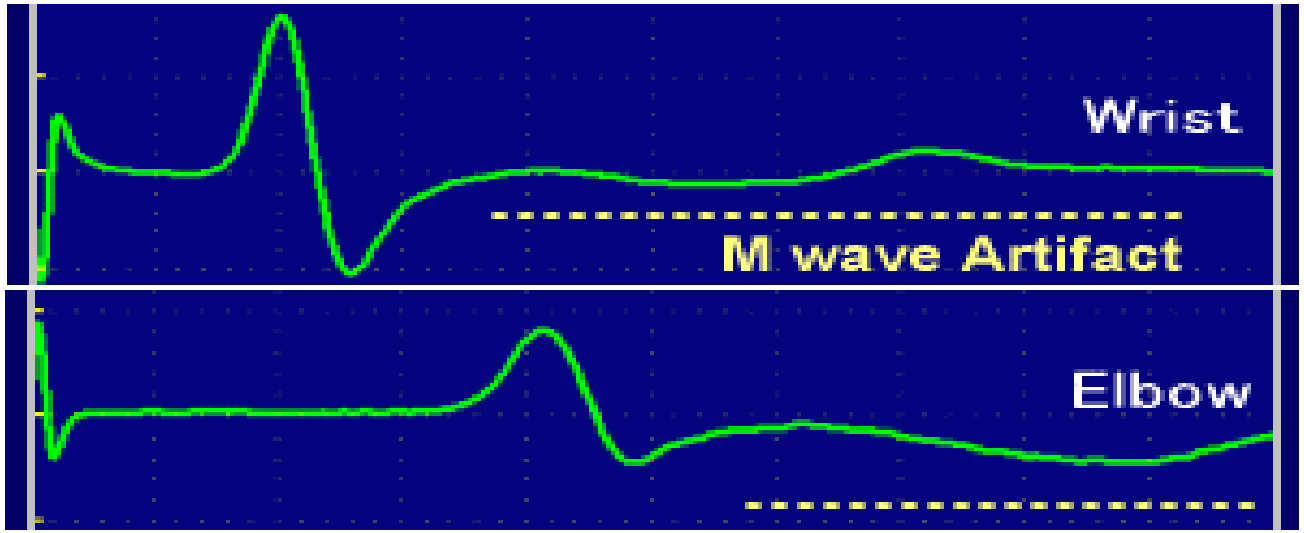
Motor Conduction Study: Median nerve (The procedure in pictures):

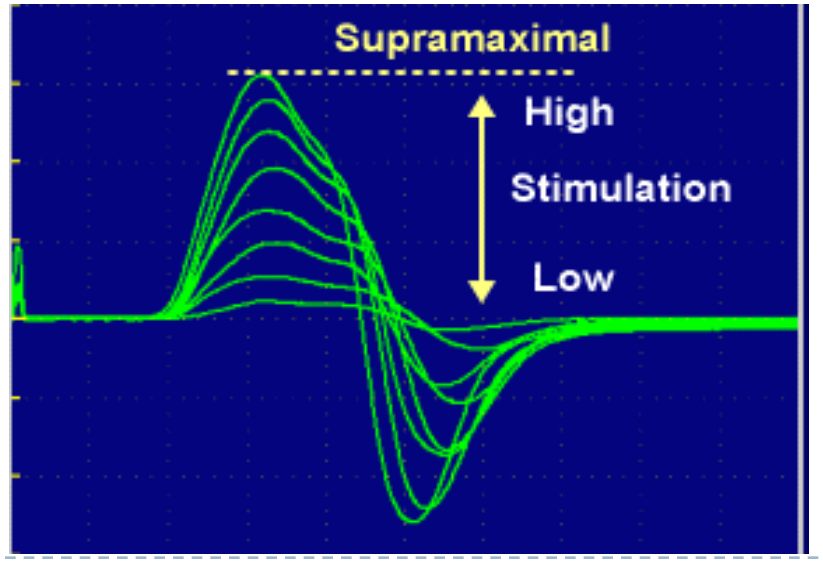


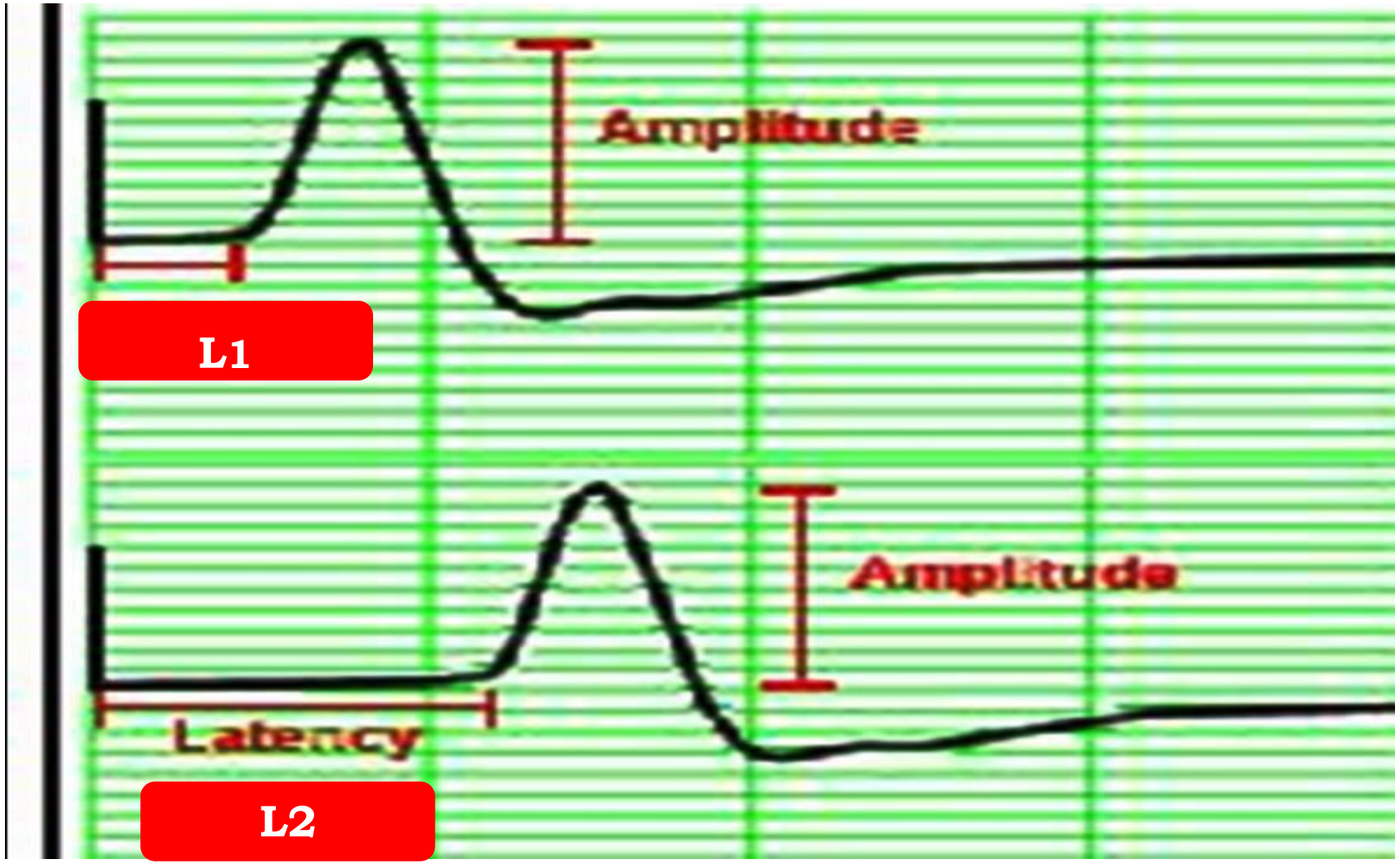
Nerve Conduction Velocity



$$NCV = \frac{D1 - D2}{L1 - L2}$$







X axis : for time.
Y axis : for voltage.

-The duration in L1 is less than L2.
-The voltage in both is same.

- Amplitude represent the number of muscle fibers that depolarize .
- Average CMAP amplitude is 3mV .

Motor Nerve Conduction Velocity (MNCV)

- MNCV will appear.

- It can also be calculated by formula MNCV (m/sec) = $\frac{Distance\ (mm)}{L2-L1\ (ms)}$

To help you remember:
Distance over time

L1 = latency at wrist L2 = latency at elbow

- Normal values for conduction velocity

In arm → –50 –70 m / sec. (Faster)

In leg → –40 –60 m / sec.

(Important)
**Do not forget to convert units when necessary!

Conduction of velocity could be more than the normal which is very good and the patient is not complaining from any thing BUT the abnormal when its become lower than the normal (slower conduction velocity)

Female Doctor's Notes on Slide 13

1. You might be asked to calculate the conduction velocity and determine whether or not it is within normal range.

2. The Doctor mentioned that:
- Below average: abnormal.
- Above average: still considered normal.

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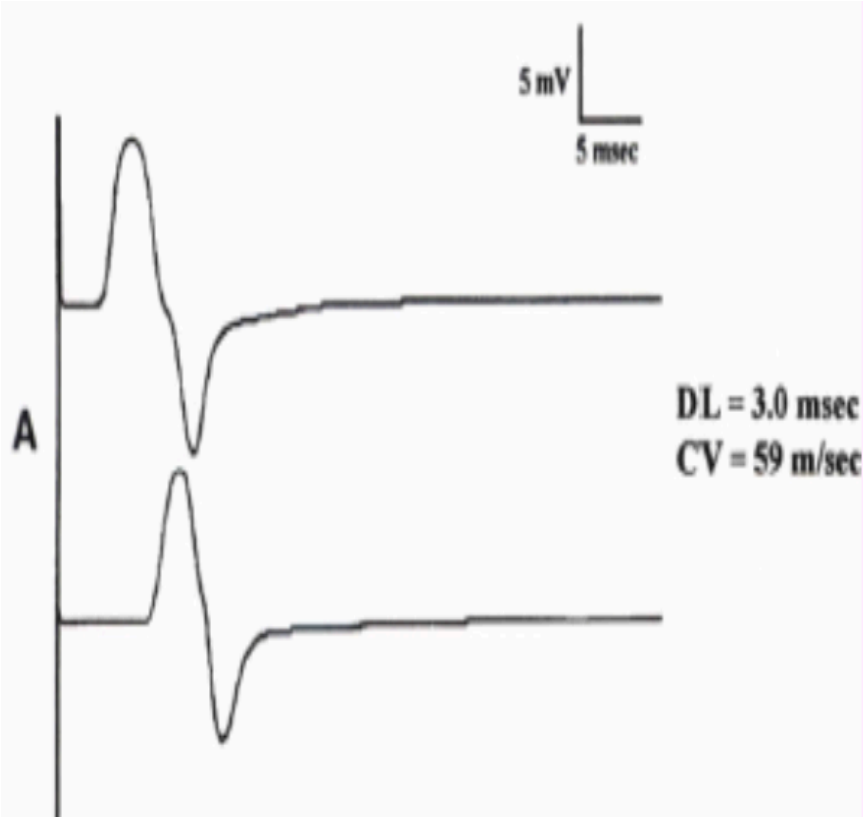
Patterns of Nerve Conduction: Normal Study of Median Nerve

- Normal median distal latency (DL) 3 ms,
- Amplitude >4 m V, and
- Conduction velocity (CV) >49 mls.



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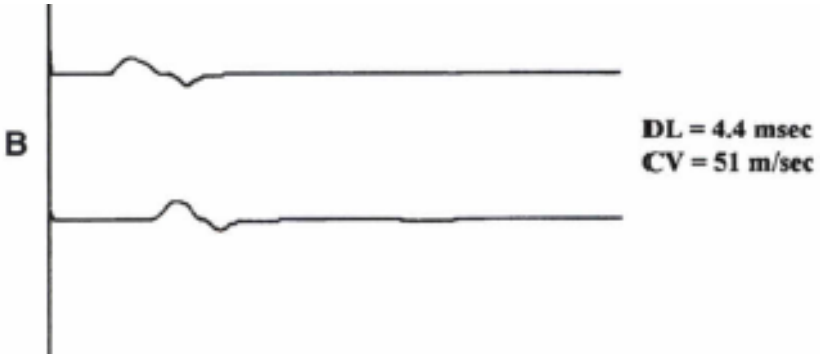
Axonal Loss and Demyelination

	Axonal loss	Demyelination
Amplitude	Decreases	No change
Distal latency	Normal or slightly prolonged	Prolonged (130% upper the normal limit)
Morphology of potential between proximal and distal sites	No change	No change
Conduction velocity	Normal or slightly slowed	Markedly slowed (75% lower than normal limit)

Axonal loss

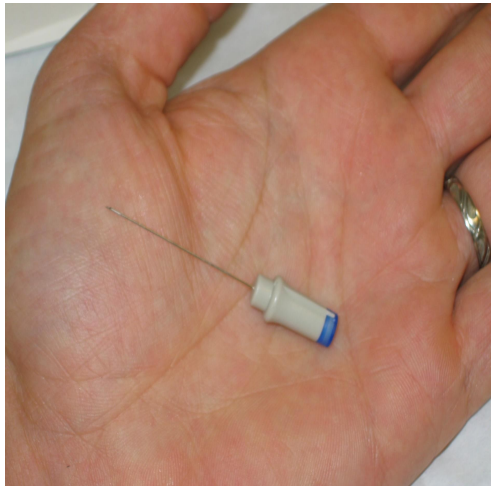


Demyelination

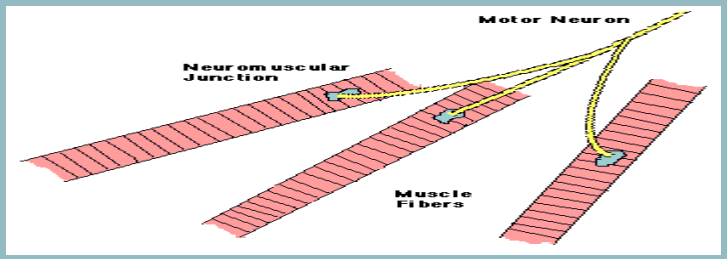
Here: Demyelination is associated with inherited disorders

Electromyography (EMG)

- EMG: is a technique for evaluating and recording physiologic properties of muscles at rest and while contracting .
- Mechanism: It is a recording of electrical activity of the muscle by inserting needle electrode in the belly of the muscles (needle EMG) or by applying the surface electrodes (surface EMG).

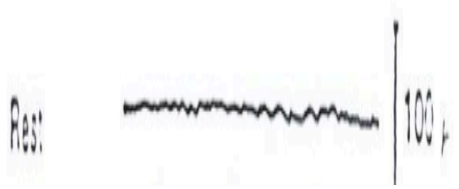
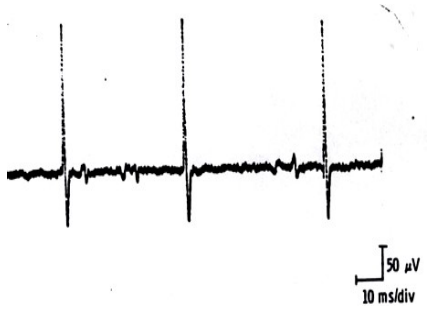
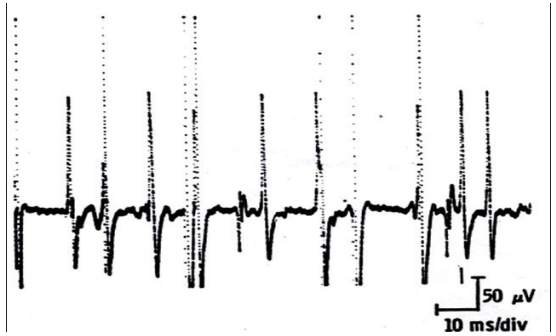
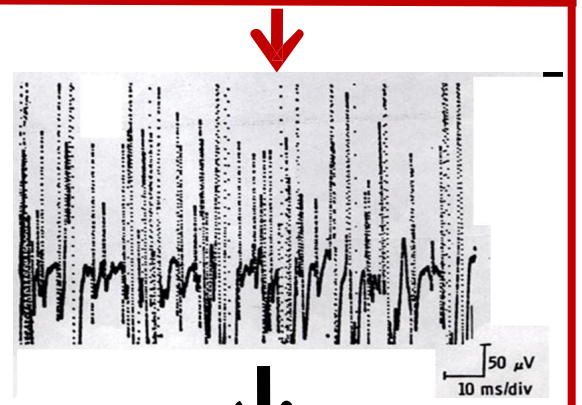


Recall:
A motor unit: is defined as one motor neuron and all of the muscle fibers it innervates.



Motor Unit Potentials (MUPs) (Normal MUP)

- (MUPs): is the potentials recorded (on volitional effort) in needle EMG are derived from motor units of the muscle.

At Rest: silent	During Mild Effort	During Moderate Effort → note recruitment of additional motoneurons	During Full Voluntary Effort . There is full recruitment (you can not see the baseline)
			

- (MUPs) Abnormalities:
- In nerve diseases: Giant MUPs due to re-innervation > 5 mV.
- In muscle disease: Small MUPs < 300µV.

Max contraction →
Full interference pattern

Analysis

- Skeletal muscles are silent at rest (spontaneous activity is absent.) يعني في الرسم البياني يكون الخط مستقيم
- Normal MUPs
  - Bi-triphasic
  - Duration 3-15mSec
  - Amplitude 300µV-5mV

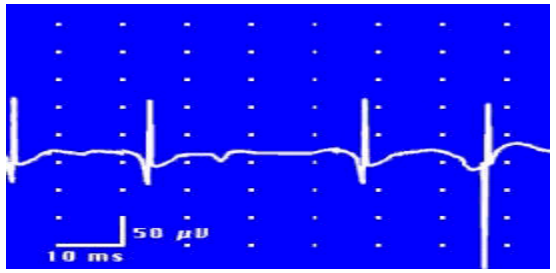
Biphasic = dome
shamed = 2 humps

In abnormal MUPs (due to neurogenic lesion or in active myositis) , these spontaneous activities are noted:

1- Positive sharp wave	Small potential 50-100µV, 5-10mSec duration with abrupt onset and slow outset.
2- Fibrillation potential*	Randomly occurring small amplitude potentials originating from the single muscle fiber of a de-innervated muscle (possibly due to denervation hypersensitivity to acetylcholine.)
3- Fasciculation potential	High voltage polyphasic long duration potentials appear spontaneously associated with visible contraction of muscle.

Abnormal MUP

Fibrillation Potentials



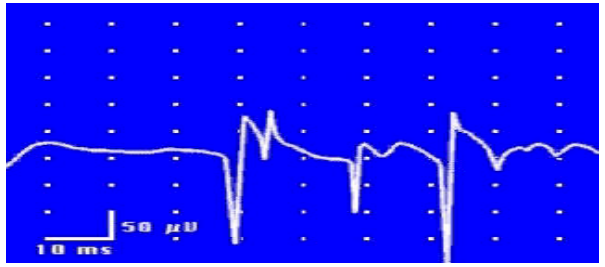
- may appear in runs

(يعني على شكل فترات)

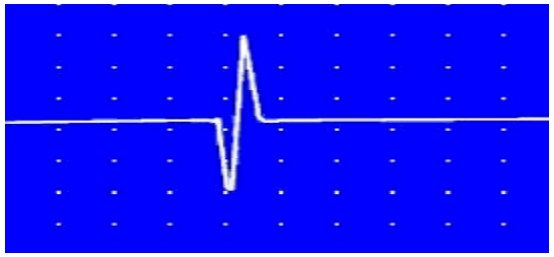
- The audio amplifier gives sound. such as; sounds of rain in a tin shade house.

مثل صوت المطر على صفيح

Positive Sharp Waves



Fasciculation Potential



They originate from a large motor unit which is formed due to re-innervation of another motor unit from the neighboring motor unit.

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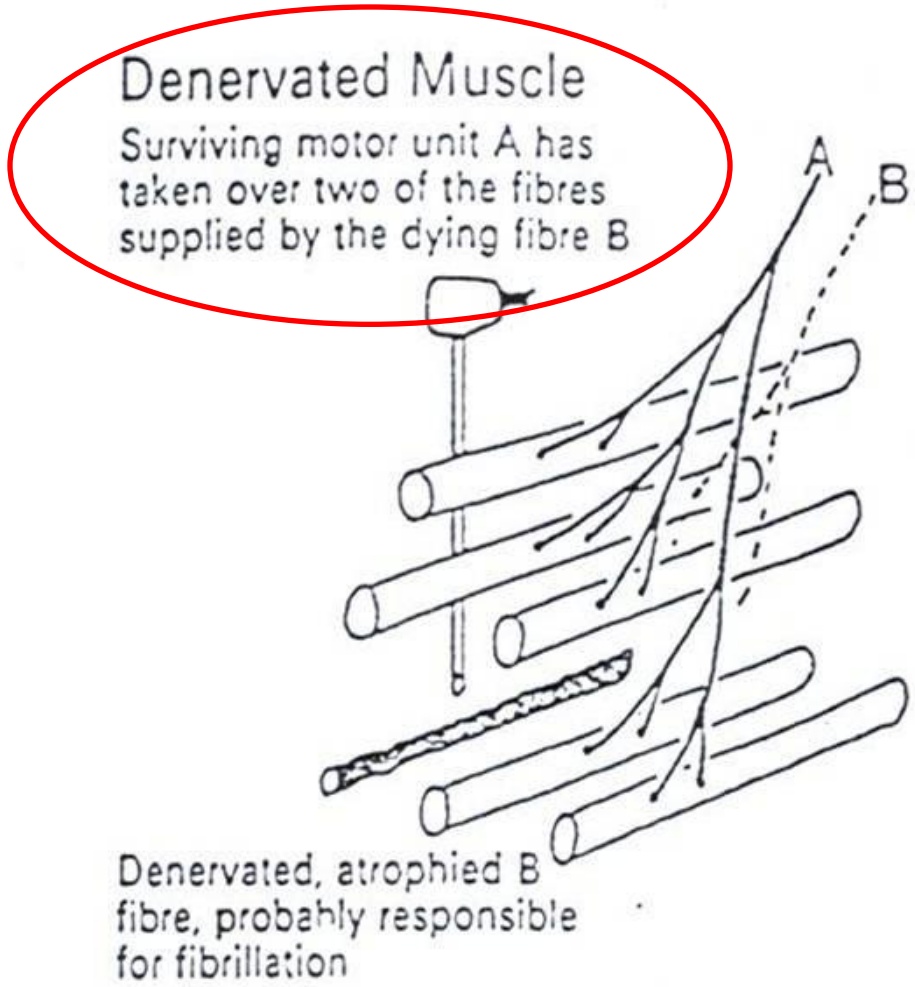
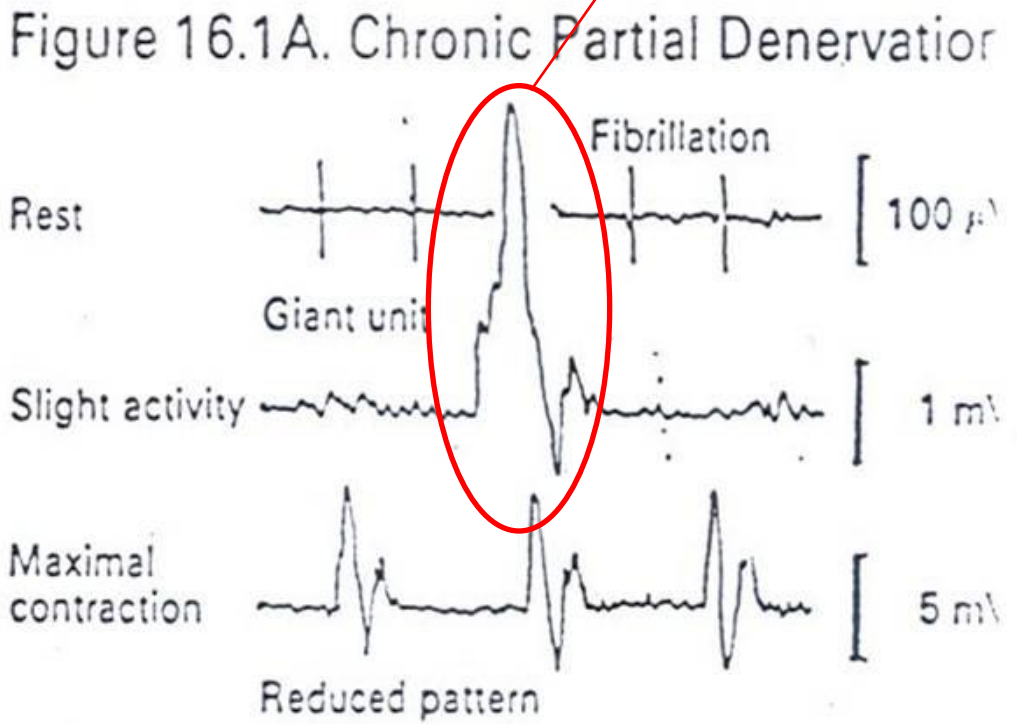
Neuropathic EMG Changes

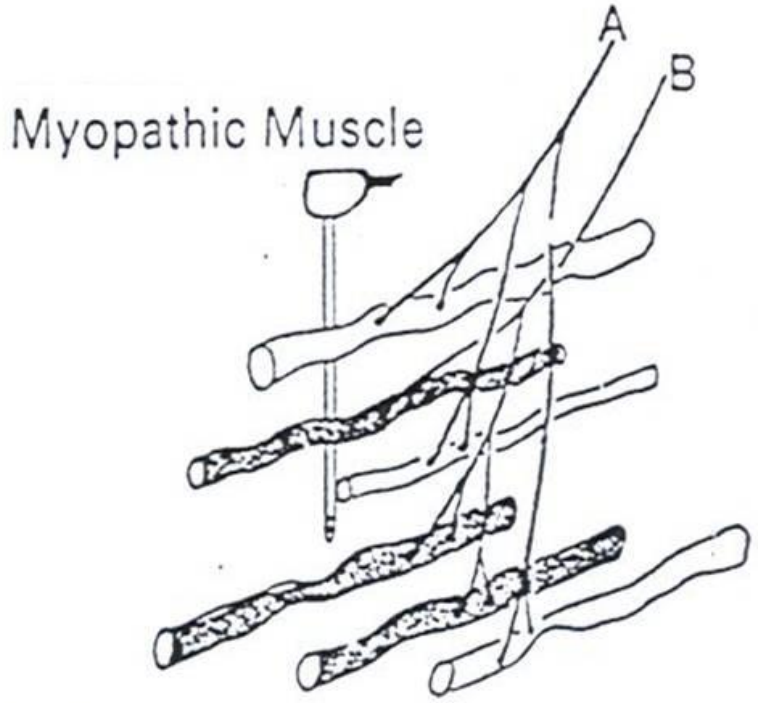
Giant unit is caused by re-innervation



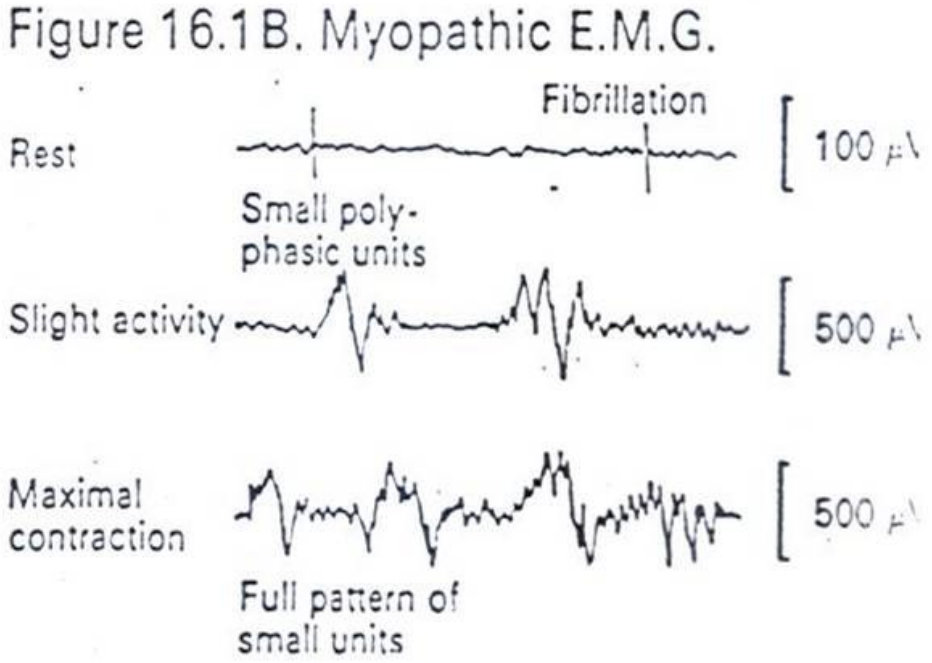


In neuropathy: maximal contraction won't produce "full interference pattern"; it will produce a "reduced pattern."

Myopathic EMG Changes

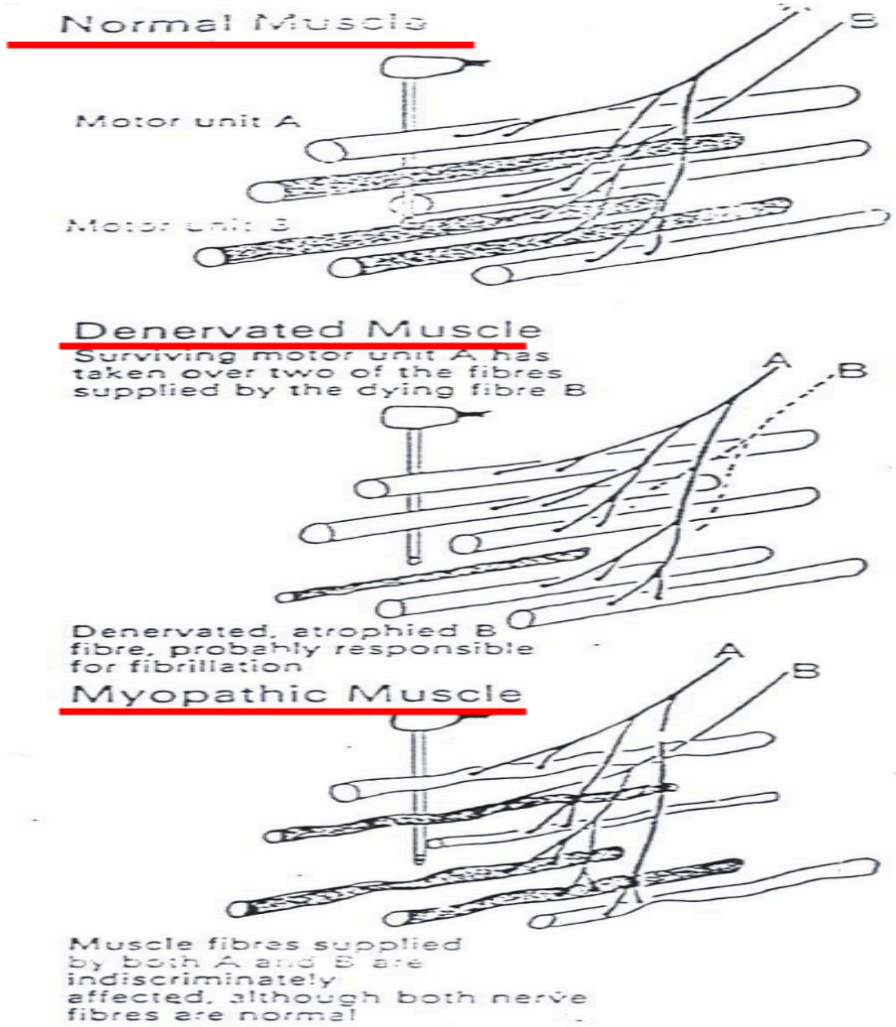


Muscle fibres supplied by both A and B are indiscriminately affected, although both nerve fibres are normal



In myopathies: maximal contraction will produce a "full interference pattern"

Summary



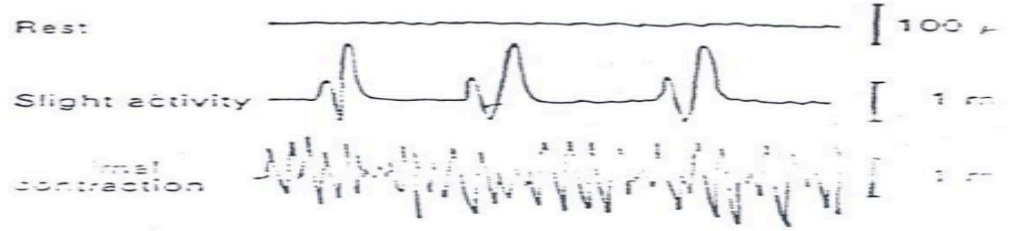


Figure 16.1A. Chronic Partial Denervation

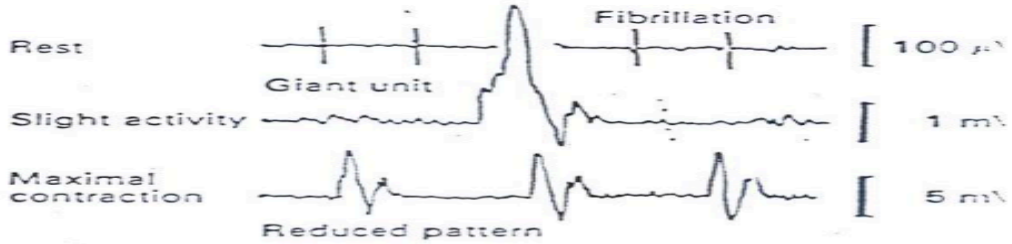
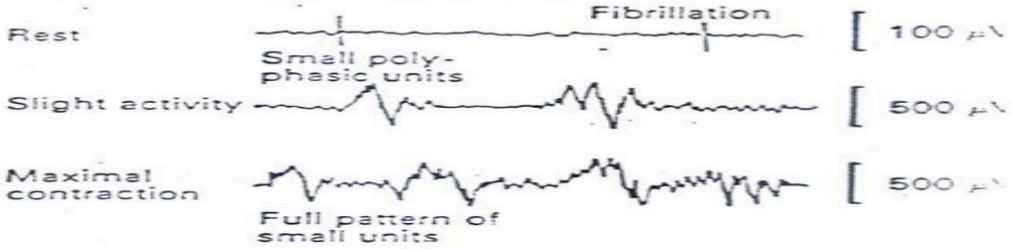


Figure 16.1B. Myopathic E.M.G.



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Analysis of a Motor Unit Potential (MUP)

MUP	NORMAL	NEUROGENIC	MYOPATHIC
Duration msec.	3 – 15 msec	longer	Shorter
Amplitude	300 – 5000 μV	Larger	Smaller
Phases	Biphasic / triphasic	Polyphasic	May be polyphasic
Resting Activity	Absent	Present	Present
Interference Pattern	full	partial	Full

Typical MUP Characteristics in Myopathic, Neuropathic, and Normal Muscle

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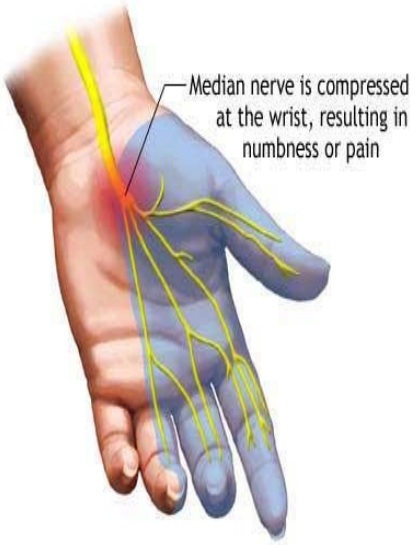
MUP	Myopathy	Normal	Neuropathy
Duration	< 3 msec	3 – 15 msec	> 15 msec
Amplitude	< 300 μV	300-5000 μV	> 5 mV
Configuration	Polyphasic	Triphasic	Polyphasic

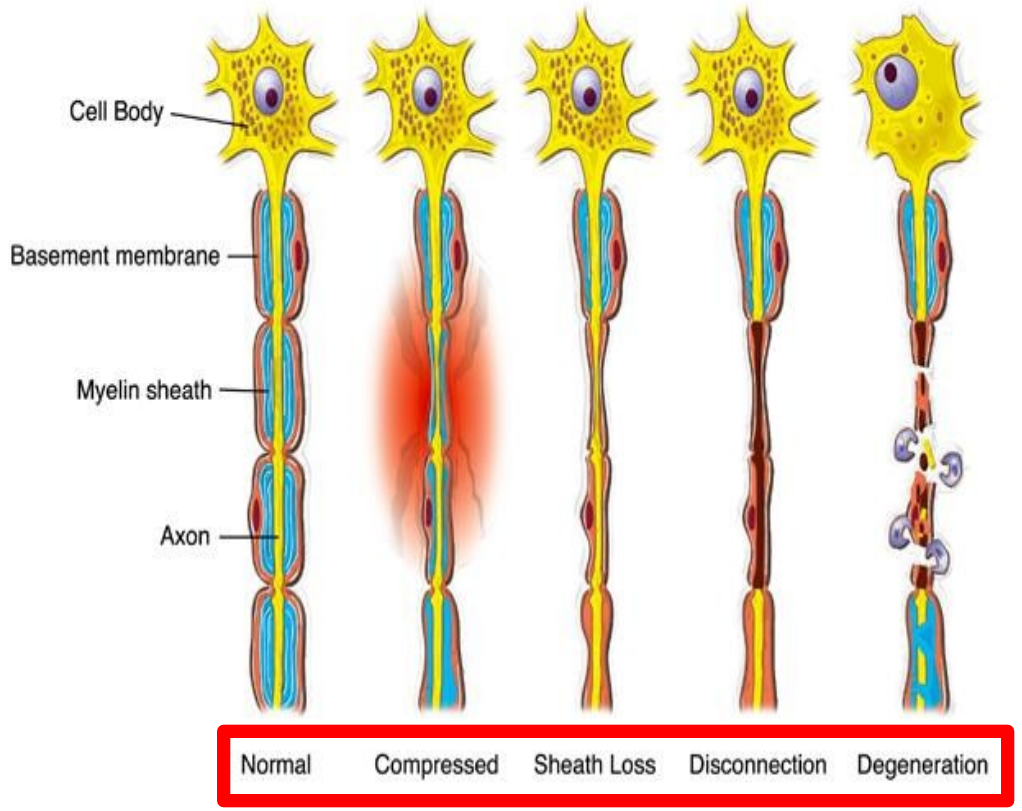
Clinical Application (3 Clinical Applications)

1- Carpal Tunnel Syndrome

Extra explanation: carpal tunnel syndrome :Involves thickening of the tunnel in the wrist which the nerve supply to hand muscle passed



2- Nerve Injury



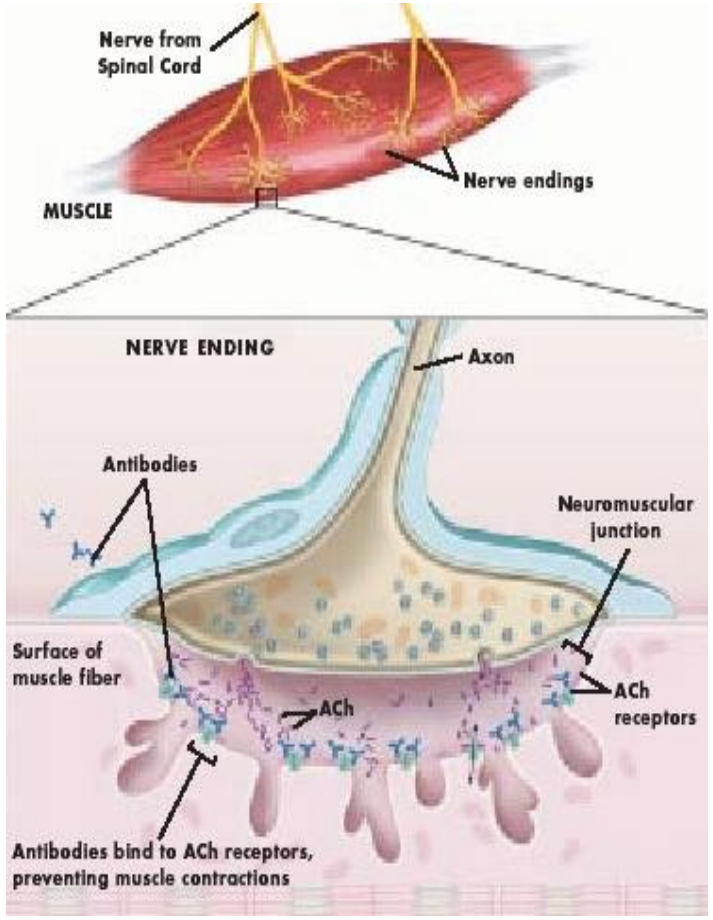
3- Myasthenia Gravis (next slide)

3-Myasthenia Gravis

Extra explanation :

Myasthenia Gravis: is an autoimmune disease involving the neuromuscular junction, it is characterized by extreme muscular weakness (gravis means severe).

Mechanism: it is an autoimmune condition in which the body produces antibodies against its own (this is why it is an autoimmune disease) motor end-plate Acetylcholine receptor-channels. Thus, not all the released Ach molecules can find a functioning receptor to bind to.



Arms raised to fatigue the muscles

Videos

- What are NCS & EMG ?
- EMG/NCS testing
- Median motor nerve conduction study
- Nerve conduction test

Quiz

- https://www.onlineexambuilder.com/emp-mncv/exam-118896

Link to Editing File

(Please be sure to check this file frequently for any edits or updates on all of our lectures.)

References:

- Girls' and boys' slides.
- (Lecture contents were not found in our reference textbook and therefore we could not add extra explanation from Guyton and Hall.)

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمعة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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