Nerve Conduction studies and Electromyography

- Color index:
  - Red: important
  - Green: doctor's notes
  - Grey: extra information
  - Pink: found only in female's slides
  - blue: found only in male's slides

Physiology 437 team work

objectives:

By the end of the lecture you will be able to:

- Define nerve conduction study (NCS) and electromyography (EMG).
- Explain the procedure of NCS
- 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.

تطبيق مع شرح
مبسط 11:06

Videos for over view

female doctor videos :

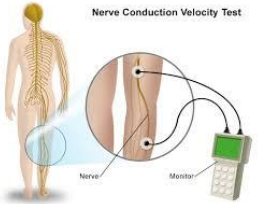
nerve conduction study :

https://www.youtube.com/watch?v=avl2rS3siig 2:36

EMG :

https://youtu.be/gpgsR5jcI8M 3:25

Nerve Conduction studies



A nerve conduction study (NCS) is a test commonly used to evaluate the function, especially the ability of electrical conduction, of the motor and sensory nerves of the human body.

* **Nerve conduction velocity** (NCV) is a common measurement made during this test.

It could be:

- Mixed NCS
- Motor NCS
  Only one will be discussed
- sensory NCS

Motor nerve conduction study

Male's slides

- The recorded potential, known as the compound muscle action potential (CMAP), represents the summation of all underlying individual muscle fiber action potentials.
- CMAP is a biphasic (ثنائي الموجة) potential with an initial upward deflection from the baseline
- 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.

Motor nerve conduction velocity

Male's slides

- Motor nerve conduction velocity of peripheral nerves may be closely correlated to their functional integrity or to their structural abnormalities.
- Based on the nature of conduction abnormalities two principal types of peripheral nerve lesions can be identified: Axonal degeneration and segmental demyelination.
- In the patients of muscular weakness, muscle atrophy, traumatic or metabolic neuropathy, these tests are considered as an extension of the physical examination rather than a simple laboratory procedure.

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).

Team 436

CMAP measurement (for nerves)

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 = Axonal neuropathy
- average CMAP amplitude 3 mv

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

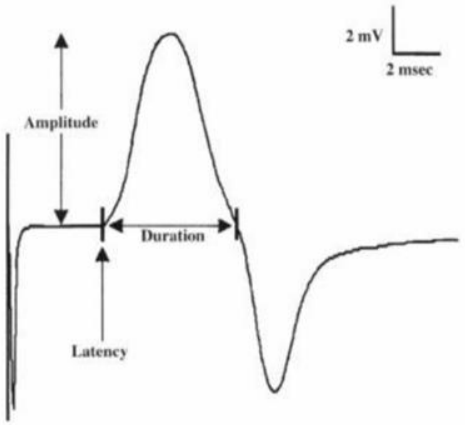
- Duration characteristically increases in conditions that result in slowing of some motor fibers (in demyelination).

Conduction Velocity

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

slow=demyelination

Next slide



MOTOR CONDUCTION STUDIES

- The recorded potential, known as the compound muscle action potential (CMAP), represents the summation of all underlying individual muscle fiber action potentials.
- CMAP is a biphasic (ثنائي الموجة) potential with an initial upward deflection from the baseline
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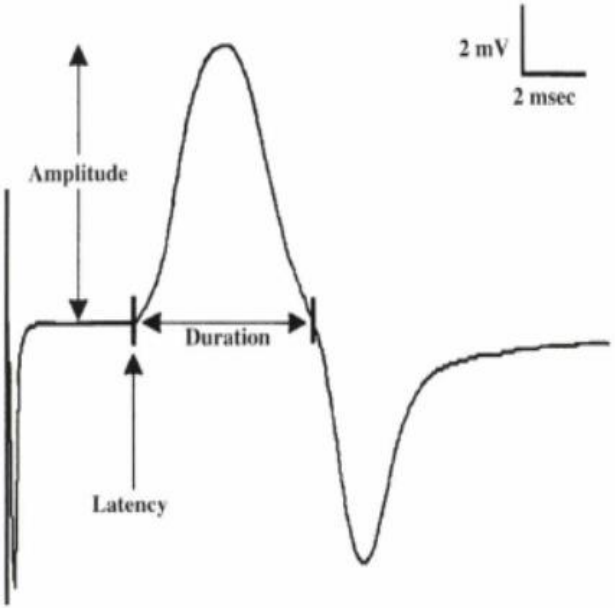


extra

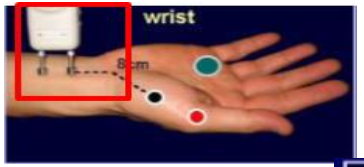
Motor NCS are performed by electrical stimulation of a peripheral nerve and recording from a muscle supplied by this nerve. The time it takes for the electrical impulse to travel from the stimulation to the recording site is measured. This value is called the latency and is measured in milliseconds (ms). The size of the response - called the amplitude - is also measured. Motor amplitudes are measured in millivolts (mV). By stimulating in two or more different locations along the same nerve, the NCV across different segments can be determined. Calculations are performed using the distance between the different stimulating electrodes and the difference in latencies.

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).

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.

Motor Nerve Conduction Velocity (MNCV)

- MNCV will appear.

speed equation+
Distance over
△time

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

L1 = latency at wrist L2 = latency at elbow

- Normal values for conduction velocity (Important)
  **Do not forget to convert units when necessary!

In arm → –50 –70 m / sec. (Faster)

In leg → –40 –60 m / sec.

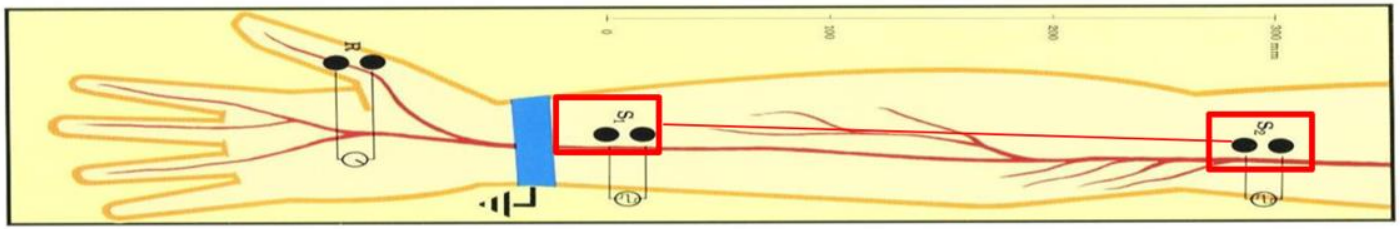
Conduction of velocity could be more than the normal which is very good

(slower conduction velocity)
(demyelination)

NCV equation

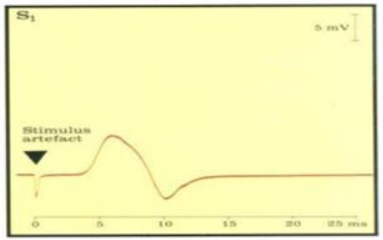
- Measure the distance from elbow to wrist with a measuring tape.

Distance
D1= 284 mm

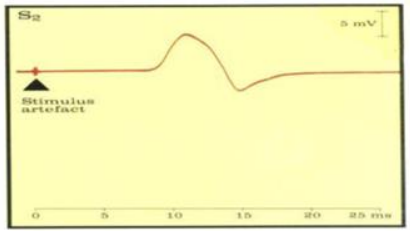


- Measure the latency in first CMAP & in the next CMAP.

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

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

$$\frac{mm}{ms} = \frac{m}{s}$$ الناتج بيطلع متر لكل الثانية

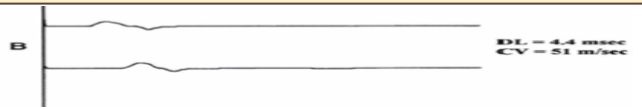
Patterns of nerve conduction Normal study of median nerve

Normal median distal latency (DL)
3 ms

Conduction velocity (CV)
> 49 mls

Amplitude
> 4 mV

Axonal Loss and Demyelination		
	Axonal loss	Demyelination
Amplitude	decrease	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)

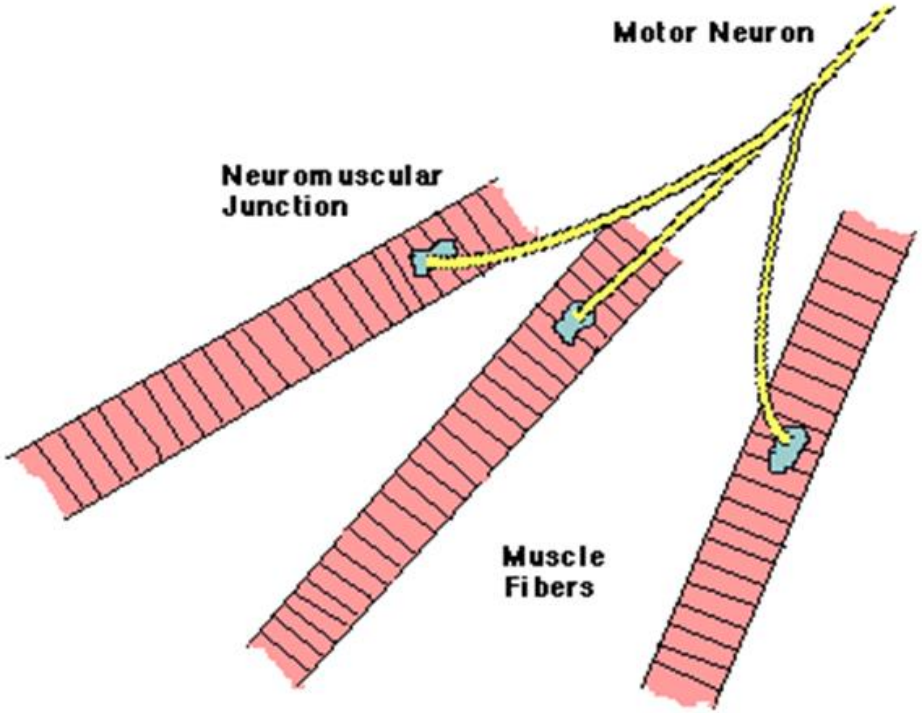


Electromyography (EMG)

EMG: is a technique for evaluating and recording physiologic properties of muscles at rest and while contracting .

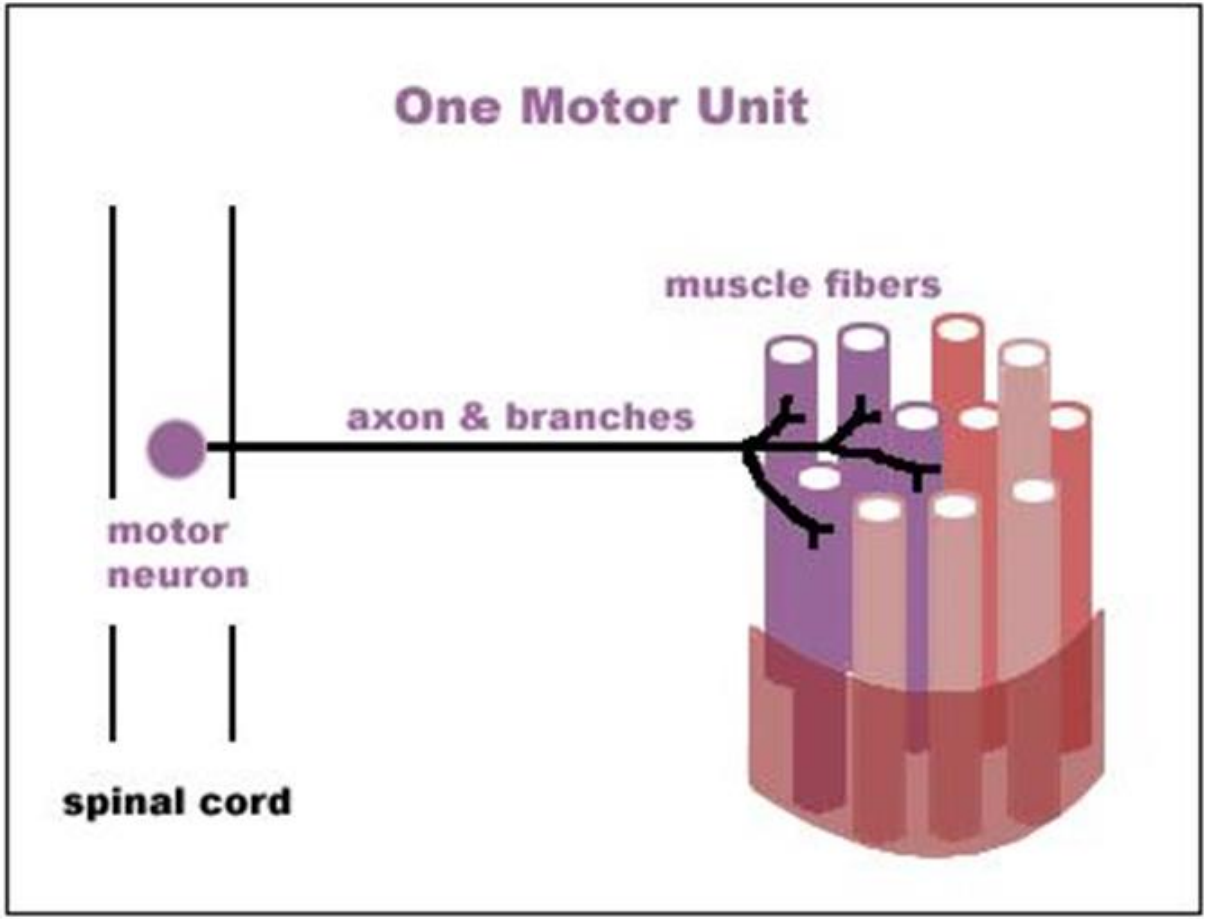
Mechanism: It is a recording of electrical activity of the muscle by inserting **needle electrode** in the belly of the muscles (needle EMG) or by applying the surface electrodes (surface EMG).

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



In the slides notes :

A motor unit is defined as one motor neuron and all of the muscle fibers it innervates. When a motor unit fires, the impulse (called an action potential) is carried down the motor neuron to the muscle. The area where the nerve contacts the muscle is called the neuromuscular junction, or the motor end plate. After the action potential is transmitted across the neuromuscular junction, an action potential is elicited in all of the innervated muscle fibres of that particular motor unit. The sum of all this electrical activity is known as a *motor unit action potential* (MUAP). This electrophysiologic activity from multiple motor units is typically evaluated during an EMG. The composition of the motor unit, the number of muscle fibres per motor unit, the metabolic type of muscle fibres and many other factors affect the shape of the motor unit potentials in the myogram.


One Motor Unit
muscle fibers
axon & branches
motor
neuron
spinal cord

Analysis

EMG

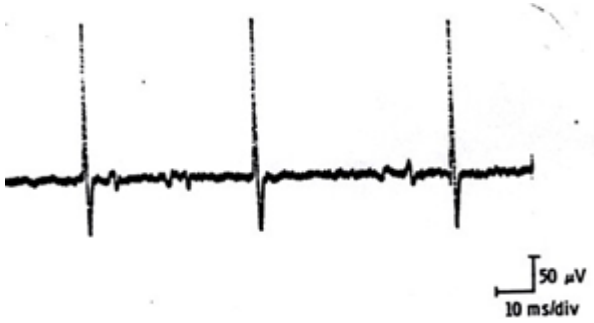
Spontaneous activity

–The skeletal muscle is silent at rest, hence spontaneous activity is absent.

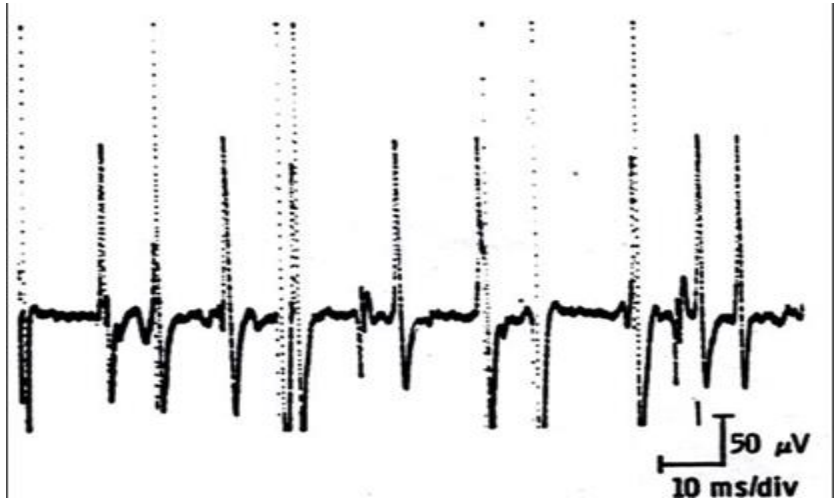
Normal MUPs

- Bi – Triphasic
- Duration – 3 – 15 mSec.
- Amplitude – 300μV – 5 mV

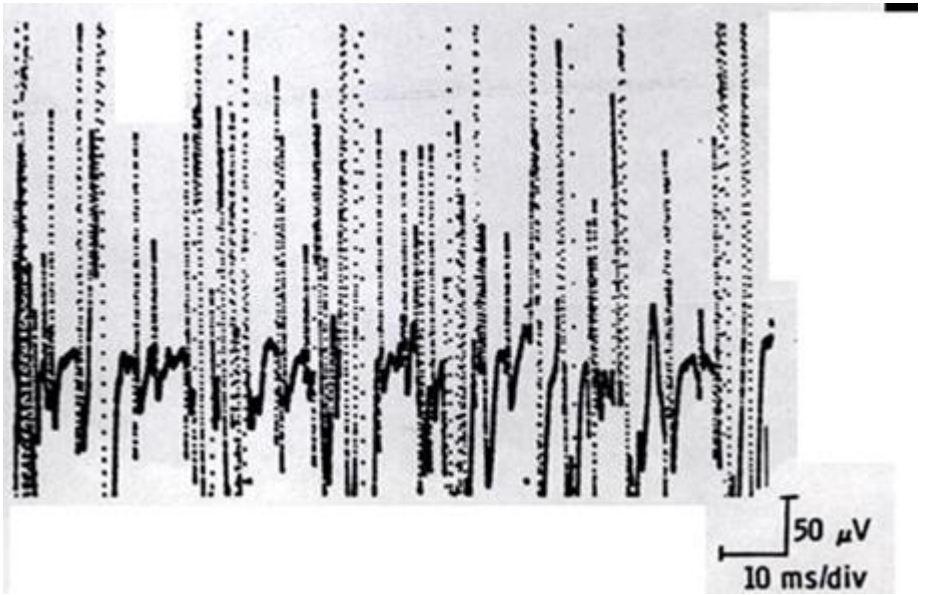
MUPs (2)



During Mild Effort

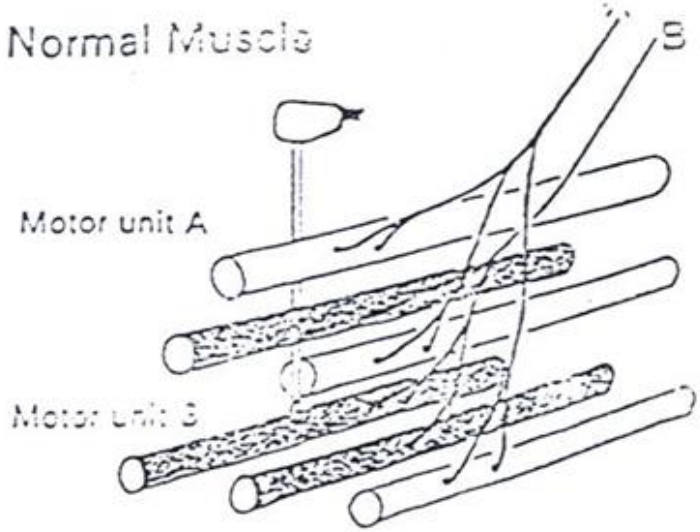


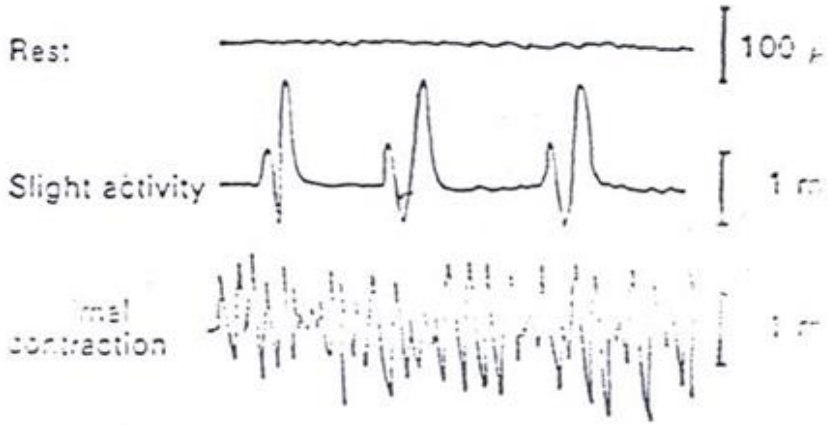
During Moderate Effort -> note recruitment of additional motoneurons



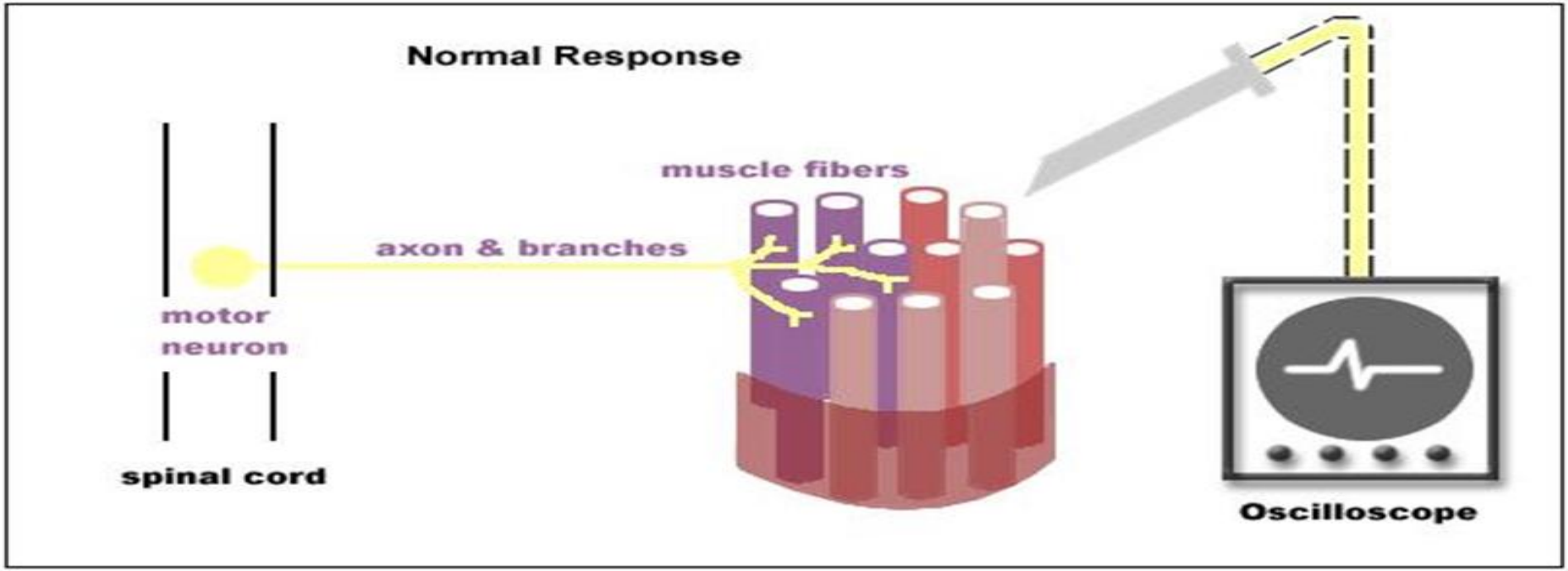
During Full Voluntary Effort . There is full recruitment **(you can not see the baseline)**

Normal Muscle





NORMAL EMG


Normal Response
muscle fibers
axon & branches
motor
neuron
spinal cord
Oscilloscope

Abnormal MUPs

In neurogenic lesion or in active myositis, the following spontaneous activity is noted

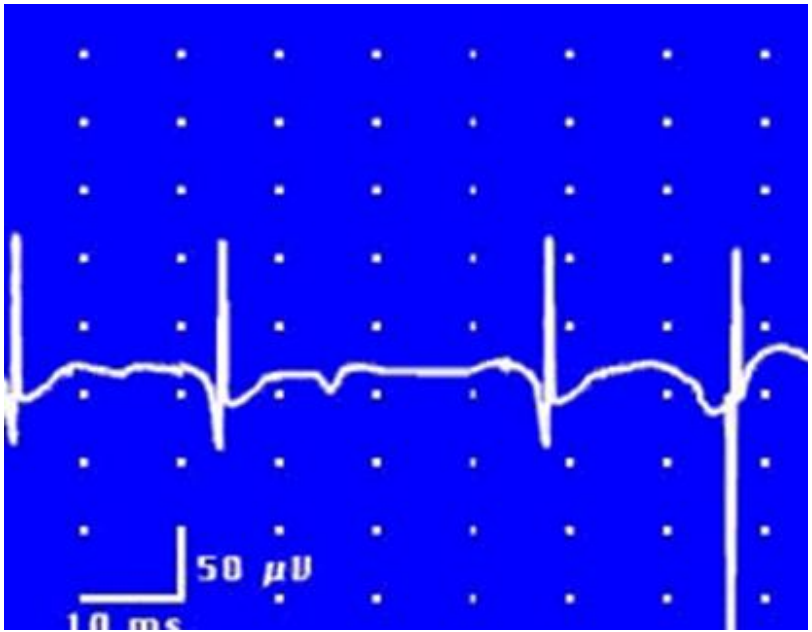
Positive sharp wave:

A **small potential** of 50 to 100 μV, 5 to 10 msec duration with abrupt onset and slow outset.

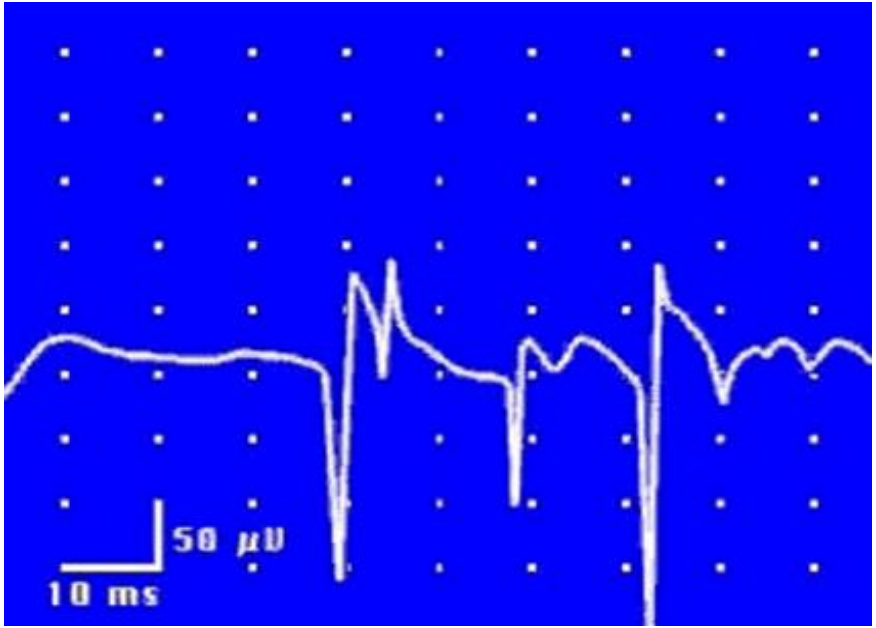
Fibrillation potential:

- these are randomly occurring small amplitude potentials or may appear in runs. The audio amplifier gives sounds, as if somebody listen sounds of rains in a tin shade house. These potentials are generated from the single muscle fiber of a denervated muscle, possibly due to denervation hypersensitivity to acetylcholine.

Fibrillation Potentials



Positive Sharp Waves



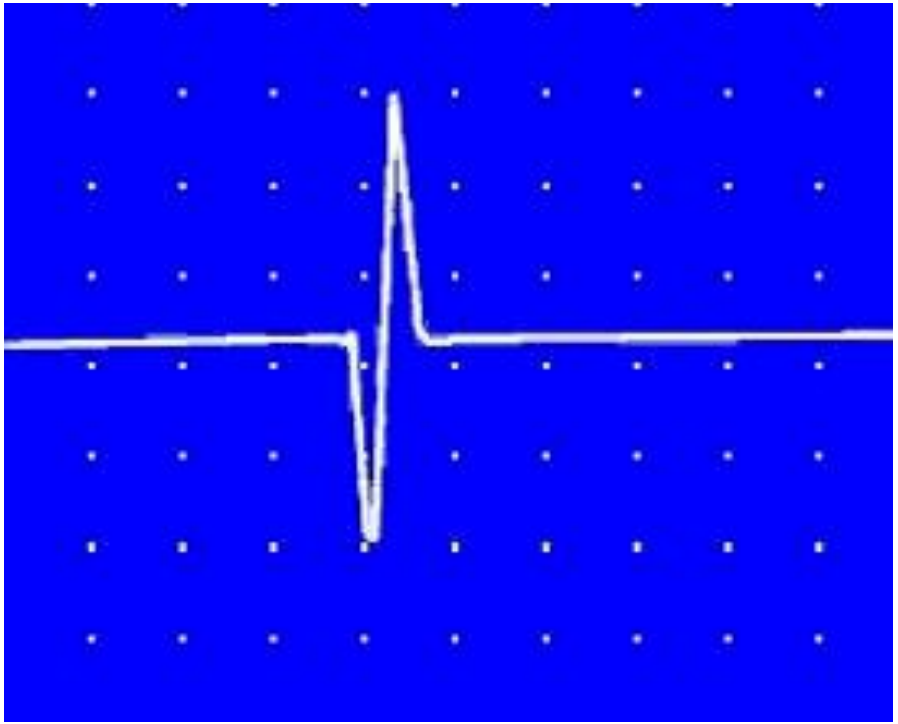
Cont...

Fasciculation potentials:

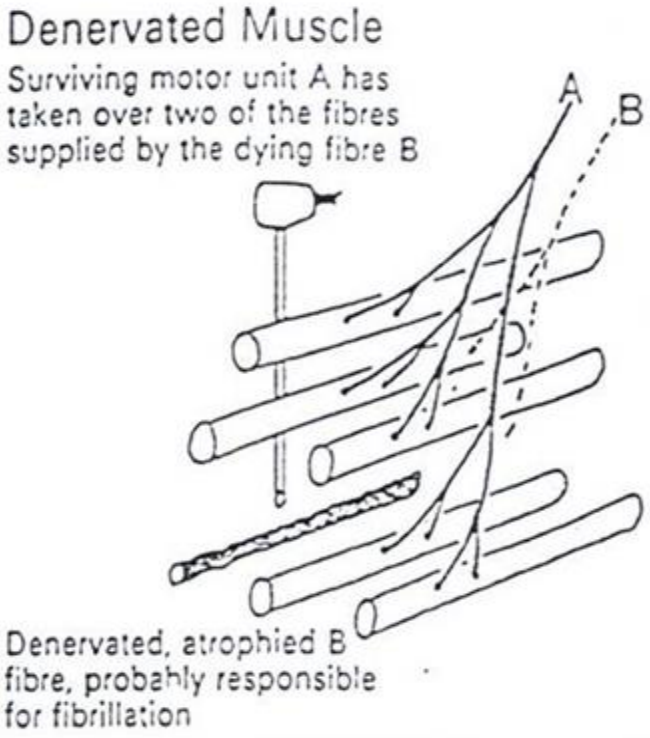
- These are high voltage, polyphasic, long duration potentials appear spontaneously associated with visible contraction of the muscle. They originate from a large motor unit which is formed due to reinnervation of another motor unit from the neighboring motor unit.

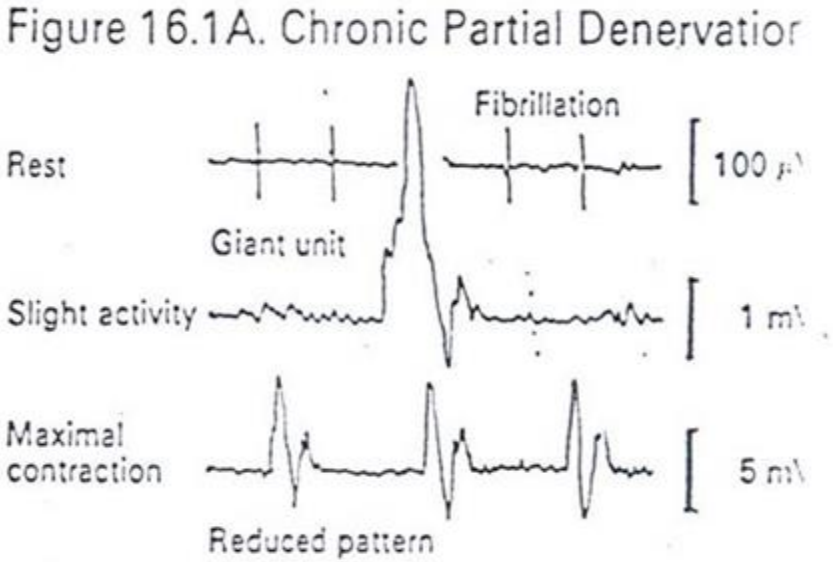
EMG: Spontaneous Activity

Fasciculation Potential

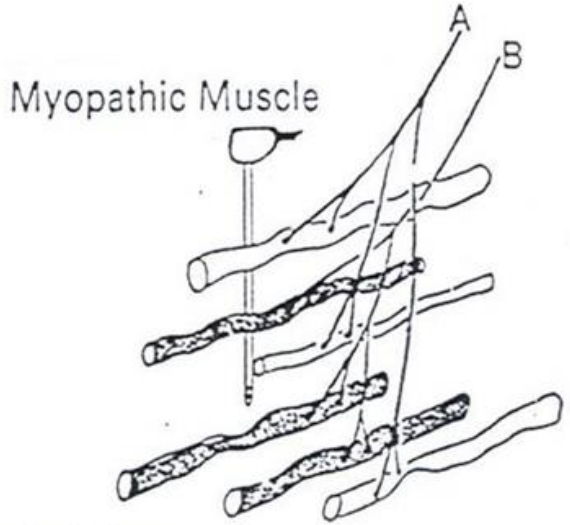


Neuropathic EMG changes

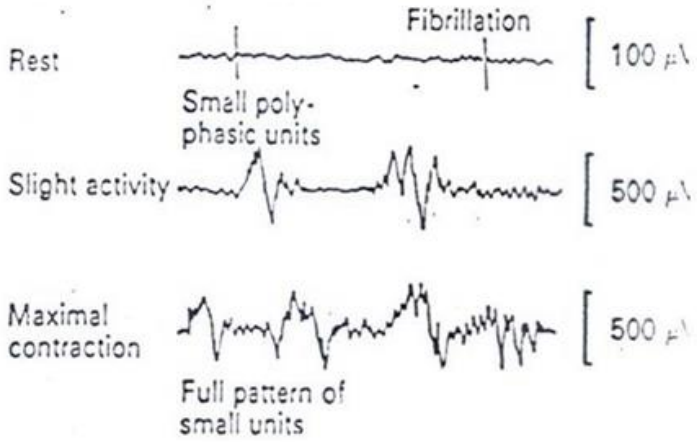




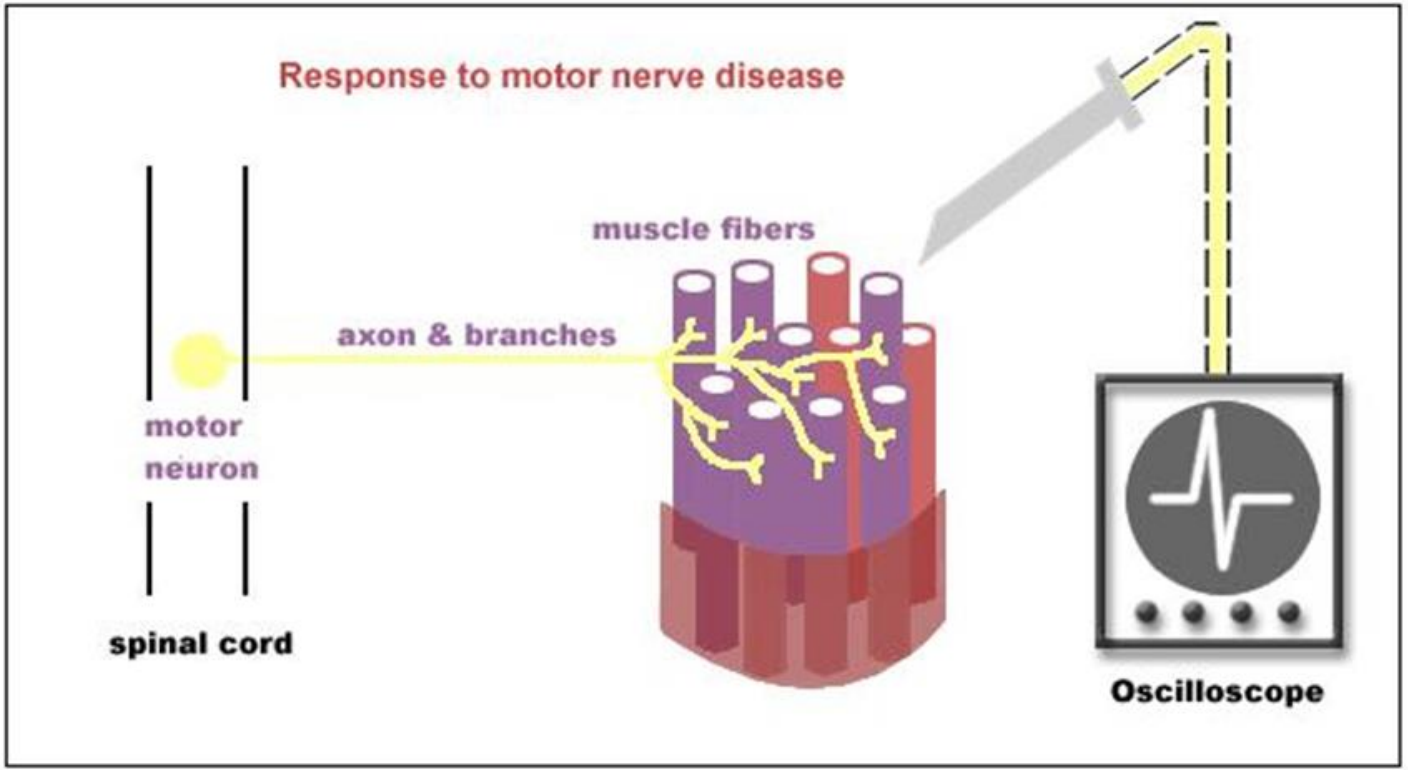
Myopathic EMG changes



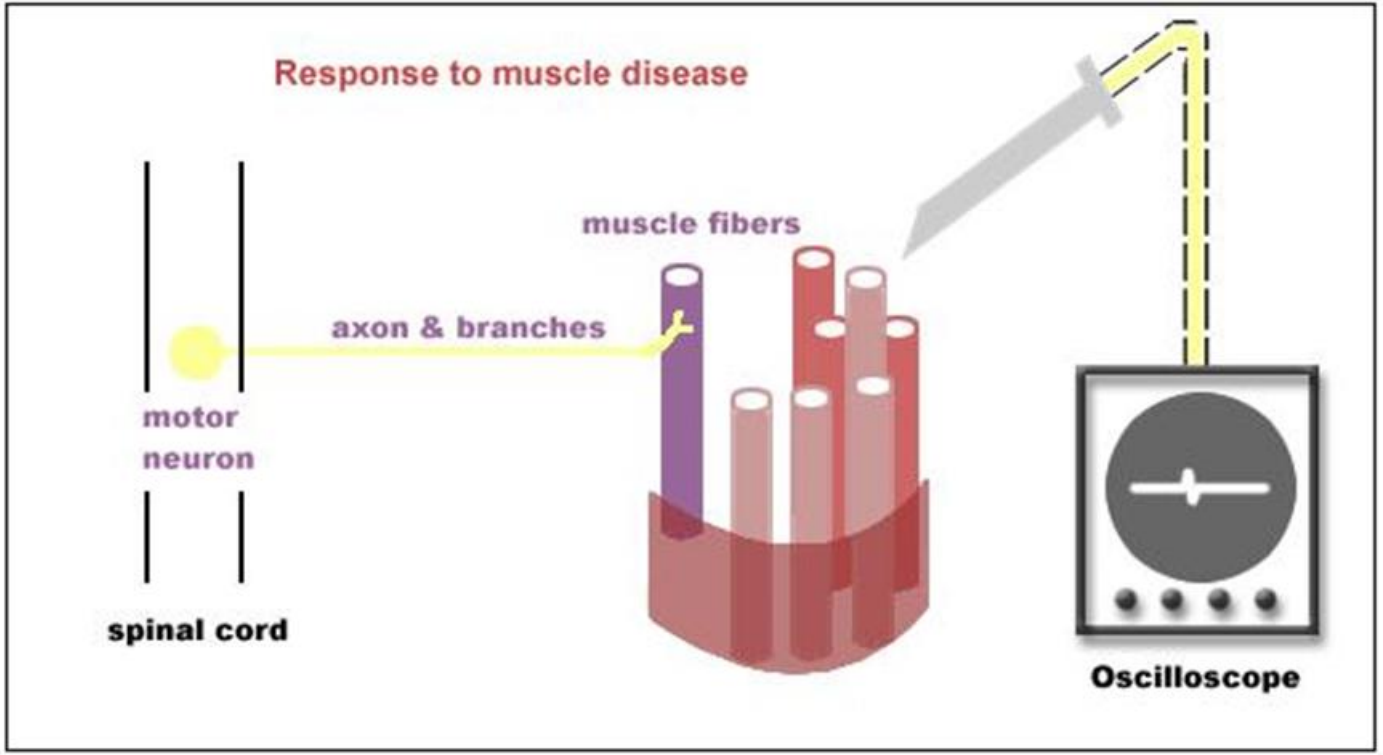
Muscle fibres supplied by both A and B are indiscriminately affected, although both nerve fibres are normal



NEUROPATHY


Response to motor nerve disease
muscle fibers
axon & branches
motor neuron
spinal cord
Oscilloscope

MYOPATHY


Response to muscle disease
muscle fibers
axon & branches
motor
neuron
spinal cord
Oscilloscope

Analysis of a motor unit potentials (MUPs)

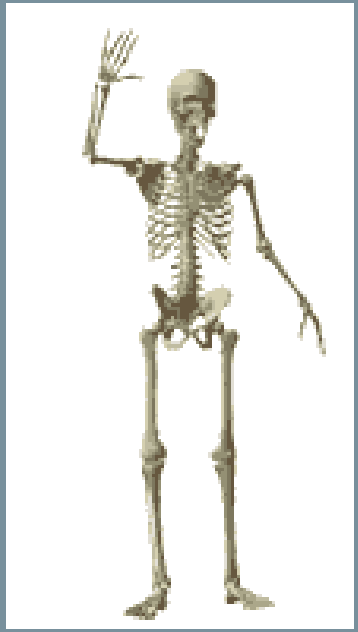
MUP	NORMAL	NEUROGENIC	MYOPATHIC
Duration msec.	3 – 15 msec	longer	Shorter
Amplitude	300 – 5000 µV	Larger(Giant MUPs)	Smaller
Phases	Biphasic / triphasic	Polyphasic	May be polyphasic
Resting Activity	Absent	Present	Present
Interference pattern	full	partial	Full

Female's team:

1. Ahad Algrain
2. Hadeel
3. Maha Alnahdi
4. Majd AlBarrak
5. Rahaf Alshammari
6. Rinad Alghoraiby
7. Munira Alhadlg
8. Sarah Alblaihed
9. Renad Almogren

Male's team:

1. Naif Almutairi
2. Saad Alfawzan
3. Mohammed Alswoaiegh
4. Saud Alatawy
5. Saif almeshari
6. Khalid alogaili



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editing file