

## Compound AP / Electrophysiological Tests

Usually, action potential is recorded from primitive animals like the squid, which has a single nerve fibers in its body that is very large (diameter less than 1mm ) and is a very fast conductor. That is the only nerve fiber in its body and its used for moving quickly and to run from enemies.

In more sophisticated creatures, like humans, there are no large nerve fibers in our bodies, instead there are myelinated and unmyelinated fibers, single nerve fibers aren't found alone, they are in bundles. And there are many fibers found in the peripheral nerve.

- Myelinated nerve fibers are almost double the number of unmyelinated ones.

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Using a electroneugraphy composed a screen where electrical activity is recorded and displayed determine if a patient is normal or suffers from abnormality.

Machine contains:

- Stimulator, of two wires (negative; cathode and positive; anode) ,held by the examiner physician to put them according to the anatomical structures.
- Recording electrode, surface electrodes that are put to the skin of the patient
- An amplifier, because electrical activity is very small, it is amplified.
- A report given to the patient to make sure what we're seeing and getting isn't an environmental noise, to tell whether the patient is normal or not
- A loud speaker.

All these confirm what is being seen on the screen to make sure the diagnosis is being made properly.

It is important for the patient to be rested and lying down and make sure to have earthing/grounding ( a way to get rid of the extra electrical charges from the body) between the stimulating and recording electrodes in order to prevent an electrical shock for both the examiner or the patient.

In the slides...

(red) is the stimulating electrode, moved according to examiner.

(green) is the fixed recording electrode, put on the part of the body that needs to be examined.

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The compound action potential is a graded type of potential produced by the machine using the stimulating electrode and isn't psychological. It is graded because it is the summation of many action potential.

Starting with the resting membrane potential and supposing a certain nerve is stimulated by 1 volt:

- If stimulated using the electrode with a sub-threshold activity ( for example 0.5 volt) , it will record nothing.
- If stimulated with the threshold voltage ( in the example; 1 volt ), there will be electrical activity recorded.
- As the voltage increases (ex: above 1 volt) the stimulus artifact will increase till it reaches the maximum. Reaching the maximum indicates that all nerve fibers that are included in that specific peripheral nerve have been stimulated.
- Any supra-maximum stimulation (if in the example 5 volts indicate the max voltage and the fiber was stimulated with more than 5) , there won't be any change in the amplitude and it'll stay the same, proving that **it's a summation of all or none action potential.**

→ Once reaching a point where all nerve fibers have been stimulated, there will be a fixed amplitude. Before that, there will be a graded type of electrical activity.

Recording from skin so that the nerve fibers that are close to the skin are stimulated first, the deeper ones need more electricity, by the time maximum stimulation is reached, all nerve fibers would have been stimulated. And any supra-maximum stimulation won't cause any affect since there are no more extra fibers to be stimulated. The stimulus artifact tells whether the electrical signal has reached the tissue.

**The compound action potential** is what is recorded from patients, not action potential nor graded electrotonic potential. When recording from a peripheral nerve like the radial or unlar nerve, the compound graded potential is the potential being recorded.

Compound action potential starts graded on the screen then ends up with a fixed amplitude since it's the summation of many action potential.

Recording potential in the upper limb involves sensory and motor nerves.

- Sensory fibers are usually the input to the brain and the central nervous system so that that conduction of the action potential moves from the distal to the proximal
- Motor fibers are orders from the brain to muscle for contraction therefore the direction of the action potential is from the proximal to distal.

➔ There are two types of recording for sensory nerves

#### 1. Orthodromic

This is the recording that follows the physiological pathway of sensory fibers. For example, recording of the ulnar nerve as a sensory fiber in the little finger. If the stimulating electrodes were at the little finger and the recording was at the wrist, that follows the physiological pathway of sensory fibers, from **distal to proximal**.

#### 2. Antidromic

The recording that goes against the physiological pathway of sensory fibers. Like stimulating near the wrist and recording from the finger, so that the record is from proximal to distal.

~ The electrical activity for sensory fibers is much better and clearer in antidromic recording than that in orthodromic ~

That is because in antidromic recording, its done proximally in the fingers where its mostly bones and small muscles and little fat. However, recording from upper parts of the hand and arm, which have many muscles and fat that prevents the spread of electrical activity.

^^ Antidromic recording is used in clinical practice.

➔ Motor recording is usually done from the muscle supplied by the nerve fiber since the electrical activity can be easily observed, for example; stimulating from the wrist or elbow and recording from the muscle.

Using the electroneuography, and in motor recording, the recording electrodes are put on the muscle and in sensory recording the electrodes are put on a superficial area where the sensory fibers are close to the skin.

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The compound action potential is not only graded until the max is reached, but it is also multiphased, when spreading the stimulating from the recording electrode, the peak is graduated and not smooth.

Reminder:

( C ) fibers are unmyelinated or partially myelinated , small , and they have slow conduction velocity and are for transmitting pain.

( A alpha) fibers are large, myelinated and the fastest fibers.

Therefore, A fibers will reach the recording electrodes faster and appear on screen first while C fibers will be the last to reach them. The difference in speeds will be obvious as the distance between the stimulating and recording electrodes increase.

\*in the slide that contains the arm with different electrodes for sensory, **orthodromic** recording of the **median nerve** , notice the ground (earthing) between the stimulating and recording electrodes \*

However, in motor recording of the median nerve, stimulating from two positions one at a time, once at the wrist and the other near the elbow, and recording from the muscle. When stimulating from the wrist, it is closer to the recording position than stimulating from the elbow where there will be a slight delay to get the electrical activity.

[The conduction velocity (m/s) = distance/time ]

- the distance is the difference between the two sites of recording using a measuring tape.
- the time is the difference between the two time periods of the two stimulus's , they're subtracted due to the delay at the neuromuscular junction that is not related to the conduction velocity and therefore it must be nullified, only the time where there is action potential is included.

The conduction velocity for the unlar, radial and median nerves is usually 56 – 58 m/s in a normal individual.

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After measuring the compound potential of sensory and motor fibers:

\*if a nerve fiber is stimulated with maximum stimulus and the resulted amplitude is less than normal (amplitude is smaller) then the patient suffers from loss of nerve fibers since the amplitude is the summation of many action potentials so if the nerve fiber is injured, it'll has less nerve fibers to conduct action potential leading to lower amplitude of the compound potential. This can also occur in cases of bone fracture where the nearby nerves are affected.

For example: a patient with a wrist drop as a result of a partial injury of the radial nerve, instead of having normal 300 fibers in the nerve, it'll have 200 so the summation will be 2/3 the normal one.

\*if the distance till the summation is reached is prolonged, that means that the conduction velocity is slower and therefore indicates demyelination .

- ➔ Any decrease in the action potential indicates axonal loss ( nerve fiber damage )
- ➔ Distance is prolonged indicates demeylination

(demeylation can occur due to vitamin b12 difficiency, diabetes and many other immunological disorders – chronic peripheral demeylinating disorders- or direct trauma and injury )

Diagnoses of the slide: recording of a compound action potential of the wrist and elbow joint. Comparing the amplitude with the normal ones, patient suffers from demyelination at the level of wrist elbow and axonal loss due to injury at the level of the elbow.

Recording from a patient of his left upper arm in comparison with the right one, and looking for obvious differences between the two by placing 4 recording electrodes on 4 sites to stimulate the ulnar nerve.

While diagnosis, comparison between the right and left side is made to make sure if patient is normal or not since there are personal variations that depend on age, sex ,etc..

\*Diagnosis of slide: Left ulnar is normal while the right unlar shows axonal lose indicating partial injury of the right ulnar above the elbow .

## ENG (تخطيط الاعصاب): Electroneurography

For diagnosing patients who suffer from slip disks, birth injury and fractures and injuries of the nerves.

It can be done by either using electrodes to record the potential or by using rubber helmet that has certain points for measurement. Recording using the helmet usually starts with 8 electrodes and can go up till 62 for diagnosing disorders, depending on what the physician is looking for.

On the slide, there are 8 ENG recordings, record 3 & 6 show temporal lesion which indicate a type of epilepsy called petit mal epilepsy (where patient doesn't lose consciousness) . Typically it occurs in kids suddenly, accompanied with eye roll to one side and the child seems absent. They usually recover after a few seconds or minutes. If it happens to a child in primary school, he'll lose a lot of information and needs to be treated. Typical ENG recording of a child with petit mal epilepsy will show many (spikes and domes).

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Attraction can either be physical/electrical attraction where our brain influences the surroundings, or chemical. Many waves can be omitted from the brain including:

- Alpha waves (8-13 hertz) : usually recorded from a normal person who is relaxed , eyes closed and almost meditating. Staying in the alpha waves is highly recommended, brain is not stressed.
- A person can stay in the alpha waves by meditating, praying, exercising, drinking a lot of water and by being surrounded by optimistic people who also emit these waves.
- Beta waves (alert brain) : when preparing for fight or flight, under stress, preparing for exams, etc..with eyes opened and the person is thinking of something serious. These waves are harmful to the brain and can also be emitted by negative people and complainers. – Stay away from them.

A person should have the alpha waves about 95% of the time and 5% in beta mode when suffering or facing a very stressful situation.

- Theta waves : less frequency, large magnitude. It is normally recorded from children but if recorded from adults when not stressed, frustrated or disappointed it might indicate pathology.
- Delta waves (1-5 hertz) : much less frequency, usually recorded in newborn babies, if recorded in adults it is abnormal.

Alpha and beta waves are normal when recorded from the brain in adults. Theta depends on the psychological condition and age of the patient. Delta, unless recorded from an infant, it is abnormal.

ENG is used to diagnose many types of epilepsy and the recording is normal when the patient isn't having an attack but differs during the fit.

Epilepsy is the disease and usually is idiopathic, happens after a trauma and in many cases occurs suddenly in a child and stays for the rest of his life, it differs from the epileptic fit which can happen to anyone who has abnormality in ions, PH, temperature, etc..

THE END

GOOD LUCK :)