Electromyography

Some Medical articles summarized by

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ELECTROMYOGRAPHY is one of several methods of electrodiagnosis the purpose of which is to establish the presence and sometimes the cause of paralysis of muscles.

Although, at the moment, it is carried out by doctors and not by physiotherapists, it is important for therapists to understand the principles on which it is based. It is unlikely to replace our Strength-duration tests but it forms a useful complement to them. The two methods are used both to diagnose and to give some idea of the prognosis, in cases of paralysis or muscle weakness.

Electrodiagnosis is done either by:—

1. Applying electrical stimuli of different durations and forms to a muscle and assessing the current or voltage needed to produce a minimal contraction, and also by studying the type of muscle contraction, and from the results, drawing a conclusion as to the degree of degeneration present, or by:—

2. Recording or studying the varying electrical potentials in a muscle fibre or motor unit.

Reaction of Degeneration

This is the altered response to an electrical stimulus applied to muscle with an impaired nerve supply. It varies in severity depending on the amount of damage to the nerve. There may be:—

I. *Complete Reaction of Degeneration*

This occurs when the nerve is destroyed and the muscle physiologically isolated from the controlling centres in the central nervous system.

II. *Partial Reaction of Degeneration*

This occurs when there is partial interruption of the peripheral nerve; that is, between the anterior horn cell and the motor end plate. Some axons are destroyed and others remain intact.

The term "Partial Reaction of Degeneration" has a wide span ranging from almost complete destruction to near normality, so no definite signs can be laid down as being representative of it. It is merely the long intermediate stage between the two extremes.

Methods of Electrodiagnosis

I. *Testing for Reaction of Degeneration*

This may be done by:—

(a) The Galvanic-Faradic test or

(b) The Strength-duration test or Voltage-duration test in which

(1) Square-wave impulses of varying duration or additionally

(2) Progressive impulses of varying duration are applied to a muscle.

II. *Recording the Electrical Potentials of the Muscle*

The contraction of a muscle fibre is accompanied by a change in the electrical potential which can be measured, amplified and recorded. The process by which this is done is Electromyography. The technique investigates the activity of single motor units, which consist of:—

(1) An anterior horn cell.

(2) The axon derived from it.

(3) The muscle fibres innervated by it.

or of a single muscle fibre.

It differs from the two methods mentioned previously as these test the muscle as a whole.

Apparatus used in Electromyography

I. *Electrodes*

For accuracy, needle electrodes must be used, as this is the only means of recording the activity of individual muscle fibres. The two poles are obtained by:—

(a) A piece of wire (the active electrode) placed inside a hypodermic needle (the indifferent) or

(b) A solid needle, insulated except at the tip, forming the active electrode, with the indifferent electrode on the surface.

II. *Recording Devices*

The electrical activity of a motor unit or a muscle fibre is picked up by the above-mentioned electrodes, considerably amplified (from microvolts to 60–100 volts) and then fed into a Cathode Ray Oscilloscope. This consists of a cathode ray tube which includes the following essentials:—

An evacuated glass tube containing:—

(a) A heated cathode to produce electrons.

(b) Several anodal plates which accelerate and focus the beam of electrons on to

(c) A fluorescent screen where the focussed beam of electrons appears as a luminous spot.

Between the cathode and the anodal plates

(d) A negatively charged grid to control the total electron flow.

Since wave forms have to be seen on the screen, it must be possible to move the beam of electrons in any direction on the screen. This is done by

(e) Two sets of deflector plates which are placed between the last anode and the screen. The two sets of plates are at right-angles to each other. One set, usually called the X plates, causes horizontal deflection of the electron beam. The other set of plates, usually called the Y plates, produces vertical movement of the luminous spot.

To produce a wave-form, a time base circuit must be incorporated. This is connected to the X plates of the tube. The time base unit must be synchronized to the frequency of the wave form to be examined.

This controlled, synchronized horizontal movement of the electron beams is the so-called "sweep."

Vertical deflection of the electron beam is produced by the potential of the electron wave which causes the spot to move up and down the screen. In this way, the electrical potential can be:—

(1) Seen on the fluorescent screen.

(2) Permanently recorded on a camera.

(3) Fed into a loud-speaker.

The character of the sound gives an indication of the amplitude and duration of the wave form.

(4) Recorded by a pen-writer.

Although this is not completely accurate owing to ted inertia of the pen, it is important because it can be studihe

at leisure after the needles have been removed from the patient's muscles. Also, exact measurements can be taken and comparisons made with the normal.

Method used to record the potentials

After the administration of a local anaesthetic, a needle is inserted into the muscle and is moved from one fibre to another, the potentials of each being viewed on the screen and recorded by one of the devices described above.

Types of Response seen in Electromyography

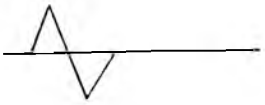
I. *Action Potential*

The contraction of a single muscle fibre is triggered off at the motor end plate and is accompanied by a wave of negativity which travels along the muscle fibres.

This wave form can be picked up by the two electrodes placed close together in the muscle fibre and will result in a diphasic wave i.e. the action potential. (Graph 1).

Normally, the whole motor unit "fires" i.e. many muscle fibres contract with the result that the amplitude is higher and the duration longer. (Graph 2.)

Graph 1



Graph 2

II. *Denervation Potential*

Rhythmic twitching of individual muscle fibres causes a series of short, rapid waves seen on the screen as denervation fibrillation.

III. *Fasciculation Voltages*

These are spontaneous, involuntary contractions of a group of muscle fibres. They are sometimes seen by the naked eye as a twitching of the muscle and may be a normal phenomenon, as in fatigue. However, it usually indicates some pathology and may be of two types:—

(1) A slow twitch at intervals of 10–20 seconds indicating a motor neuron disease such as progressive muscular atrophy.
(2) A fast, rhythmic fasciculation may be seen in the paretic muscles in poliomyelitis, neuritis and Guillain-Barré syndrome.

It may be due to irritation of the nerve, pain, or tension due to fatigue and weakness. Experience is needed to differentiate between the various types and to decide on the cause.

IV. *Synchronized Motor Unit Potentials*

These may be normal but are often a sign of pathology They occur in the following circumstances:—

(1) When a normal muscle is fatigued.
(2) When a normal muscle is working against maximum resistance.
(3) In a weakened or partially paralysed muscle.

Usually, when a muscle contracts, some of the fibres contract out of time with the others to produce a smooth contraction and delay fatigue. In the three cases mentioned above, the smoothness of the movement is forfeited in favour of obtaining maximum power. The result is a simultaneous contraction of all fibres, giving rise to synchronous motor unit potentials.

V. *Complex Motor Unit Voltages*

These are polyphasic potentials usually demonstrating five or more peaks. They are often seen in the recovery phase following a nerve lesion and so may be of prognostic value.

Specific Responses in Electromyography

I. *In Normal Muscle*

(a) *At Rest.*

There are no voltages generated i.e. a normal muscle at rest is electrically silent.

AT REST

Normal

Complete Electrical Silence

Denervated

Fibrillation Voltages

Partially Denervated

Fibrillation & or Fasciculation Voltages

DURING VOLUNTARY EFFORT

Normal

Simple Motor Unit Voltages

Denervated

Fibrillation Voltages

Partially Denervated

Simple & or Complex Motor Unit Voltages

Name of wave	Magnitude of wave in microvolts	Duration of wave in milliseconds	Frequency of wave per second	Audio-sound	Diagnostic significance
Simple motor unit voltages occurring during voluntary effort.	100–2000	2–10	5–60	LOW-pitched thumping sound.	Normal muscular contraction.
Fibrillation voltages at rest.	10–100	1–2	2–30	High-pitched click.	Abnormal wave signifying dennervation.
Fasciculation at rest.	20–1000	5–15	Irregular inconstant repetition frequency.	Harsh, low-pitched noise	Abnormal wave associated with degeneration or irritation.
Complex motor unit voltages during voluntary effort.	20–1200	5–20	5–30	Harsh, low-pitched noise	Abnormal wave associated with degeneration or regeneration.
Base-line disturbances during voluntary effort.	5–500	5–30	2–30	Distant soft indistinct rumbling sound.	Abnormal wave associated with early regeneration or late degeneration.

(b) *On Slight Contraction.*
There are action potentials or simple motor unit voltages.

(c) *On Strong Contraction.*
The Potentials have several spikes i.e. They are poly-phasic.

The other factors (parameters) which give an indication of the conditions are:—

(1) Voltage: 100–2,000 microvolts.
(2) Duration: 2–10 milliseconds.
(3) Frequency: 5–60 per second.
(4) Sound: A low, thumping sound.

II. *In a Complete Reaction of Degeneration*

Denervation fibrillation is seen at rest and on attempted movement. As compared with the action potentials, the parameters of the fibrillations are as follows:—

(1) Voltage: 5–100 microvolts.
(2) Duration: 1–2 milliseconds.
(3) Frequency: 2–30 per second.
(4) Sound: A high-pitched click.

III. *In a Partial Reaction of Degeneration*

(a) *At Rest.*
Some fibres are electrically silent and others show fibrillations. The higher the number of fibres showing fibrillations, the more severe the paralysis.

(b) *On Movement.*
On voluntary or reflex contraction, there are simple or complex motor unit voltages.

SUMMARY

Functions of Electromyography

(1) To ascertain whether action potentials exist in a given muscle.
(2) To ascertain whether they are normal or abnormal.
(3) To ascertain the type and probable cause of the abnormality.

Diagnostic Criteria

The criteria to be examined are:—

(1) The presence or absence of potentials when the muscle is at rest.
(2) The presence or absence of potentials during voluntary effort.
(3) The normal or abnormal characteristics of these potentials.

Any abnormal characteristics must then be interpreted and compared with the normal patterns.

Electromyography constitutes one of the few completely objective means of diagnosis of neurological complaints because it is impossible for the patient to control the presence or absence of fibrillations and other abnormal phenomena. They can only occur when there is impairment of the nerve supply or some genuine nervous pathology.

In conjunction with the Strength-duration method of muscle testing, it constitutes a reliable means of diagnosis and the findings may also be of prognostic value.

Acknowledgement

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